

JOURNAL OF ATHLETIC TRAINING

Official Publication of the National Athletic Trainers' Association, Inc Volume 54, Number 6, Supplement, 2019

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Take this *Supplement* to Las Vegas and use it as a guide to the
Free Communications Sessions

Dear NATA Members and Friends:

We are pleased to present the annual Supplement to the *Journal of Athletic Training*. This Supplement contains abstracts presented at the 2019 NATA Clinical Symposia & AT Expo in Las Vegas, NV as part of the NATA Foundation Free Communications Program.

The Free Communications Program provides certified athletic trainers, students and other healthcare providers an opportunity to present and learn about the latest in athletic training research. Research is presented in oral and poster formats and includes general research, NATA Foundation-funded research, clinical case reports and our Student Exchange program posters. Abstracts of the research are printed here in the order of presentation at the NATA Convention in Las Vegas for your convenience. Free Communications presentations represent a wide range of research and clinical interests. In addition, the Clinical Case Reports sessions allow you to test your clinical assessment skills. We encourage you to attend these presentations.

We also urge you to attend the sessions featuring research funded by the NATA Foundation. The NATA Foundation funds research and a variety of educational programs, including summits on issues critical to athletic training, as well as annual scholarships to undergraduate and graduate students of athletic training.

Support from NATA members, corporations, and other affiliated groups make this supplement and all of our programs possible. Please note projects funded by the NATA Foundation and by the generous contributions of our donors are specified in this Supplement. To make an investment in the future of the profession, please contact us today at 800-TRY-NATA, extension 150 or visit <https://natafoundation.org/support/ways-to-give/donate/>.

NATA and the NATA Foundation are pleased to offer this supplement as a service to NATA members. We hope that it provides theoretical and practical information you can use to improve your effectiveness as a certified athletic trainer. Thank you for your support!

Sincerely,



Brian Conway, LAT, ATC
President, NATA Research & Education Foundation



Tory Lindley, MA, ATC
President, NATA

Dear Colleagues:

On behalf of the National Athletic Trainers' Association Research & Education Foundation and the Free Communications Sub-Committee, we would like to thank all the authors who submitted abstracts to the Free Communications Program. We are happy to report a record number of submissions again this year with just under 700 Peer Reviewed and Student Exchange Track submissions, combined. We are excited about this year's Free Communications Program, as we believe it contains an exciting mix of both high caliber research reports and clinical case studies. Please keep in mind that we consider oral and poster presentations to be equal in terms of caliber and encourage clinicians and researchers to attend both oral and posters sessions.

We would also like to take this opportunity to extend a special thanks to the all of the NATA Foundation staff and especially Velma Meza, whose attention to detail and dedication makes the Free Communications Program possible. Additionally, many individuals have worked very hard to review submissions, schedule presentations, and produce this Supplement to the Journal of Athletic Training. Therefore, we would like to thank and recognize the efforts of the Free Communications Committee for their long hours of abstract reviews and creativity in developing this year's Free Communications program. The Free Communications subcommittee members are:

Michelle Boling, PhD, ATC;	Blaine Long, PhD, AT, ATC;
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Kellie Huxel-Bliven, PhD, ATC;	Erik Wikstrom, PhD, ATC, LAT;

We also acknowledge the unwavering support and guidance from Brian Conway, LAT ATC and the rest of the Foundation staff. I also specifically recognize Velma Meza who works tirelessly behind the scenes to assure a successful program each year. Lastly, we wish to thank Leslie Neistadt and the staff at the editorial office of the *Journal of Athletic Training* for making the Supplement possible.

As we move forward, we continually try to improve and make the review process more transparent. Our goal is to be as inclusive as possible while maintaining the high level of scholarship that readers expect of the Journal of Athletic Training. To further improve the process, we appreciate the feedback we have received from authors, and suggestions are always welcomed and discussed in committee meetings.

We look forward to seeing you in Las Vegas. Please take the opportunity to attend the Free Communications Best Practices Forums, peer reviewed oral and poster sessions, and the student exchange poster presentations. Please note that projects funded by the NATA Research & Education Foundation are specified in this Supplement. Finally, if you have the opportunity, please offer your thanks to those recognized above.

Sincerely,



Joseph M. Hart, PhD, ATC
Vice Chair for Free Communications
NATA Research & Education Foundation Research Committee

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The Medal for Distinguished Athletic Training Research

**Gary B. Wilkerson, EdD, ATC, FNATA
University of Tennessee at Chattanooga**

Gary B. Wilkerson was unfamiliar with the field of athletic training as an undergraduate at Eastern Kentucky University. Having played football in high school, he wanted to find an outlet that would allow him to stay connected to the sport. This position turned out to be the football manager at Eastern Kentucky University. Although this position was significant to Wilkerson in providing financial assistance, it coincided with the arrival of Bobby Barton, DA, LAT, ATC, longtime athletic trainer and program director at the university. Their relationship began when Wilkerson assisted with duties in the athletic training room. From this experience, he began to see a potential career opportunity in the field of athletic training.

In 1978, Wilkerson applied to the University of Arizona's graduate athletic training program, 1 of only 2 available at the time. As part of his program, he was assigned to provide athletic training services to a Tucson high school, expanding his ability to practice independently. But Wilkerson says his pursuit of advanced degrees and research was a slow progression. While working at another large Tucson high school after graduation, he was offered a position at a Division III school in central Kentucky. After several years, he became intrigued with foundational explanations: why did certain approaches result in improvement and others didn't? Ultimately, this motivated him to pursue a doctoral degree at the University of Kentucky, making him the first athletic trainer to receive this distinction at the institution in 1989.

Wilkerson's doctoral work concentrated on the biomechanics of the subtalar joint and chronic ankle instability. His involvement in these areas continued through his clinical work, where he saw a high volume of patients with ankle injuries undergoing rehabilitation. Advancing to become the program director of the University of Tennessee at Chattanooga master's program in athletic training, he started researching lower extremity dysfunction and the interconnectedness of the ankle, knee, hip, pelvis, and lower back, along with higher control centers and reciprocal corticospinal connections. With this information, Wilkerson has looked at risk profiles, predictive modeling of complex systems, and the accuracy of injury-prediction models.

Wilkerson acknowledges a wide chasm between researchers and clinicians in their professional relationships. He encourages his students to become involved in research because he understands the importance of applying research-based methods to clinical practice and closing this gap. Two broad areas of research that interest Wilkerson today are the profound effects of emerging technological advances in neuroimaging and electrophysiology that allow us to “see” and analyze movement patterns at a more granular level. He believes these advances will dramatically influence the way we treat patients. It is his hope that the aggregation of large datasets will help generate more specific patient risk profiles (eg, age, sex, sport) and ultimately create more value within the health care system.

At this point in his career, Wilkerson is most proud of his induction into the NATA Hall of Fame, a humbling experience that he never expected and for which he is most grateful. He recognizes Bobby Barton and Gary Delforge, EdD, ATC, as tremendous influences throughout his professional career. Additionally, he thanks his colleague, Marisa Colston, PhD, ATC, with whom he has worked at the University of Chattanooga since 2000. He is proud of the work done through Athletes in Action, which provides educational seminars for athletic trainers, physicians, and physical therapists in other countries. Volunteering for this program has allowed him to give back to the profession. He also enjoys his free time, spending it with his family and traveling with his wife, Liz.



The New Investigator Award Presented in Honor of Freddie H. Fu, MD

**David R. Howell, PhD, ATC
Children's Hospital Colorado and University of
Colorado, Denver**

David R. Howell, PhD, ATC, had his interest in athletic training sparked early in his undergraduate career. He was intrigued by the idea of merging medicine and health care with athletic and active populations. Howell enjoyed helping highly motivated athletes optimize their performance and achieve their goals. During his undergraduate and graduate school clinical experiences, Howell noted a common theme: concussions were confusing clinical injuries. Recognizing a concussion was primarily based on circular logic: asking patients with brain injuries to explain what had changed within their brain using self-reported symptom inventories. In contrast to patients with musculoskeletal injuries, every individual presented differently after a concussive injury. At summer football camps, when an unfamiliar athlete complained of a headache, Howell found it difficult to determine the cause: concussion, dehydration, homesickness, or any other potential reason. Exposure to patients with these injuries led to his research emphasis on the objective evaluation of motor and cognitive functions after concussions and postural stability and movement analysis in youth athletes.

At the University of Oregon, Howell worked alongside his mentor, Li-Shan Chou, PhD, studying the role of dual-task capabilities in human movement analysis. Currently, many clinical tests (eg, SCAT5) assess both cognitive and motor tasks; however, among athletes, we do not conduct these tasks in isolation. Howell is looking into generating new approaches that combine these tasks, such as adding a single cognitive perturbation to gait testing. Dual tasks may provide a more accurate picture of an athlete's ability to return to play than traditional clinical tests. Howell has also used sophisticated motion-analysis technology to understand dynamic balance control. As a postdoctoral research fellow at Boston's Children's Hospital, he aimed to translate this information into a more feasible, clinically applicable form for determining recovery from concussion. He has continued this work at Children's Hospital Colorado, implementing tandem-gait and dual tasks into objective measures that may assist with clinical decision making. Although he still feels that the athletic trainer assigned to a team is likely the best person to recognize, assess, remove, and refer the athlete with a concussion, he hopes that dual-task assessments can provide a complementary evaluation tool

for clinicians who care for patients with concussions. Howell plans to continue to gain a better understanding of both age- and sex-related differences in concussion recovery. To this point, most concussion studies have focused on college-aged athletes, but preadolescents and adolescents do not respond to assessments or recovery from concussions in the same way as adults. He therefore hopes to address this gap in knowledge moving forward.

Howell encourages young professionals who are interested in research to be proactive and pursue interests that excite them. He advises students to keep writing, as there is no substitute for experience and feedback from peers and mentors. Additionally, he suggests young researchers seek mentors who want what's best for them and their professional development. Overall, Howell loves coming into work trying to figure out the "how and why" to gain a better understanding of our field. He recognizes a multitude of mentors and colleague who have been very influential in his career, allowing him to develop as a scientist, researcher, and athletic trainer. These include Li-Shan Chou, PhD, and Louis Osternig, PhD, ATC, at the University of Oregon; William Meehan, MD, Dai Sugimoto, PhD, ATC, and Rebekah Mannix, MD, MPH, at Boston's Children's Hospital; and Julie Wilson, MD, Aaron Provance, MD, Jay Albright, MD, and Michael Kirkwood, PhD, at Children's Hospital Colorado.

Howell is now an assistant professor in the Department of Orthopedics at the University of Colorado School of Medicine and the Lead Researcher for the Sports Medicine Center at Children's Hospital Colorado. He appreciates this professional opportunity and is excited to continue progressing with his research line for many years to come and to contribute to the ongoing work across many areas within sports medicine at Children's Hospital Colorado. He finds enjoyment outside of his work through fly fishing, skiing, and hiking in addition to spending time with his supportive wife, Emily.



Freddie H. Fu, MD

Dr. Freddie H. Fu, a longtime advocate of certified athletic trainers, is a well-respected physician whose work in sports medicine has earned repeated honors.

The 1996 winner of the NATA President's Challenge Award, Dr. Fu is the David Silver Professor of Orthopaedic Surgery and Chairman of the Department of Orthopaedic Surgery at the University of Pittsburgh School of Medicine and the UPMC Health System.

He has been the head team physician for the University of Pittsburgh Department of Athletics since 1986. He also was instrumental in establishing the Sports and Preventive Medicine Institute in 1985. Under his leadership, the facility—now called the UPMC Health System Center for Sports Medicine—has grown into the region's largest, most comprehensive sports medicine center and is regarded as among the best in the country.

Dr. Fu holds secondary appointments as Professor of Physical Therapy and Health, Physical and Recreational Education. He was awarded an honorary doctorate of science degree from Point Park College and an honorary doctorate of public service from Chatham College.

Known worldwide for his pioneering surgical techniques to treat sport-related injuries to the knee and shoulder and his extensive research in the biomechanics of such injuries, Dr. Fu performs surgery at UPMC Health System and sees patients at the Center for Sports Medicine. He also directs the University of Pittsburgh's Sports Medicine Fellows Society.

Dr. Fu is the editor of 12 major orthopaedic textbooks and author of 60 book chapters on managing sports injuries. He has contributed to more than 150 international research publications and has given more than 400 national presentations. Former President of the Pennsylvania Orthopaedic Society, he is a member of 40 other professional and academic medical organizations.

Dr. Fu has served as Chairman of the Board and Executive Medical Director of the City of Pittsburgh Marathon Inc; Company Physician and Board Member for the Pittsburgh Ballet Theatre; and Team Physician for Mt. Lebanon High School. Additionally, he is past President and Chairman of the Children's Festival Chorus and has served the Parental Stress Center, the Pittsburgh Employment Alliance, and the Organization of Chinese Americans.



**The Doctoral Dissertation Award
Presented in Honor of David H. Perrin,
PhD, AT Ret, FNATA, FACSM
Sponsored by Friends of Dr. Perrin**

**Matthew S. Harkey, PhD, ATC
Tufts Medical Center/University of
Massachusetts Medical School**

Matthew S. Harkey was introduced to the field of athletic training unexpectedly. As a student at a small high school in North Carolina, he was never exposed to the coverage and care provided by athletic trainers. While completing his undergraduate degree at the University of North Carolina, he “bounced around” various classes, but his interest in sports science was piqued by a course in anatomy. The professor, Darin Padua, PhD, ATC, mentioned athletic training as a possible career path; this led to an informational meeting and his involvement in athletic training. Harkey found cadaver anatomy fascinating as it related to musculoskeletal injuries in sport, which later influenced his research into functional movements, musculoskeletal imaging, and injuries.

Harkey pursued a master’s degree in athletic training at the University of Toledo. It was there that he was introduced to athletic training research. Working with Brian Pietrosimone, PhD, ATC, his master’s and doctoral advisor, he developed an interest in the long-term effects of musculoskeletal injuries. Harkey’s initial research focused on individuals with chronic ankle instability, primarily looking at interventions that influenced neuromuscular changes and dynamic stability after injury. After completing his master’s degree, Harkey accompanied Pietrosimone back to the University of North Carolina to pursue a PhD in human movement science. During this time, his research concentrated on the long-term effects of anterior cruciate ligament reconstruction and methods to monitor cartilage loading and deformation, gait and landing-task alterations, and blood markers in these individuals. Because osteoarthritis may occur in one-third of patients within 10 years of anterior cruciate ligament reconstruction, protocols and interventions must be optimized for this population. It is Harkey’s hope that advancing more accessible technologies (eg, musculoskeletal ultrasound) will translate into clinical tests and monitoring techniques to improve our understanding of tissue healing during rehabilitation.

Originally, Harkey had no real intention of conducting research—but now it’s an instrumental part of his professional work. He encourages young athletic training professionals to be open to the idea of

doing research. He notes that conducting research helps broaden one's view and creates new avenues of thought in the profession of athletic training. Ultimately, he would like to see the dialogue between clinicians and researchers increase because both perspectives will help generate results that can be used to improve patient care.

Harkey currently holds positions at Tufts Medical Center and the University of Massachusetts Medical School. He and his wife, Brittney Luc-Harkey, PhD, ATC, now live in Boston and are expecting their first child this summer. And when not conducting research, they are trying to learn what hobbies interest them, joking about how much time has been invested in their work until now. Harkey enjoys watching college basketball and finding new breweries.

Harkey thanks Brian Pietrosimone for helping to push him from an “unmotivated kid coming out of undergrad” to someone who is excited to arrive at work every day and keep improving. In Harkey's words, Pietrosimone's “passion for what you do and your ability to make people excited about your research is remarkable, and I would not be anywhere if it was not for your guidance.”

Harkey also thanks J. Troy Blackburn, PhD, ATC; Anthony Hackney, PhD; Michael Lewek, PhD, PT; and Randy Schmitz, PhD, ATC, for all their expertise and guidance throughout his dissertation research. Additionally, he thanks his research assistants (Arianna Douglas; Daniel Farrell; Ryan Fockler; Samantha Hammock, ATC; Leslie Sierra-Arevalo, ATC; Gabrielle Smith; Nicole Thomas; and Kyle Wolfe) for all the hours they devoted to helping him collect and process the data for the project, which could not have happened without their help.

Last, but definitely not least, Harkey would not have been able to complete his dissertation without his wife, Brittney Luc-Harkey (who was also completing her PhD at the time). As he noted, the dissertation process can be a long and hard journey, but having your best friend to lean on throughout the process makes it much easier.



David H. Perrin, PhD, AT Ret, FNATA, FACSM

David H. Perrin, PhD, FNATA, FACSM, is a respected researcher, educator, mentor and friend of athletic training. This 2003 NATA Hall of Fame inductee is a noted pioneer of terminal degrees in sports medicine, and his dedication to athletic training is making an impact on the profession's development even today.

Serving as editor-in-chief of the *Journal of Athletic Training* and founding editor of the *Journal of Sport Rehabilitation* are only two of Dr. Perrin's significant achievements. Others include being awarded NATA's Sayers "Bud" Miller Distinguished Educator Award in 1996, Most Distinguished Athletic Trainer Award in 1998, and All-University Outstanding Teaching Awards from the University of Virginia in 1997 and 1998.

Dr. Perrin has built research education programs at the undergraduate, master's, and doctoral levels and has fully dedicated himself to mentoring and developing future scholars. Dr. Perrin makes every effort to maximize his students' potential by offering sound advice and helping them make the most of their educational programs. Many of his students have gone on to bright careers in the profession, as researchers, program directors, clinical supervisors, and award-winning scholars.

Dr. Perrin is dean of the College of Health and professor of Exercise and Sport Science at the University of Utah.

The NATA Foundation Doctoral Dissertation Award, presented in honor of David H. Perrin, recognizes outstanding doctoral student research and is a fitting tribute to a man who has dedicated the duration of his career to mentoring and developing future scholars.

**Miscellaneous Best Practices Forum: Head Impacts and Neck Workload:
Applications in Military, Fast Jet Pilots, and Athletes**

Tuesday, June 25, 2019, 8:30AM-9:30AM, Mandalay Bay A; Moderator: Julianne Schmidt, PhD, ATC
Discussants: Jeremy Witchalls, PhD; Jason Mihalik, PhD, CAT(C), ATC

Heat/Hydration Best Practices Forum: Examining Adherence to Therapeutic Rehabilitation

Tuesday, June 25, 2019, 10:00AM-11:00AM, Mandalay Bay A; Moderator: Ashley Schwieterman, MA, ATC
Discussants: Jessica Rager, MS, ATC; Jessica Kirby, MSED, ATC

Free Communications, Oral Presentations: Ankle Injury Risk Factors

Tuesday, June 25, 2019, 11:30AM-12:30AM, Mandalay Bay A; Moderator: Kenneth Lam, ScD, ATC

Ankle Injury Risk Screening Tests Do Not Change Over the Course of a Single Season

McGrath ML, Yancy JT, Allen KM: University of Montana, Missoula, MT; DURO Healy LLC, Portland, OR

Context: Lateral ankle sprains (LAS) are the most common injury sustained during participation in athletics. Several methods have been proposed to identify individuals who may be at greater risk of suffering LAS, including clinical assessment of dorsiflexion range of motion (ROM) and dynamic single-leg balance. However, little research has examined how the results of these screening tests change over time, both in healthy athletes and those with a history of LAS. Therefore, the objective of this study was to quantify changes in dorsiflexion ROM and dynamic balance across a single soccer season.

Methods: A repeated measures study was performed during the first week of sanctioned practices during the fall season (PRE), and then one month after the final game (POST). All data collection occurred in the athletic training facility, using the same investigators during both testing periods (ICC_{3,1}=0.87-

0.98). Eighteen healthy NCAA Division I women's soccer players (age: 19.1±1.1years, height: 168.3±6.8cm, mass: 64.1±6.8kg) were divided into two groups based on self-reported injury history: one with prior history of LAS ("LAS", n=7, Foot-Ankle Ability Measure (FAAM) ADL=98.8±2.3%, FAAM Sport=93.9±7.4%), and those without ("Healthy", n=11). Participants performed the weight-bearing lunge test (WBLT) and the Y-balance test (Ybal) on both legs in random order. WBLT was measured as the greatest distance from the tip of the front 1st phalanx to the wall, keeping the heel of the front foot on the ground. Ybal measurements in the anterior, posteromedial, and posterolateral directions were normalized to leg length, and composite Ybal score (comp) was calculated as the sum of the reaches/three times leg length. For comparison, the "injured" leg was defined as the ankle with prior LAS, or the non-dominant leg for healthy participants. If LAS were bilateral, the ankle with the most recent LAS was defined as "injured". Mixed-model ANOVAs (group x time) were utilized with $\alpha \leq 0.05$. **Results:** There were no changes in pre-season

to post-season WBLT on the "injured" side (F_{1,16}=1.01, p=0.33) or "non-injured" side (F_{1,16}=0.03, p=0.88) between groups. Similarly, there were no changes in pre-season to post-season Ybal scores on the "injured" side (F_{1,16}=0.20, p=0.66) or "non-injured" side (F_{1,16}=0.16, p=0.69) between groups (see Table 1). Main effects for time were non-significant for WBLT and Ybal on both legs (p=0.15-0.17, cohen's d=0.31-0.39). There were also no differences in WBLT or Ybal-comp between groups at either testing session (p=0.38-0.90, cohen's d=0.03-0.52).

Conclusions: Results of two common clinical screening tests for LAS do not appear to change over the course of a season, regardless of self-reported history of LAS. The relative stability of these test results support the use of a single annual screening period to evaluate athletes at risk of LAS.

Table 1: Pre- and Post-season values for WBLT and Ybal composite measurements

		WBLT		Ybal composite	
		Injured/ Non-dominant	Non-injured/ Dominant	Injured/ Non-dominant	Non-injured/ Dominant
Hx LAS	Pre	9.9 ± 3.3cm	11.0 ± 3.6cm	97.0 ± 7.2%	98.5 ± 4.2%
	Post	10.8 ± 2.6cm	11.5 ± 2.3cm	100.5 ± 7.0%	101.5 ± 7.6%
No Hx LAS	Pre	11.5 ± 2.8cm	11.5 ± 3.2cm	100.6 ± 9.1%	99.6 ± 9.5%
	Post	11.7 ± 2.9cm	12.1 ± 3.4cm	102.4 ± 9.8%	101.3 ± 8.2%

Clinical Risk Factors for Recurrent Ankle Injury in Chronic Ankle Instability: A 1-Year Prospective Study

Son SJ, Page GL, Bruening DA, Feland JB, Seeley MK, Hopkins JT: CHA University, Seongnam, South Korea; Brigham Young University, Provo, UT

Context: Little is known about risk factors for ankle reinjury in the CAI population. The purpose of this study was to identify risk factors for recurrent sprains in CAI in a 1-year prospective study.

Methods: This study was a controlled laboratory trial. 93 of 100 CAI patients completed a 12-month follow-up survey. 23 CAI patients (14M, 9F, 22±2yrs, 175±11cm, 77±15kg) reported recurrent sprains in the involved side, 8 CAI patients (4M, 4F, 21±2yrs, 176±9cm, 73±8kg) reported reinjury in the contralateral side, and 62 CAI patients (30M, 32F, 22±2yrs, 173±11cm, 74±14kg) reported no reinjury. Risk factors were collected including SEBT-ANT (% of leg length), Biodex static overall stability index, figure 8 hop for time (sec), triple crossover hop for distance (m), static dorsiflexion ROM (degree), arch height index, BMI, self-reported scores (FAAM ADL & Sports), physical activity exposure (hours/week), durations since last sprain, previous number of sprains, and previous giving way episodes. One-way ANOVA analysis was performed to examine differences between the 3 groups. The Tukey-Kramer HSD test was performed for post-hoc comparisons ($\alpha = 0.05$). **Results:** CAI patients with recurrent sprains demonstrated a shorter reach distance in SEBT-ANT compared to the no reinjury group (59.8±7% of leg length vs 63.8±6% of leg length; $p < 0.038$; Cohen's d effect size, ES: 0.61). The reinjury group showed higher Biodex static overall stability index compared to the no reinjury group (0.94±0.28 vs 0.75±0.19; $p < 0.00$; ES: 0.79). The reinjury group showed less dorsiflexion ROM compared to the no reinjury group (42.2±5.9 degree vs. 46.3±6.6 degree; $p < 0.03$; ES: 0.65).

The arch height index was identified as a risk factor for recurrent sprains where the reinjury group showed lower arch height index compared to the no reinjury group (0.35±0.02 vs. 0.37±0.02; $p < 0.01$; ES: 1.0). The previous number of sprains (4.3±2.1 vs. 3.2±1.5; $p < 0.04$; ES: 0.60), and “giving way” episodes in the past 12 months (4.2±3.1 vs. 1.8±1.7; $p < 0.00$; ES: 0.96) were higher in the reinjury group compared to the no reinjury group. No differences were identified in figure 8 hop for time, triple crossover hop for distance, BMI, self-reported scores (FAAM ADL & Sports), physical activity exposure, and durations since last sprain. **Conclusions:** Several risk factors for ankle reinjury were identified in this 1-year prospective study. Limited dorsiflexion ROM and lower arch height index increased the risk of ankle reinjury, which may affect altered joint position and loading during movement. Both static (Biodex stability index) and dynamic balance (SEBT-ANT) seem to increase risk of ankle injury. In addition to the higher number of previous ankle sprains, a greater number of giving way episodes appeared to increase the risk of ankle reinjury. These risk factors would provide important information for prevention of ankle reinjury in the CAI population.

The Epidemiology of Ankle Injuries in Middle School Sports, 2015/16-2016/17 Academic Years

Caswell SV, Vipperman JW, Kelshaw PM, Abrams V, Cortes N, Lincoln AE, Kerr ZY: George Mason University, Fairfax, VA; MedStar Sports Medicine, Baltimore, MD; University of North Carolina, Chapel Hill, NC

Context: Ankle sprains continue to be a healthcare burden comprised of a considerable proportion of injuries sustained in collegiate and high school sports. Yet, little is known about the incidence of ankle injuries among middle school student-athletes. Therefore, the purpose of this study was to describe the incidence of ankle injury among middle school student-athletes by diagnoses, sport, sex, mechanism, event-type, and restricted participation time. **Methods:** A cross-sectional study was conducted with 4081 middle school student-athletes participating in 12 scholastic-sponsored sports at 9 middle schools in Virginia (ACHIEVES Project) during the 2015/16-2016/17 academic years. Athletic trainers attended practices and games at each middle school and collected all ankle injury (e.g., abrasion, contusion, sprain, strain, and inflammatory condition) and athlete-exposure (AE) data. An AE was defined as one athlete participating in one event-type (practice or competition). Ankle injuries were classified as non-time loss (NTL; <24 hours sport participation restriction) or time loss (TL; ≥24 hours participation restriction). Injury frequencies and rates (IR) were calculated. Injury rate ratios (IRR) were used to compare IR by sex in sex-comparable sports (e.g., soccer, basketball, baseball/softball, and track and field). IRRs with 95% confidence intervals (CI) excluding 1.0 were considered statistically significant. **Results:** Overall, 256 ankle injuries were reported (IR = 1.64/1000 AE; 95% CI: 1.44-1.84/1000 AE). The most common ankle injuries were sprains (59.7%, $n = 153$, IR = 1.26/1000 AE), inflammatory conditions (18.4%,

n = 47, IR = 0.26/1000 AE) and contusions (13.7%, n = 35, IR = 0.23/1000 AE). The sports with the highest ankle injury rates were girls' track and field (3.25/1000 AE), girls' soccer (3.19/1000 AE), and girls' basketball (2.18/1000 AE). In sex-comparable sports, girls had higher rates than boys for all ankle injuries (2.69 versus 1.18/1000 AE; IRR = 2.29; 95% CI: 1.68-3.13) and ankle sprains (1.62 versus 0.62/1000 AE; IRR = 2.61; 95% CI: 1.71-3.99), respectively. Overall, 64.0% (n = 164) of all ankle injuries and 86.0% (n = 131) of sprains were due to non-contact mechanisms. The ankle IR did not differ between competitions and practices (1.92 versus 1.55/1000AE; IRR=1.24; 95%CI: 0.93-1.63), respectively. Ankle injuries were nearly evenly divided between those resulting in NTL (49.6%, n=127) and TL (50.4%, n=129). Among TL ankle injuries, most (83.1%, n=107) resulted in <7 days and (14.7%, n=19) 7 to 21 days of restricted participation, respectively. Few ankle injuries (1.2%, n=3) resulted in >21 days of restricted time.

Conclusions: Our findings of ankle injury incidence and restricted participation time in middle school student-athletes are similar to previous findings in the high school population. Compared to boys, girls in sex-comparable sports had higher rates of ankle injuries and ankle sprains. Variations associated with ankle injuries by sex and sport highlight the need for sport-and sex-specific injury prevention strategies. Given the lack of research in the middle school sport setting, future research is needed to further understand ankle injuries among this population and develop interventions for prevention.

Return to Play Probabilities by Division After New and Recurrent Lateral Ankle Sprains in Collegiate Men and Women's Basketball

Morris SN, Medina McKeon JM, Quetant SL, Wasserman EB, Collins CL: Datalys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN; Department of Exercise and Sport Sciences, Ithaca College, Ithaca, NY

Context: Return to play (RTP) has historically been determined using subjective reasoning; there is a need for more objective methods to assist in the determination of RTP timelines. RTP is typically reported using rates or proportions, but these measures can be inaccurate in instances where a lack of follow-up data excludes some athletes from analysis. Time to event analysis can provide more accurate estimates for time to RTP by accounting for all injured athletes regardless of lack of follow-up. **Methods:** Athletic trainers (ATs) participating in the National

Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) reported injury data for 32,462 men's basketball athlete-exposures (AEs) and 31,440 women's basketball AEs during the 2009/10-2017/18 academic years. Number of days lost from participation were calculated using the injury date and date of RTP. For athletes that did not return during the season, number of days lost from participation were calculated using a season end date of March 15; these injuries were identified as censored cases. RTP probabilities for same day return, 1-6 days, 7-13 days, 14-29 days and more than 30 days were calculated using the Life-Table Method stratified by new versus recurrent lateral ankle sprain (LAS). **Results:** From 2009/10-2017/18, ATs reported a total of 974 LAS. Most of those sprains were new injuries (n=768; 80%) rather than recurrence of an injury from the current or previous academic year (n=189; 20%). Of the 974 LAS, 362 (37%) were reported from Division I, 229 (24%) from Division II, and 383 (39%) from Division III. For new LAS, there was a significant difference in RTP probabilities between divisions ($p=.0001$). For

DI, the probability of same day return was 0.51; the probability of returning in the first week was 0.57 and then decreased over time (Table 1). For DII, the probability of same day return was 0.33; the probability of returning in the first week was 0.52 and decreased over time. For DIII, the probability of same day return was 0.25 and increases to 0.56 for return in the first week. There was no significant difference in RTP probabilities between divisions for recurrent LAS ($p=.5$). **Conclusions:** For new lateral ankle sprains in collegiate basketball, return to play timelines were significantly different across divisions. Division I had higher RTP probabilities in the first two weeks after injury than Divisions II and III. Anecdotal evidence used to estimate RTP timelines can be inaccurate and, coupled with pressure from coaches, athletes, and other external influences, athletes can be cleared to return too early. These RTP probabilities provide an evidence-based, objective addition to the body of evidence to help provide more accurate estimates of return times and more confidence in returning an athlete to play.

Table 1. Estimated return to play probabilities for collegiate men and women's basketball by division for new and recurrent lateral ankle sprains

	Division I P^1 (95% CI)	Division II P^1 (95% CI)	Division III P^1 (95% CI)
New injuries			
Same-day return	0.51 (0.45, 0.57)	0.33 (0.26, 0.40)	0.25 (0.20, 0.30)
1-6 days	0.57 (0.49, 0.65)	0.52 (0.43, 0.61)	0.56 (0.49, 0.62)
7-13 days	0.41 (0.29, 0.53)	0.34 (0.22, 0.46)	0.39 (0.29, 0.49)
14-29 days	0.38 (0.22, 0.54)	0.19 (0.07, 0.32)	0.47 (0.34, 0.60)
More than 30 days	0.10 (0.00, 0.27)	0.13 (0.00, 0.31)	0.33 (0.12, 0.55)
Recurrent injuries			
Same-day return	0.35 (0.22, 0.48)	0.35 (0.22, 0.48)	0.33 (0.23, 0.42)
1-6 days	0.59 (0.42, 0.75)	0.74 (0.59, 0.89)	0.69 (0.57, 0.81)
7-13 days	0.21 (0.00, 0.43)	0.50 (0.15, 0.85)	0.56 (0.33, 0.79)
14-29 days	0.18 (0.00, 0.41)	0.25 (0.00, 0.67)	0.38 (0.04, 0.71)
More than 30 days	0.20 (0.00, 0.55)	0.50 (0.00, 1.00)	0.00 (0.00, 0.00)

¹Probability of return to play during the time interval given that the athlete has not returned prior to that interval.

Free Communications, Rapid Fire Oral Presentations: Concussion Education and Reporting

Wednesday, June 26, 2019, 7:00AM-8:00AM, Mandalay Bay A; Moderator: Avinash Chandran, PhD, MS

Perceptions & Experiences of Faculty in Higher Education Regarding the Return-to-School Process Following Concussion

Ha ML, Kasamatsu TM, Montgomery MM, Marttinen RH: Sports Conditioning and Rehabilitation, Orange, CA; California State University, Fullerton, CA; George Mason University, Manassas, VA

Context: Concussion symptoms can affect a student's ability to function in school. Without proper management, symptoms can be exacerbated, lead to a prolonged recovery, and may affect their academic performance. Faculty play a key role in a student's return-to-school (RTS) by implementing academic accommodations (AA) to decrease symptom exacerbation. As most researchers have focused on secondary school professionals, little is known about faculty's perceptions of concussions in higher education. The purpose of this study was to examine the perceptions and experiences of faculty in higher education regarding concussion.

Methods: Using a qualitative study design, 12 faculty (11 departments; higher education teaching experience ranged from 1-12 years; 4.73±3.77 years of experience at the university) were purposefully recruited for in-person interviews on their perceptions of concussions. Interviewees were recruited from contact information collected from a prior survey distributed to part-time and full-time faculty at one public university. To reach data saturation, email addresses obtained from the university website were used to recruit additional interviewees. A semi-structured interview guide was developed using current literature and piloted with two professors. All interviews were recorded, de-identified, and transcribed verbatim for analysis. Interviewees were emailed their interview transcripts to confirm content accuracy as a form of member checking to enhance trustworthiness.

Two researchers used an inductive coding approach and independently coded transcripts over three rounds to develop a codebook and confirm findings. **Results:** Four themes emerged: Issues during RTS, Perceptions of AA, Mechanics of RTS, and Strategies for integration. Interviewees described *issues students would encounter when RTS* (relating to their coursework), including difficulty processing information, environmental challenges, difficulty engaging in instructional activities, and access to resources. Regarding *perceptions of AA*, many faculty stated they have not had training on accommodations or concussion management, but described how they would accommodate a student in need. Although many faculty would be willing to help a student informally without coordination via Disability Services, others indicated they would need a formal process and a better understanding of the *mechanics of RTS* at the University. Furthermore, some faculty did not feel prepared to implement AA and were unsure how to initiate the process. Lastly, to aid in *integration of AA after concussion*, faculty indicated interest in additional training or resources on RTS. **Conclusions:** Although faculty in higher education identified issues a student may encounter during the RTS after concussion and were willing to assist a student, they reported being ill-prepared and unsure of who to contact for a student in need. To support faculty, development of a formalized protocol and targeted resources to guide implementation of AA are recommended. Athletic trainers can assist in developing a university-wide RTS protocol that can enhance the quality of care provided to a student following concussion.

Delayed Versus Immediate Reporting of Concussion and Its Impact on Length of Recovery Among Athletes

Barnhart M, Wilson A, Welch Bacon CE, Marshall AN, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Despite recent legislation and increased education at all levels of play, it has been suggested that 30-70% of concussions suffered by athletes are either not immediately reported, or unreported. Of concern with delayed or underreporting of concussion is the potential for second impact syndrome, repeat injury, and prolonged recovery. Thus, immediate recognition and reporting of suspected concussion symptoms is important for clinicians to perform a complete concussion assessment and remove the individual from the event. Therefore, our purpose was to review the literature to answer the following clinical question: Among athletes who have sustained a concussion, does immediate reporting result in faster return-to-play (RTP) times when compared to delayed reporting. **Methods:** We searched PubMed, MEDLINE, CINAHL, and hand searched the reference lists of articles retrieved. The search terms included: *athletes, immediate reporting, concussion, delayed reporting, and return to play*. Studies were considered if they included athletes as their target population and investigated the result of immediate vs. delayed reporting of concussions on RTP times. The sample was limited to English language, published in the past 10 years, and those which were CEBM level 4 evidence or higher. Studies that investigated the effect of delayed treatment on RTP were excluded. **Results:** The initial literature search returned five studies, four of which met our inclusion and exclusion criteria. Collectively, athletes who immediately reported a concussion, on average athletes had a 10 day longer RTP with a range of 3-22

days faster than those who delayed reporting. Three of the studies suggested that delayed reporting increased the athlete's likelihood of prolonged recovery by 0.61-8.80. However, there were also instances where athletes in the delayed reporting groups presented with a delayed symptom onset, thus inhibiting their ability to report symptoms immediately. All of the studies reported that athletes who experienced delayed removal from participation had higher acute symptom severity and performed worse on post-injury cognitive testing compared to those removed immediately, which may also influence RTP length. Additional factors that influenced prolonged recovery included level of consciousness, psychological disorders, amnesia, learning disability, and concussion history. **Conclusions:** Grade B evidence suggests that the time that it takes athletes to report a concussion may influence the length of recovery. Immediate reporting of a concussion, as compared to delayed reporting, results in a lower symptom burden and faster RTP in an athletic population. Clinicians can use this information to better educate athletes on the benefits of recognizing concussion symptoms immediately after the injury and the importance of reporting concussion-like symptoms to a coach or medical provider. Future research should investigate proposed contributors to delayed reporting, such as fear of reduced playing time, inability to identify symptoms, and/or the fear of coaches' reactions.

Factors Impacting Concussion-Related Decision-Making by Certified Athletic Trainers

Kay MC, Kerr ZY, DeFreese JD, Kucera KL, Petschauer MA, Ribisl KM, Register-Mihalik JK: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Limited empirical evidence exists on how athletic trainers' (ATs') education, environment, and personal perceptions of concussion predict concussion-related decision-making. This study hypothesized and identified whether demographic, educational, intrapersonal, and interpersonal factors predict certified ATs' intentions to make appropriate concussion-related decisions. **Methods:** A cross-sectional Qualtrics survey was delivered to ATs registered with the National Athletic Trainers' Association and reported graduating from their professional-level program in or after 2012 (n=1643/8974; 18.3% response rate). Eligibility criteria included working in high-school or collegiate sports and a graduation date in or after 2012. Overall, 1029 (63% of respondents) qualified for survey completion based on inclusion criteria verification (n=724 female; age=26.0±3.7 years; experience=3.1±1.8 years). A model using theory-driven variables (precursors and potential mediators) and outcomes was hypothesized. Precursor variables were quality and quantity of communication and

collaboration for healthcare decisions education. Demographic factors (age, gender, setting, degree) were potential mediators. The following variables regarding concussion-related decision-making were also mediators: concussion decision-making attitudes, norms, personal agency, knowledge, salience, and communication/collaboration practices. Primary outcomes were intention to make appropriate concussion-related decisions. Intention was separated into three constructs: settings (sideline versus clinic), situations (game versus practice, etc.), and pressures (coach, parents, etc.). For cases with greater than 60% completion, mean imputation was applied to all missing scale variables of interest (27.4% of 526 cases). A structural equation model determined the paths and extent of influence of educational precursors, demographic, and intrapersonal and interpersonal mediators on the intentions to make appropriate concussion-related decisions (α -level=0.05). **Results:** Means and standard deviations were calculated for quality (9.8±2.6; range=2-14) and quantity (60.0±95.9; range=0-1000) of healthcare communication educational focus. Figure 1 illustrates a trimmed model of precursor and mediator effects on intentions. Stronger salience of concussions being a problem was significantly predictive of better setting-related intentions to make appropriate concussion-related decisions ($\beta=0.013$; $p=0.004$). Better general attitudes towards concussion ($\beta=0.047$; $p=0.002$), self-efficacy to make

appropriate decisions ($\beta=0.805$; $p<0.001$), and communication/collaboration practices ($\beta=0.290$; $p=0.016$) were predictive of positive concussion-related situational intentions. Lastly, better general attitudes towards concussion ($\beta=0.033$; $p=0.012$), perceived behavioral control ($\beta=0.118$; $p<0.001$), self-efficacy to make appropriate decisions ($\beta=0.561$; $p=0.000$), and communication/collaboration practices ($\beta=0.212$; $p=0.044$) were predictive of positive pressure-related intentions to make appropriate decisions. Employment within a collegiate setting significantly predicted better situational intentions to make appropriate decisions ($\beta=0.457$; $p=0.024$) and worsened communication/collaboration practices ($\beta=-1.495$; $p=0.082$). **Conclusions:** These data highlight the multifaceted factors influencing concussion-related decision-making. In particular, modifiable factors including attitudes, perceived behavioral control, self-efficacy, and communication/collaboration strategies influence concussion-related decision intentions. These modifiable factors are targets for future intervention to prepare current and future ATs for concussion-related decisions. By designing and implementing theory-driven interventions, improvements in athletic training education can improve athlete health and AT confidence. Funded by: NATA Foundation Doctoral Grant.

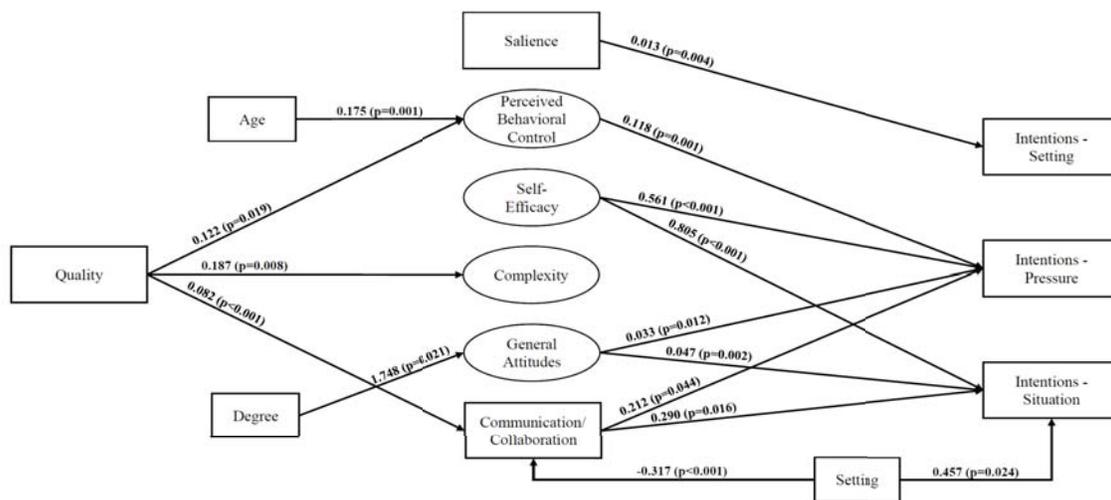


Figure 1. Path Analysis of Factors Impacting Concussion-Related Decision Intentions

Perception of Child Concussion Risk in Adults Without Children

Broglio SP, Memmini AK, Van Pelt KL, Wicklund AH: University of Michigan, Ann Arbor, MI; Orthopaedic & Spine Center of the Rockies, Fort Collins, CO

Context: Increased attention on sport concussion is one factor thought to be causing a shift away from high-collision sports like football. The purpose of this study was to determine the level of contact sports that adults would allow a “hypothetical child” to participate in. We hypothesized that an adult’s professional background, gender, and concussion history would influence the level of contact sports that they would allow a potential son or daughter to participate in. **Methods:** Between 2017 and 2018, an anonymous electronic survey (Qualtrics, Provo, UT) was administered to faculty and staff at a large university (n=5848, age=39.52 ± 13.80 years). Responses were included if 95% of the survey was completed and if they were not currently parents (n=2275). Participants specified their demographics, followed by questions related to sport participation for a hypothetical son (n=1502) and/or daughter (n=1527). For hypothetical daughters, most respondents were female (n=1075, 70.4%), reported no concussion history (n=1323, 86.6%), and were non-medical professionals (n=1283, 84.2%). Responses regarding hypothetical sons were also primarily female (n=1044, 69.5%), did not report concussion history (n=1307, 87.0%), and were non-medical professionals (n=1262, 84.1%). Sport participation options were divided into high-contact, partial-contact, and non-contact categories. Responses that included multiple sports were categorized based on the highest level of contact category. Data were analyzed using chi-square tests to determine relationships between adult gender, professional background, and concussion history, and effect on hypothetical child sport participation. Follow-up logistic regression was used

to assess the strength of the relative covariates. **Results:** Chi-square analyses for the hypothetical daughters’ highest contact sport category revealed no significant relationship with adult’s professional background ($\chi^2=0.39$, $p=0.82$, $df=2$), adult gender ($\chi^2=1.24$, $p=0.975$, $df=6$), or concussion history ($\chi^2=1.40$, $p=0.50$, $df=2$). For the hypothetical sons’ highest contact sport category, chi-square analyses revealed no significant relationship with an adult’s professional background ($\chi^2=0.57$, $p=0.75$, $df=2$), however there was a significant relationship with maximum sport category and concussion history ($\chi^2=8.67$, $p=0.01$, 95%CI:(2.981, 2.994), $df=2$), as well as with adult gender ($\chi^2=125.46$, $p<0.01$, 95%CI:(-1.20, -0.80), $df=3$). Between-group nominal logistic regression revealed a statistically significant ($p<0.01$) difference in adult concussion history and the level of contact sport for a hypothetical son. An additional logistic regression proved that adult gender was not a significant difference for levels of contact sport that they would permit a hypothetical son to participate in ($p=0.78$ Adult Female, $p=0.83$ Adult Male). **Conclusions:** Preliminary results demonstrated no significant relationships for hypothetical daughter sport allowance with adult gender, professional background or concussion history. These results suggest that adults without concussion history were more likely to allow their hypothetical sons to participate in high-contact sports. Future analyses will investigate the effects varying medical professionals and their knowledge of concussion management on youth sport participation.

Virginia Concussion Initiative: Stakeholder Perspectives of Disparities in Concussion Policy Implementation

Nolton EC, Resch JE, Kerr ZY, Broshek DK, Brenner J, Reynolds JD, Como-Lesko N, Ambegaonkar JP, Cortes N, Caswell A, Caswell SV: George Mason University, Fairfax, VA; University of Virginia, Charlottesville, VA; University of North Carolina at Chapel Hill, NC; Children’s Hospital of the King’s Daughters, Norfolk, VA; Fairfax County Public Schools, Fairfax, VA

Context: Sport-related concussions (SRCs) are a public health burden and management of concussed school-aged children remains challenging. Since 2010, all states passed legislation regulating concussion management in public schools. The Virginia Department of Education (VDOE) provided guidelines to assist all 131 school divisions with integrating the unfunded mandate in policy and practice; however, implementation has not been evaluated. The purpose of the current study was to evaluate policy implementation in Virginia public high schools to understand real and perceived barriers to effective implementation. **Methods:** A sequential, mixed-methods approach was employed to analyze policy content and

understand stakeholder perspectives. A rubric (total 54 points) was developed to assess compliance of publicly-available school division policy documents to the VDOE guidelines. Three coders independently scored policy documents ($\alpha=.919$). A K-means cluster analysis was performed using a local ability-to-pay index and percentage of students eligible for free/reduced lunches. Using a cluster-stratified, random sample of divisions, stakeholder interviews (n=60) were conducted to gain multiple stakeholder perspectives from defined Concussion Management Team (CMT) roles (i.e. coordinators, facilitators, practitioners, and consumers). The interview protocol was properly vetted by subject-matter experts and approved by the local IRB. Open emic codes of the interviews were analyzed for emerging themes. **Results:** Overall compliance of policy documents was 59.2%±12.7%. Content analysis revealed high-resourced divisions tended to have policy documents and ones that were more recently revised (Table 1). Broad themes emerged as factors of implementation from the qualitative interviews: urbanicity (i.e. proximity to community services), school culture, communication, education quality, stewardship, and resources. Models for concussion literacy and injury management also became apparent, which were not previously described in the VDOE guidelines.

There was discrepant self-identification as coordinators of concussion management protocols between ATs and school nurses within their respective schools. There was also a disparity in perceived barriers or implementation quality across stakeholders within schools—administrators spoke highly of local practices despite practitioners reporting distinct challenges. Stakeholders from rural south and southwest border regions of Virginia also reported seeking medical services from providers located in neighboring states. **Conclusions:** Our data suggest that implementation of an unfunded health policy in an educational setting is complex. The coordination of various internal and external stakeholders requires a mechanism for communication between all parties. Management models differ within each school due to available resources and support. Additionally, the involvement of practitioners from neighboring states may necessitate interjurisdictional strategies to ensure care is compliant with Virginia guidelines. Diverse states like Virginia face unique challenges in supporting policy implementation within disparate school environments and are further complicated as policy aligns to evolving best practices. Virginia school divisions are in need of culturally-responsive resources that will build capacity for effective policy implementation.

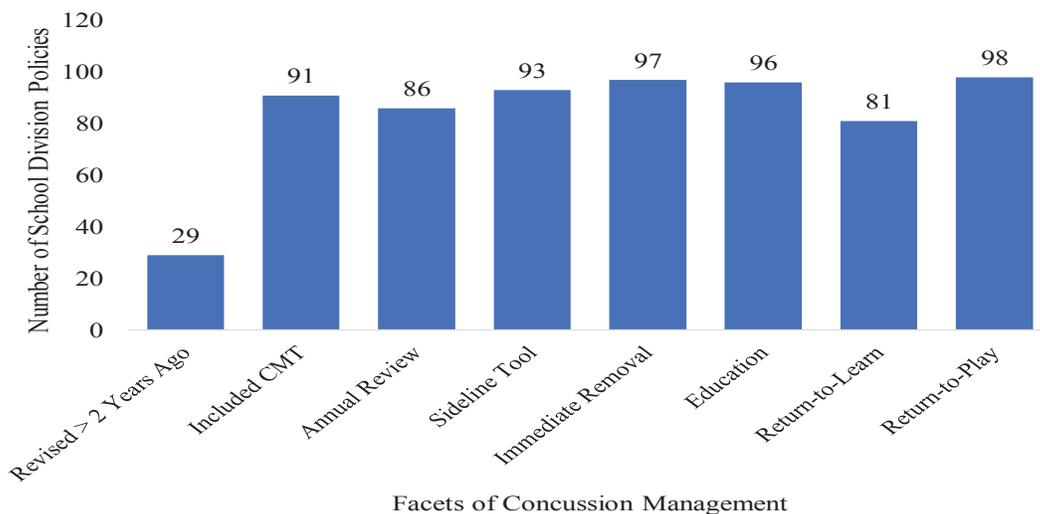


Figure 1. Counts of School Division policy documents (N=131) that included these major facets of concussion management that are outlined in the Virginia Department of Education guidelines.

Assessment of Taekwondo Athletes' Knowledge of and Attitude Toward Sport-Related Concussions

Freer SM, Simpson D, Dompier TP, Shapiro BS: Rocky Mountain University of Health Professions, Provo, UT; IMG Academy, Brandenton, FL; Lebanon Valley College, Annville, PA; Barry University, Miami, FL

Context: Sports-related concussions have been recognized as a public health concern among athletes. Previous literature indicates that contact or collision sports have a higher incidence of concussions than non-contact sports. Taekwondo (TKD), a combat sport, has been reported to have a concussion rate, per 1000 A-E (95% CI), to range from 1.0 (0.9, 2.9) to 55.2 (27.2, 83.1) in males and from 2.4 (0.0, 4.8) to 49.3 (12.3, 85.8) in females. The overall purpose of this study was to assess the current knowledge of and attitude toward sport-related concussions (SRC) in a population of TKD athletes. **Methods:** The present study used a mixed methodological design which included a modified Rosenbaum Concussion Knowledge and Attitude Survey (RoCKAS) and a semi-structured interview. The population usable for data analysis consisted of 97 males (28.37 ± 9.08 years of age and 10.60 ± 4.87 years of experience) and 73 females (25.96 ± 7.02 years of age and 9.79 ± 4.49 years of experience). Eight males (28.13 ± 7.61 years of age, 13.38 ± 7.27 years of competitive experience) and seven females (26.71 ± 8.92 years of age, 8.71 ± 4.11 years of competitive experience) completed the interview at an average of $20.93 (\pm 3.88)$ minutes per interview. **Results:** The overall mean scores for the CKI and CAI were 18.71 ± 3.93 and 56.25 ± 8.70 , respectively. Educational format was shown to have a significant effect on athlete's knowledge ($F_{(3,169)} = 3.501$, $p = 0.017$) and attitudes ($F_{(3,166)} = 3.468$, $p = 0.018$). Between-group comparisons concluded that athletes ($M = 19.56 \pm 3.53$, 95% CI 18.67, 20.46)

educated by a healthcare provider were more knowledgeable than those ($M = 17.78 \pm 4.20$, 95% CI 16.84, 18.73) that had not receive any formal concussion education. Conversely, athletes, regardless of the education format, had similar attitudes towards concussions. During the interview, participants endorsed a number of accurate signs and symptoms of concussions; however, responses identified discrepancies in risks and both safe and risky attitudes towards concussion. Overall, the results of the current study indicated moderate concussion knowledge with potentially risky attitudes. **Conclusions:** Most TKD athletes had a good general sense and practical understanding of signs and symptoms of concussions. However, there are some deficiencies in concussions knowledge and risks along with misconceptions towards concussions bringing their attitude into question. These findings are capable of providing the groundwork for TKD governing bodies to develop education materials, regarding injury risks, symptomology, assessment, and the consequences of mismanaging a concussion, for TKD athletes and competitors.

Head/Spine Best Practices Forum: Designing Effective Concussion Education Programs to Impact Clinical Care: What's Working and What's Not?

Wednesday, June 26, 2019, 8:00AM-9:00AM, Mandalay Bay A;

Moderator: Monica Lininger, PhD, LAT, ATC

Discussants: Debbie Craig, PhD, ATC; Johna Register-Mihalik, PhD, ATC, FNATA

Free Communications, Oral Presentations: Patient-Centered Outcomes Following ACLR

Wednesday, June 26, 2019, 9:45AM-11:15AM, Mandalay Bay A; Moderator: Janet Simon, PhD, ATC

Increased Pain 4 Weeks Post ACL Reconstruction is Predictive of Lower Self-Reported Sports Function at 6 Months

Hunt ER, Conley C, Johnson DL, Ireland ML, Lattermann C, Jacobs CA: University of Kentucky, Lexington, KY; Brigham and Women's Hospital, Harvard Medical School, Boston, MA

Context: The aim of anterior cruciate ligament reconstruction (ACLR) is to reestablish joint stability, increase function of the knee joint and return patients to their pre-injury level of function. Unfortunately, a portion of athletes do not return to sport and end up having poor outcomes including persistent pain and continued dysfunction. Emerging literature suggests an athlete's readiness to return to sport is multifaceted, and it remains unknown whether persistent pain after reconstruction contributes to a decrease in self-reported sports function. Therefore, the purpose of this study was to determine if one-month postoperative pain predicts Knee Injury and Osteoarthritis Outcome Score (KOOS) Sport scores at 6 months post-surgery. **Methods:** Athletes (ages 14-33) who suffered an ACL tear were enrolled in this prospective trial. Patients were excluded if they had previous surgery on either knee, open growth plates, a posterior cruciate ligament tear, or a collateral ligament sprain greater than a grade 2. Patients completed a 100 mm visual analog scale (VAS) for pain 4-6 weeks post-surgery and the KOOS Sports questionnaire six months post-surgery. A correlation was utilized to determine which post-operative variables predict KOOS-Sport scores at 6 months post-surgery ($p < 0.05$). We also utilized a ROC curve to threshold one-month VAS pain scores followed by an odds ratio to determine how VAS pain at 4 weeks effects 6-month KOOS sport. **Results:** Nineteen patients who underwent ACLR (18.4 ± 2.8 yrs,

BMI 27.3 ± 5.0 , 8M, 11F) completed this study. The average 4-week post-operative VAS score was 29.5 ± 26.8 mm. 4-week post-operative VAS pain scores significantly predicted 6-month KOOS sport scores (Adjusted $R^2 = 0.35$, $P = .006$). ROC curve analysis determined a threshold score of 35.5 for one-month VAS pain ($P = .01$). Patients with VAS pain scores > 35.5 were significantly more likely to have 6 mo KOOS Sports scores below the PASS threshold (Odds ratio = 24, $P = .02$, 95% CI: 1.67, 341.01) **Conclusions:** Patients who have VAS pain scores > 35.5 4 weeks post-reconstruction are 24 times more likely to exhibit lower self-reported sports function at 6 months. These results emphasize the importance of reducing pain during the early postoperative period. Clinicians are also able to identify patients with elevated pain at 4 weeks that may require additional pain-related interventions and these results may also be used when counselling patients on return-to-play expectations.

Rationale for a Parsimonious Measure of Subjective Knee Function after ACL Reconstruction: A Rasch Analysis

Duckett TR, Hart JM, Fox C, Norte GE: The University of Toledo, Toledo, OH; University of Virginia, Charlottesville, VA

Context: The International Knee Documentation Committee (IKDC) Subjective Knee Evaluation is often used as an indicator of subjective knee function with return-to-sport decision-making after ACL reconstruction (ACLR). Yet, current research has not demonstrated whether the IKDC only measures knee function or additional dimensions that would distort the intended measure. Our purpose was to test the extent to which the 19 IKDC items formed a meaningful unidimensional measure of knee function that could differentiate ACLR patients from healthy individuals. **Methods:** A convenience sample of 80 patients with a history of primary, unilateral ACLR (38 females, age: 21.7 ± 7.8 years, time from surgery: 6.3 ± 1.0 months) and 80 healthy individuals (43 females, age: 22.1 ± 4.1 years) participated in this cross-sectional study. The IKDC was administered to all participants in a university laboratory. Participant responses from the total sample were analyzed using the Rasch measurement model. Model diagnostics (item reliability, variance explained, and mean square errors for item fit) were examined to determine the best set of items and rating scale structure that met the criteria for a unidimensional measure of knee function. This psychometric evaluation yielded a reduced 9-item version (IKDC-9). Next, receiver-operating-characteristic (ROC) curve analyses were used to identify cutoff values that maximized the ability of the IKDC and IKDC-9 to discriminate patient status (ACLR vs. healthy). The area under the curve (AUC), sensitivity, specificity,

positive likelihood (LR+), and negative likelihood (LR-) ratios were calculated for each ROC curve analysis. **Results:** The IKDC-9 exhibited higher item reliability (0.99 vs. 0.90), explained more variance (70.4% vs. 50.4%), and included fewer misfitting items (0 vs. 3), suggesting the improved rating scales and retained items of the IKDC-9 serve as better indicators of a unidimensional measure of knee function. An IKDC value of 91.5 (0-100) demonstrated excellent discrimination in patient status (AUC: 0.93 [95% CI: 0.89-0.97], $P < .001$), and yielded a moderate effect on the probability of being classified as having an ACLR (sensitivity: 0.86, specificity: 0.88, LR+: 7.47, LR-: 0.16). An IKDC-9 value of 23.5 (0-26) also demonstrated excellent discrimination in patient status (AUC: 0.91 [95% CI: 0.86-0.95], $P < .001$), and yielded a moderate effect on probability of being classified as having an ACLR (sensitivity: 0.74, specificity: 0.91, LR+: 8.27, LR-: 0.28). **Conclusions:** The new parsimonious IKDC-9 offers increased reliability, unidimensionality, and a more stable linear progression of patient perception from low to high knee functioning, all of which are necessary psychometric prerequisites of a commonly utilized outcome measure. Additionally, the IKDC-9 demonstrated an equivalent shift in probability of being classified as having an ACLR compared to the IKDC. A shorter instrument may enhance mental acuity during completion, while the increased validity of the IKDC-9 will provide a necessary foundation for its use in sports medicine outcomes research.

The Relationship Between Injury-Related Fear and Visuomotor Reaction Time in Individuals After Anterior Cruciate Ligament Reconstruction

Genoese FM, Baez SE, Heebner NR, Hoch MC, Hoch JM: University of Kentucky, Lexington, KY

Context: Individuals who sustain an ACL injury have exhibited deficits in reaction time prior to their injury. Increased levels of injury-related fear are cited as a primary reason for lack of return to sport after anterior cruciate ligament reconstruction (ACLR). Injury-related fear may also hinder the ability to process information and make decisions, which could further contribute to deficits in visuomotor reaction time (VMRT) and increase risk for additional injury in this population. The objective of this study was to examine the relationship between injury-related fear and VMRT in individuals with a history of ACLR. **Methods:** Twenty participants (15 females; age = 24.47 ± 4.75 years, height = 168.94 ± 9.12 cm, mass = 67.91 ± 14.63 kg, 5 males; age = 24.6 ± 2.41 years, height = 183.39 ± 9.4 cm, mass = 82.83 ± 7.46 kg) with history of unilateral ACLR at least one year post-operatively (7.15 ± 4.43 years) participated in this cross-sectional study. Participants completed the Fear-Avoidance Beliefs Questionnaire (FABQ) before completing a lower extremity VMRT task bilaterally. The FABQ is a dimension specific patient-reported outcome designed to measure fear-avoidance beliefs about sport (FABQ-S) and physical activity (FABQ-PA). Higher scores on each subscale represented elevated levels of fear-avoidance beliefs. Lower extremity VMRT was measured bilaterally using a novel clinical neurocognitive testing protocol. The VMRT test required participants to touch lighted targets systematically positioned on the ground with their foot as quickly as possible while standing on a single limb. Higher VMRT (seconds) represents slower reaction time. Descriptive statistics were summarized for all variables (mean \pm standard deviation). Spearman's

Rho correlations were employed to examine the relationship between injury-related fear and lower extremity VMRT (seconds). Correlations were interpreted as very weak (0.00-0.19), weak (0.20-0.39), moderate (0.40-0.59), strong (0.60-0.79) and very strong (0.80-1.0). Alpha was set *a priori* $p < 0.05$. **Results:** The average FABQ-S score was 9.85 ± 8.15 and the FABQ-PA was 6.70 ± 5.13 . The average VMRT for the injured limb was 0.55 ± 0.05 seconds and the uninjured limb was 0.56 ± 0.07 seconds. There was a moderate correlation between FABQ-S scores and injured limb VMRT ($r_s = 0.559$, $p = 0.01$). There was a strong correlation between the FABQ-PA scores and injured limb VMRT ($r_s = 0.635$, $p = 0.003$). The correlation between the FABQ-S and uninjured limb VMRT was weak ($r_s = 0.327$, $p = 0.159$), while the FABQ-PA score and uninjured limb VMRT was moderate ($r_s = 0.412$, $p = 0.071$). **Conclusions:** Our results indicate individuals with a history of ACLR who have greater levels of injury-related fear have slower lower extremity VMRT. This relationship appears to be stronger on the injured limb. Deficits in reaction time may increase susceptibility to errors in judgement or loss of coordination when trying to respond to environmental cues during sport. Injury-related fear may be considered a modifiable factor that could potentially reduce injury risk and improve VMRT. Future research should explore interventions, such as graded exposure therapy, to address injury-related fear and VMRT in individuals after ACLR.

Psychological Readiness of Athletes to Return To Play Following Injury

Monahan AC, Hunt TN, Harris BS, Mutchler J: Rhodes College, Memphis, TN; Georgia Southern University, Statesboro, GA

Context: Return to play decisions made without the assessment of an athlete's psychological readiness could lead to athletes being returned to play before psychologically ready. Returning an injured athlete to sport before they are both physically and psychologically ready can lead to increased or prolonged psychological concerns, fear-avoidance behavior and higher risk of re-injury. The purpose of this study was to investigate the psychological readiness and fear-avoidance of student-athletes to return to play following injury. We hypothesized that among student-athletes currently returning to play, some athletes would not be psychologically ready to return. We also hypothesized that if there were student-athletes who were not psychologically ready, those athletes would have higher fear avoidance compared to those who were psychologically ready.

Methods: Thirty-four Division I student-athletes (20 males, 14 females; 19.76 ± 1.42 years old) volunteered to participate in the cross-sectional study. All participants were returning to play following injury that resulted in at least one missed practice or competition. Within 24 hours of return to play, as decided by each athlete's Athletic Trainer, the participants completed the Injury-Psychological Readiness to Return to Sport Scale (I-PRRS), and the Athlete Fear Avoidance Questionnaire (AFAQ). None of the investigators were involved in return to play decisions. Both questionnaires have been previously assessed for acceptable reliability and validity for use with sport-related injury. A cut-off of 50 on the I-PRRS was used to determine psychological readiness, based on previous literature that a score of 50 indicates the athlete is highly confident to return to play. Participants

were placed into two groups: I-PRRS scores > 50 = Ready, and I-PRRS scores < 50 = Not Ready. An independent *t*-test was used to compare AFAQ scores between groups. Significance level was set to $p < 0.05$, and effect size was calculated. **Results:** Of the 34 participants, 17 scored into the Ready group (mean I-PRRS = 55.76 ± 2.75), and 17 scored into the Not Ready group (mean I-PRRS = 38.12 ± 6.42). The Ready group reported significantly less fear avoidance as compared to the Not Ready group (Ready: 14.76 ± 3.75 , Not Ready: 22.59 ± 8.71 ; $p = 0.003$; ES = 0.89). Observed statistical power was 81% for the difference in AFAQ scores between groups. **Conclusions:** The results of this study suggest not all athletes returning to play are highly confident in their ability to return to play. Athletes whom lack confidence in returning to their sport may experience higher fear avoidance that could go undetected by the Athletic Trainer if not assessed prior to return to play. The assessment of psychological readiness and fear avoidance should be completed prior to returning an athlete to their sport in order to appropriately address any concerns.

The Association Between Psychological Readiness to Return to Sport and Self-Perceived Function After Anterior Cruciate Ligament Reconstruction

Miller JR, Evans CM, Chouinard DM, Welch Bacon CE, Valovich McLeod TC, Marshall AN: A.T. Still University, Mesa, AZ

Context: Anterior cruciate ligament (ACL) tears are frequent and surgical reconstruction is often recommended to facilitate a return to preinjury sports participation and function. Current protocols for ACL reconstruction (ACLR) rehabilitation are well developed and focus on strong clinician-based goals supported by objective data. While physical function is an important component of clinical decision making, it has been hypothesized that an athlete's psychological deficits throughout the rehabilitation process could play a large role in determining return to sport (RTS) following surgery. The ACL-Return to Sport after Injury (ACL-RSI) scale was developed specifically for assessing the psychological status of ACL reconstruction patients, but has not yet been compared to athletes' self-perceived function. Therefore, our clinical question was: *What is the relationship between readiness to RTS, as evaluated by the ACL-RSI, and self-perceived function at the time of RTS following ACLR?* **Methods:** The literature was searched for studies that investigated psychological factors and self-perceived function at RTS after an ACLR surgery. Terms used to guide the search strategy included: *ACLR rehabilitation, athletes, psychological factors, and ACL-RSI*. Searches were conducted through the Cochrane Library, PubMed, and CINAHL databases, and through a hand search of included article reference lists. Inclusion criteria consisted of studies that were a CEBM Level 3 evidence or higher, evaluated athletes who underwent ACLR surgery and RTS, evaluated the ACL-RSI and perceived level of function at RTS, and were

published in English between 2012-2018. Exclusion criteria were studies that did not exclusively study athletes, studies that included athletes who did not sustain a sport-related injury, or studies that utilized the ACL-RSI to aid in RTS decision-making. **Results:** The search produced 25 possible studies related to the clinical question, four of which met the inclusion criteria and were included in this review. All included studies concluded that the ACL-RSI was an effective patient reported outcome measure to address readiness to RTS following ACLR. Patients who did not feel comfortable returning to sport generally did not, regardless of physical signs of readiness. Additionally, returning to pre-injury levels of play was difficult if psychological aspects were not addressed during the rehabilitation process. Two of the primary reasons that athletes did not return to play was a fear of reinjury and lack of trust in knee function. Athletes that returned to their preinjury level of sport at 12 months after surgery scored significantly higher on the ACL-RSI preoperatively and at 4 months postoperatively. **Conclusions:** Grade B evidence demonstrates that there is a clinically meaningful association between self-perceived function and psychological readiness to RTS. All included studies concluded that psychological aspects should be addressed during the rehabilitation process to facilitate high RTS rates. Future research should focus on effective methods to address psychological deficits once identified.

Free Communications, Oral Presentations: Injury Risk Across Ages and Sports

Wednesday, June 26, 2019, 5:15PM-6:30PM, Mandalay Bay A; Moderator: Wanda Swiger, EdD, ATC

Neuromechanical Factors Associated With College Football Injury Risk

Anthony RC, Palmateer TM, Ruiz-Malca GG, Wilkerson GB, Acocello SN: University of Tennessee at Chattanooga, Chattanooga, TN

Context: Subtle motor control impairments related to concussion can persist beyond symptom relief and may elevate risk for subsequent concussion or musculoskeletal injury. Altered coupling of visual, cognitive, and motor processes may adversely affect neuromechanical responsiveness to environmental changes during sport participation. The purpose of this study was to assess the predictive value of sport-related concussion history (SRC-Hx), visuomotor reaction time (VMRT), and whole-body reactive agility (WBRA) for identification of college football players who possess elevated risk for core or lower extremity injury. **Methods:** A cohort study design was used to screen 89 NCAA Division I-FCS football players (20 ± 1.3 yrs; 100.6 ± 19.2 kg; 183.74 ± 6.59 cm) prior to the beginning of preseason practice sessions. VMRT testing was performed using the Dynavision D2 System. Players manually hit illuminated buttons as quickly as possible during a 60-s test and average VMRT was recorded (ms). WBRA was assessed using the Trazer® Sport Stimulator. Players performed 20 lateral shuffling movements to the right and left as directed by the appearance of virtual reality targets on a monitor. Total time (seconds) and reaction time (ms) were recorded. A 10-item Sports Fitness Index (SFI) survey quantified persisting effects of previous injuries, including SRC-Hx. Injury surveillance was conducted throughout preseason and 11-game season, with each practice or game counted as 1 exposure. Injury was defined as any core or LE sprain or strain requiring evaluation and treatment. Receiver operating characteristic,

cross tabulation, and logistic regression analyses identified the strongest predictors of subsequent injury. Time-to-event analysis (Cox regression) was performed to further evaluate final model.

Results: A 4-factor prediction model included ≥ 5 Games Played, VMRT ≥ 745 ms, WBRA total time ≥ 101 s, and positive SRC-Hx (Model $\chi^2(4) = 20.08$; $P < .001$; Hosmer & Lemeshow goodness-of-fit $\chi^2(6) = 5.88$; $P = .437$; Nagelkerke $R^2 = .285$). Cox regression analysis of ≥ 2 of the 4 factors positive demonstrated significant time to event difference (Model $\chi^2(4) = 14.45$; $P < .001$; HR = 4.16). **Conclusions:**

Game exposure is often neglected as a potentially important effect-modification factor in football injury risk assessment studies. Our findings support emerging evidence that SRC-Hx is associated with elevation of musculoskeletal injury risk. Suboptimal neuromechanical performance capabilities may represent modifiable factors that should be assessed as part of preseason injury-risk screening. Slow VMRT and slow WBRA could be consequences of SRC-Hx, or may be independent injury risk factors. Injury susceptibility may relate to speed of motor responses to rapidly changing environmental conditions, as well as spatial position awareness, both of which were represented in measures derived from our neuromechanical tests.

The Association Between Injuries and Overtime Play in National Collegiate Athletic Association Soccer

Wasserman EB, Morris SN, Quetant SL, Collins CL: Datalys Center for Sports Injury Research and Prevention, Indianapolis, IN

Context: Unlike most professional soccer leagues, National Collegiate Athletic Association (NCAA) soccer regular season games tied at the end of regulation proceed to two 10-minute sudden victory overtime (OT) periods. Given the extra activity time, OT play may be associated with increased risk of injury. The purpose of this study was to examine the association between injury rates and OT play. **Methods:** As part of the NCAA Injury Surveillance Program, athletic trainers (ATs) reported injuries requiring medical attention from 2,710 NCAA men’s and 4,356 NCAA women’s soccer games during the 2009/10 through 2016/17 academic years. Using data from the NCAA statistics department, we determined which games went to OT and the number of OTs played. We calculated injury rates per 1,000 minutes played and 95% Confidence Intervals (CI) by game

segment (first half vs. second half vs. OT). Incident Rate Ratios (IRRs) compared injury rates. The minutes played in the first and second halves were the length of the half (45 minutes) multiplied by the number of players on the field (11). For games played from 2014/15–2016/17, the NCAA statistics department provided the length of OT, and this was multiplied by 11 players on the field. For games played from 2009/10–2013/14, if a game went two OTs but ended in a tie, the OT length was 20 minutes; if there were two OTs but did not end in a tie, we assumed 15 minutes of OT play; if there was one OT, we assumed 5 minutes of OT play. Analyses assumed no red cards (i.e., 11 players on the field at all times). **Results:** In men’s soccer, 447 (16%) games went to OT: 134 (30% of OT games) finished in the first OT, and 313 (70% of OT games) had two OTs. In women’s soccer, 772 (18%) went to OT: 214 (28% of OT games) finished in the first OT, and 558 (72% of OT games) had two OTs. In both men’s and women’s soccer, injury rates were highest in the second half (Table 1). Injury rates were significantly higher in the second half compared to the first half (men’s IRR=1.65, 95%CI:1.43-1.89; women’s IRR=1.42, 95%CI:1.27-1.59); however,

rates were not significantly different between overtime and either half of play (men’s OT vs. first half IRR=1.25, 95%CI:0.80-1.94; men’s OT vs. second half IRR=0.76, 95%CI:0.49-1.17; women’s OT vs. first half IRR=1.03, 95%CI:0.73-1.45; women’s OT vs. second half IRR=0.72, 95%CI:0.51-1.02). **Conclusions:** The injury rate was no higher in overtime than either of the halves, meaning injuries are not more likely to occur during overtime; however, we can expect more injuries in a game that has overtime than one that does not because the players are on the field for more time.

Table 1: NCAA Soccer Injury Rates by Competition Segment, 2009/10-2016/17 academic years

Sport	1 st Half Injury Rate per 1,000 minutes played (95% CI)	2 nd Half Injury Rate per 1,000 minutes played (95% CI)	Overtime Injury Rate per 1,000 minutes played (95% CI)
Men’s Soccer	0.24 (0.21, 0.26)	0.39 (0.36, 0.42)	0.30 (0.17, 0.42)
Women’s Soccer	0.25 (0.23, 0.27)	0.36 (0.33, 0.38)	0.26 (0.17, 0.34)

CI=Confidence Interval

Predictive Value of Injury Risk Screening for Collegiate Volleyball Players

Gaylor AB, Daniels AB, Petty RJ, Acocello SN, Wilkerson GB: University of Tennessee at Chattanooga, Chattanooga TN

Context: Models for prediction of upper extremity(UE) musculoskeletal injuries among female athletes may be useful for implementation of individualized injury risk reduction strategies. The purpose of this study was to identify the most powerful prediction model for quantification of injury risk among female collegiate volleyball players. **Methods:** A cohort study design was used to assess the power of various risk screening metrics derived from tests of UE, lower extremity(LE), and core performance for prediction of musculoskeletal injury. Forty-eight collegiate volleyball players from 4 teams representing NCAA Division I, Division, III, and NAIA participated in the study. Pre-participation screening included the Horizontal Trunk Hold (HTH), Y-Balance Anterior Reach (YAR), single-leg vertical jump (SVJ), Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), Wall Angel Test (WAT), Lateral Scapular Slide Test (LSST), isometric internal rotator (IR) and external rotator (ER) strength, and the 10-item Sport Fitness Index (SFI), which assesses persisting effects of previous injury on function. Throughout the subsequent competitive season, number of sets played and all time-loss musculoskeletal injuries (UE, LE, core) were recorded for each athlete. Exposure-outcome associations were assessed using receiver-operating characteristic analysis, and logistic regression was used to identify the strongest multivariable prediction model. **Results:** Performance on CKCUEST (≥ 24 hand touches), YAR (≥ 62 cm), SVJ (≥ 57 cm), SFI score (≤ 78), and LSST (≥ 1.15 cm asymmetry) were associated with both injury occurrence and volume of game exposure (number of sets played). A 3-factor model

including SFI score (≤ 78), game exposure (≥ 100 sets), and LSST (≥ 1.15 cm asymmetry) predicted the occurrence of time-loss musculoskeletal injury (≥ 2 factors positive: $\chi^2(3)=19.57$; $P<.001$; OR=16.15). Quantification of previous injury effects (SFI score) was the strongest predictor, particularly among players with low game exposure. **Conclusions:** Asymmetry in LSST (≥ 1.15 cm) was the only upper extremity screening metric that predicted subsequent musculoskeletal injury. Game exposure is a factor that is often neglected in injury prediction studies, which mediated the association between high-level performance capabilities and injury occurrence. Quantifying persisting effects previous injury appears to be valuable for identification of potentially modifiable risk factors. Additionally, scapular positioning asymmetry may be addressed through therapeutic exercise.

Poor Balance as a Predictor of Injury in Adolescent Athletes

Lange CA, Tierney RT, Mansell JL, Russ AC: Collingswood High School, Collingswood, NJ; Temple University, Philadelphia, PA

Context: As adolescent participation in sports increases, athletic injury is increasingly common. Balance deficits, a common occurrence in this population, may increase risk of injury. The purpose of this analysis was to examine the link between injury rates and poor balance in the adolescent population. **Methods:** PubMed and Medline were searched in July of 2018 using the Boolean phrase: (balance AND adolescent AND athlete AND balance AND injury NOT concussion). Only prospective studies involving adolescent athletes reporting injury rates were considered. Studies using rehabilitation programs or reporting concussions were excluded. The Critical Appraisal Skills Program (CASP) for cohort studies was used for validity. Outcome measures assessed injury rate ratios based on baseline balance scores. Balance scores were assessed using single leg balance test (SLB), Star Excursion Balance Test (SEBT), Y Balance Test (YBT), and a postural sway test on a balance platform. 95% CIs were calculated if not provided. **Results:** The search returned 149 articles, 4 of which were selected meeting inclusion criteria. There was an increase in injury rates with poor balance found in each study. In one study, injury occurrence was 2.5 times increased in lower extremity injury ($p<.05$ 95% CI 1.4, 5.3) with a side to side anterior reach difference in the SEBT of greater than 4cm. Additionally, females with a composite reach distance less than 94% of their limb length were 6.5 times more likely to have a lower extremity injury ($p<.05$ 95% CI 2.4, 17.5). In another study, a 3.86 increase in lower extremity injury occurred ($p=.001$ 95% CI .24, 10.29) with a side to side reach difference of 4 cm in the YBT. Also, composite reach score differences were more than 12 cm and a 1.93 increase in

injury occurred (95% CI .77, 4.56). In another study using single leg balance test, athletes with a positive SLB had a 2.54 overall increase in ankle injuries (95% CI 1.02, 6.03). In a fourth study, single leg postural sway was tested using a balance platform to assess balance. Athletes with high sway had a 6.7 increase in ankle sprains ($p=.0002$) compared to those with good balance. CASP scores ranged from 8 to 11 out of 12. **Conclusions:** SORT rating: B. Consistent research indicates that poor balance is a risk factor for injury, however additional research should further examine this relationship. Baseline balance measures should be taken prior to the beginning of the season to identify athletes at risk for injury. Future research should focus on the effectiveness of balance training programs on decreasing risk of injury in at-risk adolescent athletes.

A Pilot Study Examining the Effects of an Injury Prevention Program on Lower Extremity Injury in Middle School Boys' Soccer

Van Wert KM, Kerr ZY, Cortes N, Kelshaw PM, Abrams V, Caswell SV: George Mason University, Fairfax, VA; University of North Carolina, Chapel Hill, NC

Context: With over 3 million adolescents participating in soccer in the United States, examining the effect of injury prevention programs (IPPs) on reducing lower extremity injuries is warranted. Previous research has examined the effectiveness of IPPs in soccer athletes, estimating 36%-88% reductions in lower extremity injury incidence in collegiate and high school aged soccer players. However, the effects of IPPs among middle school aged soccer players remains relatively unknown. The purpose of our study was to assess the effect of an IPP on reducing lower extremity injury rates in middle school boys' soccer players. **Methods:** Three middle school boys' soccer teams were recruited to participate in this two-year pretest-posttest study design as part of a large-scale surveillance study in Virginia (ACHIEVES Project). In year 1 (Pre-Intervention) no IPP was implemented to the 66 players (aged 13 ± 0.9 years) on the team rosters. In year 2, (Intervention), the IPP was implemented to the 67 players (aged 13 ± 0.9 years) on the team rosters. The IPP consisted of a six-week, fifteen-minute warm-up program that included dynamic stretching, strengthening, core stability, and plyometric exercises implemented prior to each practice. On-site athletic trainers administered the IPP and provided verbal feedback to the participants to ensure performance quality of the IPP. The athletic trainers also collected data on lower extremity injuries and athlete-exposures (AE) from school-sanctioned games and practices. These data were used to compute the main outcome of injury rates. Follow up injury rate ratios (IRRs) compared injury

incidence between the Pre-Intervention and Intervention years, with 95% confidence intervals (CI) excluding 1.0 being considered statistically significant. IRRs were also considered for specific lower extremity regions. **Results:** In the Intervention year, the IPP was implemented an average 3 times per week, with 83% compliance among the 67 athletes. Overall, 31 injuries (Pre-Intervention $n=18$; Intervention $n=13$) were reported during the two-year period, leading to lower extremity injury rates of 7.86/1000AE (95%CI: 4.23-11.49) and 4.80/1000AE (95%CI: 2.19-7.40). Thus, the IPP was associated with a 39% reduction in the lower extremity injury rate, although this finding was not statistically significant (IRR=0.61; 95%CI: 0.30-1.25). A greater reduction (also not statistically significant) was seen when restricted to injuries at the knee (Pre-Intervention $n=6$, Intervention $n=2$; 72% reduction; IRR=0.28; 95%CI: 0.06-1.40). **Conclusions:** Although the IPP was not associated with a statistically significant reduction in lower extremity injury rates, our findings may be clinically useful as effect estimates (e.g., 39% reduction and IRR of 0.61) are similar to those from previous literature from other soccer settings. Thus, further research with a larger sample is warranted to evaluate the effectiveness of IPPs in reducing the incidence of lower extremity injuries in middle school boys' soccer.

Free Communications, Oral Presentations: Recovery From and Treatment for Lateral Ankle Sprains

Thursday, June 27, 2019, 7:00AM-8:00AM, Mandalay Bay A; Moderator: Matthew Hoch, PhD, ATC

Does Injury History Impact the Recovery of Self-Report of Function During the First Two Weeks After an Ankle Sprain Injury? A Report From the Athletic Training Practice-Based Research Network

Lam KC, Marshall AN, Bay RC, Wikstrom EA: A.T. Still University, Mesa, AZ; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Previous injuries can have long-term consequences on patient-oriented outcomes. Little is known about the impact of a previous ankle sprain injury on recovery of self-reported function following a subsequent ankle sprain injury. Our objective was to determine if injury history impacted self-reported function at intake and two weeks after an ankle sprain injury. **Methods:** Forty-eight patients (male=25, female=23, age=16.3±2.1 years, height=176.4±9.1 cm, weight=79.3±26.3 kg) representing ten sports were diagnosed with an ankle sprain injury by an athletic trainer within the Athletic Training Practice-Based Research Network. Patients were grouped by self-report of previous ankle sprain injury at intake: positive (INJ) (n=15) and negative (No-INJ) (n=33) injury. Patients received usual care from an athletic trainer and completed the Foot and Ankle Ability Measure (FAAM) during treatment sessions at post-injury Time 1 [(T1); range=0-7 days post-injury] and Time 2 [(T2); range=10-19 days post-injury]. The FAAM is a reliable and valid self-report of function measure with two subscales: activities of daily living (FAAM-ADL; 21 items) and sport (FAAM-Sport; 8 items). Subscale scores range 0-100%, with higher scores indicating better function. The minimal clinically important difference (MCID) values for FAAM-ADL and FAAM-Sport are 8% and 9% points, respectively. Descriptive statistics (mean±SD) are reported, and

a generalized mixed model (gamma link) compared differences between injury groups at and between T1 and T2. Alpha was $P < .05$, two-tailed. The percentages of patients reporting scores greater than 90 on FAAM-ADL or 80 on FAAM-Sport were also reported. Previously, these score thresholds have been reported to represent meaningful deficits in ankle function. **Results:** The interactions between injury group and time were not significant for FAAM-ADL ($p = .98$) or FAAM-Sport ($p = .51$). Injury groups did not differ at T1 (INJ: FAAM-ADL = 54.2 ± 32.5 [range = 6-99], FAAM-Sport = 22.5 ± 32.3 [range = 0-100]; No-INJ: FAAM-ADL = 58.3 ± 24.9 [range = 15-100], FAAM-Sport = 35.2 ± 32.0 [range = 0-100]) or T2 (INJ: FAAM-ADL = 85.1 ± 16.2 [range = 43-100], FAAM-Sport = 58.7 ± 34.5 [range = 0-100]; No-INJ: FAAM-ADL = 91.2 ± 13.0 [range = 39-100], FAAM-Sport = 73.7 ± 26.6 [range = 0-100]). Main effects for injury group were not significant for FAAM-ADL ($p = .48$) or FAAM-Sport ($p = .19$). Both FAAM-ADL ($p < .001$) and FAAM-Sport ($p < .001$) improved significantly over time. Most patients reported changes between time points exceeding the MCID for FAAM-ADL (INJ: 80.0%, $n = 12/15$; No-INJ: 78.8%, $n = 26/33$) and FAAM-Sport (INJ: 73.3%, $n = 11/15$; No-INJ: 66.7%, $n = 22/33$). At T2, a lower percentage of patients with a previous injury scored above 90 points on the FAAM-ADL (INJ: 46.7%, $n = 7/15$; No-INJ: 75.8%, $n = 25/33$) and 80 points on the FAAM-Sport (INJ: 33.3%, $n = 5/15$; No-INJ: 51.5%, $n = 17/33$) than those without a previous injury. **Conclusions:** Preliminary findings suggest that a previous ankle injury may not impact self-reported function at intake or the recovery of self-reported function during the first two weeks after a subsequent ankle sprain injury. Future research with more robust data sets should determine if injury history impacts long-term recovery of self-reported function and evaluate how treatment strategies influence self-reported function.

Comparison of Y Balance Test Scores at Baseline and 2-4 weeks Following an Acute Lateral Ankle Sprain in Collegiate Athletes

Wisthoff BA, Gustavsen G, Kaminski TW: Athletic Training Research Laboratory, University of Delaware, Newark, DE

Context: Previous research has identified lateral ankle sprains (LAS) as the most commonly observed type of ankle sprain. Following a LAS, deficits in dynamic balance exist and reversing them is critical in improving functional performance. The Y Balance Test (YBT) is a reliable dynamic balance assessment involving single-limb stability and an identifiable cut-off point of 89.6% for the composite score, relative to limb length. This research compared YBT scores at baseline (prior to injury) and 2-4 weeks after an acute LAS. **Methods:** We employed a longitudinal cohort design in a university Athletic Training Research Laboratory. Thirteen (7 males, 6 females) university student-athletes (age = 19 ± 0.5 years, height = 179.9 ± 8.9 cm, mass = 78.3 ± 12.8 kg) who sustained an acute LAS were included in the analysis. An injury history questionnaire was completed at each testing session (baseline and post-injury), along with a clinical examination to determine LAS severity (grade 1 or 2) was completed 24-72 hr. post-injury. The YBT was performed at baseline and post-injury time points with limb length calculated from the ASIS to most distal portion of medial malleolus. Single-limb reach distances normalized to limb length using the YBT in three reach directions; anterior (ANT), posteromedial (PM), and posterolateral (PL) were calculated, as well as composite scores (COMP) which combined all directions and normalized limb length. The independent variable was time (baseline and post-injury), while the dependent variables included

reach direction (ANT, PM, PL) and COMP as a percentage of limb length. Individual t-tests were computed to examine if significance differences between baseline and post-injury existed.

Results: There were significant differences between baseline and post-injury in PM (92.0 ± 4.4 vs 108.8 ± 6.9 , $p < 0.001$) and in PL (90.4 ± 4.4 vs 103.6 ± 6.6 , $p < .001$). A trend toward significance in ANT scores (60.4 ± 2.9 vs 58.5 ± 3.7 , $p = .076$) persisted. There was no significant difference in COMP (83.9 ± 6.9 vs 83.4 ± 9.0 , $p = .764$) between time points.

Conclusions: Improvements in YBT reach distances in PM and PL, 2-4 weeks after an LAS, were evident in this cohort of student-athletes when compared to their pre-injury baseline values. Because our population of student-athletes received dedicated and daily rehabilitation under the direction of a certified athletic trainer, we were not at all surprised to see this improvement in single-limb balance. Conversely, the ANT reach did not improve between the time points suggesting that a decrease in dorsiflexion range-of-motion persists 2-4 weeks after LAS. This study points to the importance of supervised and systematically guided rehabilitation following LAS to enable athletes to surpass pre-injury levels of single-limb balance.

Association Between Rehabilitation and Goal Achievement in Athletes Discharged From Care Following an Ankle Sprain: A Report From the Athletic Training Practice-Based Research Network
Corbett RO, Marshall AN, Lam KC, Hertel J: University of Virginia, Charlottesville, VA; A.T. Still University, Mesa, AZ

Context: Ankle sprains are among the most prevalent musculoskeletal injuries in physically active populations. Little research exists describing the association between the quantity of treatment provided for these injuries and whether goals are achieved at discharge. The purpose of this study was to evaluate the volume of rehabilitation and the goal achievement of athletes that have been discharged from care following an ankle sprain.

Methods: Data collected from 63 athletic training facilities (high school=54, college=8, clinic=1) located in 14 states were retrospectively analyzed. Participants included 154 ATs (female = 61, age = 28.5 ± 7.7 years, years certified = 3.7 ± 5.1 , years employed at site = 1.4 ± 3.7) within the Athletic Training Practice-Based Research Network. Ankle sprain cases were included if they contained an evaluation report, an ICD-9 diagnosis code for ankle sprain (845.0: Sprain/Strain, 845.01: Deltoid Ligament Sprain, 845.03: Tibiofibular Ligament Sprain), treatment information using CPT treatment codes, and a discharge note. Descriptive statistics were computed for diagnosis, injury severity, and days from injury to evaluation. Frequencies were calculated to assess the volume of rehabilitation by determining the number of episodes of care (EOC) per case, the amount of athletic training services provided, and the length of time per service. Goal achievement was determined by the clinician categorizing outcomes as either being "Achieved" or "In Progress" at time of discharge.

Results: Four hundred and sixty-three patient cases were identified: sprain/strain =76.9%,

tibiofibular ligament sprain=17.1%, deltoid ligament sprain=5.4%. Of those ankle sprains reported, 60.7% of those reported as either mildly or moderately severe. Football (32.4%) and basketball (26.4%) accounted for the highest sport participation, and overall the top two mechanisms of injury were twisting (33.9%) and from contact (26.4%). Athletes were evaluated 7.8 ± 32.4 days following occurrence of their ankle sprain, and were receiving care within the span of 31.6 ± 39.1 days. Athletic Trainers documented 4.4 ± 4.2 EOC per patient case, with patients receiving three or less athletic training services provided during 81.2% of all EOC. In addition, 84.3% of the EOC lasted 15 minutes long ($n=337/400$). The most frequently documented athletic training services provided were athletic trainer re-evaluation (32.3%, $n=129/400$) and therapeutic exercise (22.3%, $n=89/400$). At discharge, 91.1% of patients achieved the proposed goals for balance, 93.1% for full range of motion, and 92.9% for strength.

Conclusions: This analysis quantified the amount of care provided to patients that had been discharged from care following an ankle sprain injury, and what proportion had outcome goals that were achieved. Although less than 100% of the athletes achieved their outcome goals, all of patients were discharged. This discrepancy warrants further investigation.

Comparison of Practice Patterns With International Ankle Consortium Recommendations for the Clinical Assessment of Lateral Ankle Sprain Injuries: A Report From the Athletic Training Practice-Based Research Network

Marshall AN, Lam KC: A.T. Still University, Mesa, AZ

Context: A recent consensus statement from the International Ankle Consortium (IAC) provides evidence-based guidelines for a structured assessment of acute lateral ankle sprains (LAS), including both the diagnosis and identification of mechanical and/or sensorimotor deficits. However, it is unknown if clinicians incorporate these components into their routine evaluations. Our objective was to compare athletic trainers' (ATs) evaluation patterns for acute LAS injuries to the IAC recommendations. **Methods:** Electronic patient records, created by ATs between October 2009 and May 2018 for 96 athletic training facilities (high school = 79, college = 16, clinic = 1) located in 15 states, were retrospectively analyzed. Participants included 201 ATs (females = 126, age = 28.8 ± 8.0 years, years certified = 4.7 ± 6.3, years employed at site = 2.0 ± 5.0) within the Athletic Training Practice-Based Research Network. Injury evaluation forms were extracted using the ICD-9 diagnostic code for LAS (845.0: sprain of ankle), and were compared to the IAC recommendations, including a diagnostic component (ie, mechanism of injury [MOI], previous medical history of a LAS [PMH], weight-bearing status [WB], clinical assessment of bones [BONES], clinical assessment of ligaments [LIGAMENTS]) and a rehabilitation-oriented component (ie, ankle joint pain, swelling, range of motion [ROM], arthrokinematics, joint muscle strength, static postural balance [STATIC-BAL], dynamic postural balance [DYNAMIC-BAL], gait, physical activity level prior to injury [PA], and ankle joint specific patient-reported outcome measures [PROMs]). Summary statistics (percentages, frequencies) were calculated to

describe AT clinical evaluation patterns, respective to the IAC guidelines. **Results:** During the study period, 1,557 patients (male = 56.1%, age = 16.2 ± 2.0 years, height = 170.8 ± 13.9 cm, mass = 71.1 ± 17.0 kg) were diagnosed with an acute LAS. A majority of patients participated in basketball (25.6%, n = 399), football (24.1%, n = 376), and soccer (15.1%, n = 235), and reported twisting (35.4%, n = 551), contact (22.4%, n = 349), and non-contact (20.8%, n = 324) MOIs occurring most commonly during in-season practice (43.9%, n = 683) and in-season game (34.1%, n = 531). ATs generally followed the diagnostic recommendations: MOI = 100.0% (n = 1,557/1,557), PMH = 99.3% (n = 1,546/1,557), WB = 93.5% (n = 1,457/1,557), BONES: palpation = 96.1% (n = 1,497/1,557) and special tests = 9.3% (n = 144/1,557), LIGAMENTS: palpation = 96.1% (n = 1,497/1,557) and special tests = 47.7% (n = 742/1,557). However, the utility of the recommended rehabilitation-oriented components was inconsistent: pain = 99.8% (n = 1,554/1,557), swelling = 99.7% (n = 1,553/1,557), ROM = 41.1% (n = 640/1,557), arthrokinematics = 0.0% (n = 0/1,557), strength = 62.9% (n = 979/1,557), STATIC-BAL = 8.8% (n = 14/1,557), DYNAMIC-BAL = 0.0% (n = 0/1,557), gait = 49.5% (n = 771/1,557), PA = 0.0% (n = 0/1,557), PROMs = 8.2% (n = 127/1,557). **Conclusions:** While ATs generally follow the recommendations for the clinical diagnosis of acute LAS, the utilization of special tests is inconsistent. Similarly, clinicians consistently assess pain and swelling, but seldom or rarely incorporate more functional measures such as ROM, strength, balance, and gait. It is evident that ATs are not evaluating arthrokinematics, physical activity, or PROMs, components that are valuable for rehabilitation progression. Clinicians should utilize the evidence-based IAC recommendations to improve acute evaluations and identify impairments to target during injury management and rehabilitation. Future research should evaluate whether optimizing treatment plans according to these recommendations improves long-term outcomes following LAS injuries.

**Ankle Best Practices Forum: Sacrificing Long Term Health for Quick Return-to-Play:
Ankle Sprain to Ankle Osteoarthritis**

Thursday, June 27, 2019, 8:00AM-9:00AM, Mandalay Bay A; Moderator: Phillip Gribble, PhD, ATC, FNATA
Discussants: Tricia Hubbard-Turner, PhD, ATC; Janet Simon, PhD, ATC

Knee Best Practices Forum: Enhancing Rehabilitation Outcomes Following Knee Injury: Overcoming Psychological Barriers

Thursday, June 27, 2019, 10:45AM-11:45AM, Mandalay Bay A; Moderator: Jennifer Earl-Boehm, PhD, ATC, FNATA

Discussants: Grant Norte, PhD, ATC, CSCS; Neal Glaviano, PhD, ATC

Free Communications, Oral Presentations: Lower Extremity Post-Traumatic Osteoarthritis and Cartilage Health

Thursday, June 27, 2019, 12:00PM-1:15PM, Mandalay Bay A; Moderator: Abbey Thomas Fenwick, PhD, ATC

The Epidemiological Study of Post-Traumatic Knee Osteoarthritis After Cruciate Ligament Injury in the Young & Middle-Aged Population Using Korean National Health Insurance Sharing Service 201,051 Cohort Data

Lee SY, Hyung-Pil J, Lee SY: Yonsei University, Seoul, South Korea; Dong-A University, Busan, Seoul

Context: It has been known that the early development of post-traumatic knee osteoarthritis (PTOA) is highly associated with Cruciate Ligament (CL) injury. However, it is not sufficient to understand and develop a preventive strategy of OA due to limited evidence by small sample size and lack of patient information. Therefore, the aims of the study were: 1) to identify a Mean Survival Time (MST) which is the time from CL injury to PTOA and 2) to determine the risk of knee PTOA following CL injury with multi-knee injury and other patient-related factors using 201,051 Korean. **Methods:** Using National Health Insurance Sharing Service (NHISS) database, we identified all patients who were between twenty and forty-five years of age and had undergone CL injury in Korea from 2002 to 2005. Case-patients were matched by demographic characteristics with five times of healthy population, who had no history of lower extremity injury. Among 201,051, 17,643 (male = 11,881, female = 5,715; age = 31.34 ± 7.53 yrs) patients were only CL injured (CL), 6,385 (male = 5,518, female = 852; age = 30.20 ± 7.24 yrs) were CL injured with meniscus injury (CM), 5,374 (male = 4,350, female = 1,016; age = 30.97 ± 7.32 yrs) were CL with MCL or LCL injuries (CML), and 171,649 (male = 88,696, female = 80,487; age = 31.19 ± 7.75 yrs) were remnant. All patients were

followed up until 2016 to compare risk for PTOA between the CL and healthy population. Kaplan-Meier analysis was used to identify the MST and Cox proportional-hazard model was used to determine a risk factor for knee PTOA. Adjusted hazard ratios (AHRs) and 95% confidential intervals (CIs) were estimated. **Results:** MST of CL (12.72 ± 0.003 yrs) was shorter than healthy population (11.15 ± 0.028 yrs). MST of female (10.67 ± 0.053 yrs) was shorter than the male (11.38 ± 0.032 yrs). CL (HR: 7.21; 95% CI: 6.67-7.80), CM (6.07; 5.35-6.88), and CML (4.91; 4.26-5.66) were having significantly higher risk than healthy population for the development of knee OA. Females (2.16; 1.96-2.31) were having a higher risk of knee OA than males. The 30s (1.70; 1.50-1.92) and 40s (4.51; 4.05-5.03) were having a higher risk of OA than 20s. Overweight (1.36; 1.26-1.48) and Obese (1.77; 1.48-2.12) population were having a higher risk of OA than normal-weight population. The AHRs of CL for knee PTOA were 8.73 (95% CI: 7.88-9.68) in males, 5.63 (4.71-6.09) in females, 9.31 (7.67-11.37) in 20s, 8.15 (7.00-9.50) in 30s, 6.29 (5.67-6.98) in 40s, 7.45 (6.75-8.23) in the normal-weight, 7.18 (6.26-8.24) in the overweight, and 5.10 (3.55-7.31) in the obese. **Conclusions:** CL & Complex CL injury, female gender, old age, and obesity seem to be significant risk factors for the development of early PTOA. Our results suggest that individuals need to engage in preventative exercise at an earlier stage and control weight for preventing PTOA and minimizing risks.

Talar Cartilage T1rho MRI Based Volume is Associated With Talar Cartilage Ultrasonography Based Thickness

Song K, Pietrosimone BG, Casey M, Karakash W, Mueller C, Overman CB, Wikstrom EA: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: The condition of Chronic ankle instability (CAI) demonstrates early deleterious changes in cartilage composition without declines in cartilage volume, consistent with the early stages of posttraumatic osteoarthritis development. Compositional changes have been noted using advanced MR-based imaging techniques which are not clinically accessible or cost-effective. Ultrasonography (US) has emerged as an alternative to MR to assess cartilage morphology and composition of the tibiofemoral cartilage but it remains unclear if US is a valid assessment tool for talar cartilage. Therefore, our aim is to determine the associations between US measurements of talar cartilage thickness and MR-based measures of talar cartilage volume. **Methods:** Fifteen CAI (21.2 ± 1.8 years, 1.7 ± 0.8m, 67.0 ± 7.7kg) and fifteen uninjured controls (21.0 ± 2.5 years, 1.7 ± 0.8m, 69.6 ± 13.2kg) volunteered to participate. Inclusion criteria followed International Ankle Consortium guidelines. Participants were non-weight bearing for 30-minutes prior to undergoing a T1ρMRI (Siemens Magnetom TIM Prisma 3T scanner with an 8-channel flex coil) while supine. Segmentation of the T1ρ talar cartilage was performed manually using ITK-SNAP software. Talar segmentation created overall, anteromedial (AM), anterolateral (AL), posteromedial (PM), and posterolateral (PL) regions of interest (ROI). Then, the cartilage volume (mm³) of each ROI was calculated. The US images of talar cartilage thickness were acquired using a LOGIQe system with a 12 MHz linear

probe after unloading the cartilage for 30 minutes. Participants were positioned supine with their knee positioned to 90 degrees of flexion and their ankle in a foot flat position. The US probe was placed transversely in line with the medial and lateral malleolus and rotated to maximize rejection of the articular cartilage surface. Talar cartilage images were manually segmented using ImageJ software to identify the medial, lateral, and overall cross-sectional area (mm²). Then, area was normalized to the length of the cartilage-bone interface to obtain an average thickness (mm). Pearson correlations with $p \leq 0.05$ were used to determine statistical significance for all analyses. **Results:** The average medial US thickness was positively associated with MR volumes in the AM ROI ($r=0.661$, $p<0.001$), AL ROI ($r=0.430$, $p=0.013$), and the overall talar dome ($r=0.627$, $p<0.001$). The average lateral US thickness was positively associated with MR volume in the AL ROI ($r=0.551$, $p=0.002$) and overall talar dome ($r=0.407$, $p=0.026$). The overall average US thickness was positively associated with the MR volume for the AM ROI ($r=0.511$, $p=0.004$), AL ROI ($r=0.608$, $p<0.001$), and overall talar dome ($r=0.597$, $p<0.001$). **Conclusions:** Our results indicate that thicker US cartilage is associated with increased T1 ρ MR-based volumes of talar cartilage. US thickness measures of talar cartilage appear to be a clinically accessible and cost-effective method for evaluating ankle cartilage morphology but future research is needed to determine if US based measures of composition (i.e. deformation, resiliency) are also valid.

Dominant to Non-Dominant Limb Measures of Knee Cartilage Thickness

Wang HM, Lai JC, Lin YC, Hsu GS: China Medical University, Taichung, Taiwan; Taichung Armed Forces General Hospital, Taichung, Taiwan; Chang Gung Memorial Hospital, Taoyuan, Taiwan; National Taiwan University of Sport, Taichung, Taiwan

Context: Knee cartilage thickness is one possible in-vivo measure to identify knee cartilage health. While proper mechanical loading is critical for knee cartilage health, little is known about limb dominance differences of knee medial and lateral cartilage thickness. **Objective:** To examine in-vivo knee medial and lateral cartilage thickness between dominant to non-dominant limbs. **Methods:** Design: Cross-sectional. Setting: Controlled laboratory. **Patients or Other Participants:** 16 healthy long-distance male runners (1.70 ± 0.04 m, 57.5 ± 3.9 kg, 19.8 ± 1.5 yrs) with no current knee orthopedic injury or history of knee surgery in both knees. **Interventions:** The participants underwent ultrasound measures of the medial and lateral femoral condyle articular cartilage on both limbs. **Main Outcome Measures:** The dominant limb was defined as the leg used to kick a ball to maximum distance. Medial and lateral femoral condyle articular cartilage thickness was obtained via ultrasound imaging. Each cartilage was divided into anterior, middle and posterior regions. Paired samples t-tests examined dominant to non-dominant differences on medial and lateral cartilage thickness. **Results:** There were no differences in medial cartilage thickness of the anterior (1.4 ± 0.2 mm Vs 1.4 ± 0.2 mm, $p = .300$), middle (1.4 ± 0.2 mm Vs 1.4 ± 0.2 mm, $p = .589$) and, posterior regions (1.2 ± 0.1 mm Vs 1.3 ± 0.1 mm, $p = .096$) and in lateral cartilage thickness of middle (1.2 ± 0.2 mm Vs 1.2 ± 0.3 mm, $p = .379$) and posterior regions (1.4 ± 0.2 mm Vs 1.4 ± 0.2 mm, $p = .783$), but significant difference in anterior region of the lateral cartilage

was found (2.1 ± 0.2 mm Vs 2.2 ± 0.2 mm, $p = .001$) between the dominant and non-dominant limbs. Comparing the medial to the lateral cartilage, there were significant differences between medial and lateral cartilage thickness in the anterior (1.4 ± 0.2 mm Vs 2.1 ± 0.2 mm, $p = .000$; 1.4 ± 0.2 mm Vs 2.2 ± 0.2 mm, $p = .000$), middle (1.4 ± 0.2 mm Vs 1.2 ± 0.2 mm, $p = .003$; 1.4 ± 0.2 mm Vs 1.2 ± 0.3 mm, $p = .005$) and, posterior regions (1.2 ± 0.1 mm Vs 1.4 ± 0.2 mm, $p = .002$; 1.3 ± 0.1 mm Vs 1.4 ± 0.2 mm, $p = .003$) from the dominant to non-dominant limbs. **Conclusions:** Only the anterior region of lateral cartilage on non-dominant limb is thicker than dominant limb. The lateral cartilage is thicker in the anterior and posterior regions, but thinner in the middle region compared to the medial cartilage on both limbs. This work suggests that limb dominance may not impact cartilage health and that asymmetry of medial and lateral cartilage exists. Future work should continue to investigate other structural factors associated with cartilage health.

Ankle Cartilage Composition Associates With Physical Activity and Fear-Avoidance in Those With Chronic Ankle Instability

Wikstrom EA, Song K, Casey M, Karakash W, Mueller C, Overman CB, Pietrosimone B: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Chronic ankle instability (CAI) has been linked with the development of ankle post-traumatic osteoarthritis. To date, composition MRI techniques including T1rho and T2 mapping have noted degeneration at the talocrural and subtalar joint in those with CAI relative to uninjured controls. These compositional MRI techniques (T1rho and T2) estimate the initial loss of proteoglycan density and the subsequent increase in water content and collagen fiber disorganization, respectively. However, it remains unclear if these early compositional changes are associated with injury history (e.g. number of recurrent sprains, giving way episodes), physical activity levels, or perceived disability. Therefore, our objective was to determine the associations among talocrural and subtalar joint T1rho MRI relaxation times and patient-reported outcomes in those with CAI. **Methods:** Fifteen (21.13 ± 1.81 years, 4.00 ± 2.07 previous ankle sprains) participants volunteered. Inclusion criteria followed International Ankle Consortium guidelines. Participants were non-weight bearing for 30-minutes prior to undergoing a T1rho MRI (Siemens Magnetom TIM Prisma 3T scanner with an 8-channel flex coil) while supine. While unloading, participants completed the Identification of Functional Ankle Instability (IdFAI), Foot and Ankle Ability Measure (FAAM), and injury history questionnaire, the Fear-Avoidance Beliefs questionnaire (FABQ), and the International Physical Activity Questionnaire (IPAQ). Dependent variables included T1rho values for talocrural and subtalar cartilage regions of interest. T1rho values

were obtained by manually segmenting the T1rho image from the 0ms spin lock duration using ITK-SNAP software. For this investigation, subtalar cartilage was defined as the full thickness of the talocalcaneal cartilage layers at the anterior, medial, and posterior subtalar articulations. Full thickness cartilage was used due to concerns about having enough pixel rows per cartilage layer. Talocrural segmentation created overall, anteromedial, anterolateral, posteromedial, and posterolateral regions of interest of the talar cartilage. Greater T1rho were interpreted as greater degenerative changes. The number of ankle sprains, giving way episodes, IDFAI score, FAAM scores, IPAQ MET minutes a week (IPAQ-MET), and FABQ scores were also calculated. Pearson product moment correlations quantified associations with $p \leq 0.05$ used to determine statistical significance for all analyses. **Results:** Anteromedial Talar dome T1rho was associated with the FABQ-work subscale ($r=0.594$, $p=0.020$) and with the IPAQ-MET ($r = -0.518$, $p=0.048$). As cartilage degeneration increased, fear-avoidance increased and physical activity decreased. Anterior subtalar T1rho was associated with the FABQ-work subscale ($r=0.654$, $p=0.008$). As cartilage degeneration increased, so did fear avoidance beliefs. No other significant associations were noted ($p>0.05$). **Conclusions:** The results indicate that lower physical activity levels and great fear-avoidance are associated with talocrural and subtalar joint compositional changes in those with CAI. However, injury history and traditional CAI questionnaires (IdFAI, FAAM) are not. This may suggest that movement patterns and loading characteristics (e.g. intensity, volume) should be targeted to slow deleterious changes in cartilage composition.

Ultrasonographic Analysis of Acute Cartilage Morphological Alteration Following Conventional Rehabilitative Exercises in Patellofemoral Pain Individuals

Jeon HJ, Thomas AC: University of North Carolina at Charlotte, Charlotte, NC

Context: Patellofemoral pain (PFP) is a multifactorial knee pathology prevalent in physically active individuals. PFP patients experience pain aggravation during and after athletic activities that involve knee joint loading, particularly running, squatting, and jumping movements. A number of rehabilitative exercises are prescribed to alleviate pain for PFP patients and are proven to be effective; however, no research has analyzed cartilage response after one bout of those athletic activities in patients with PFP. Understanding how cartilage responds to these activities is important in understanding the long-term impact of PFP. **Methods:** Study design: Case-control study. **Setting:** Research laboratory. **Patients or Other Participants:** Seven (n=4 PFP, age: 20.8±1.3yrs, body mass index [BMI]: 21.3±2.9kg/m²; n=3 healthy, age: 21.0±1.0yrs, BMI:

22.1±1.4kg/m²) physically active adults participated in this ongoing investigation. Participants were matched based on age, BMI, and physical activity level measured by the Tegner activity scale. Participants were excluded if they had a history of orthopedic injuries to either limb with the exception of PFP in the PFP group. **Interventions:** Participants completed treadmill running, lower extremity strengthening exercises and plyometric exercises each for 30 minutes. Each session was completed at the same time of day and separated by 1 week to mitigate any muscle fatigue and soreness and to ensure the same amount of joint stress at the beginning of each session. **Main Outcome Measures:** Femoral cartilage ultrasonographic images were obtained at 140°, 110° and 90° knee flexion. Ultrasound images were segmented into medial and lateral by the intercondylar notch. Medial and lateral cartilage cross sectional area (CSA; mm²) and echo intensity (EI), defined as the average gray-scale from 0 to 255, were analyzed by ImageJ software. Lower EI appears darker and indicates greater cartilage water content. Percent change scores of CSA and EI were calculated. Pain level was measured before and after activities using a 10cm

visual analog scale (VAS) and the pre-to post-exercise difference was recorded. Independent t-test compared change scores between groups. **Results:** There was no significant group difference in CSA or EI percent change after exercises in all degrees of knee flexion (Table 1). However, significant group differences were observed in VAS scores (PFP_{running}: 5.3 ± 0.5, Healthy_{running}: 0.0 ± 0.0, p = 0.004; PFP_{strengthening}: 3.5 ± 1.9, Healthy_{strengthening}: 0.0 ± 0.0, p = 0.03; PFP_{plyo}: 4.5 ± 1.7, Healthy_{plyo}: 0.0 ± 0.0, p = 0.012). **Conclusions:** Pain increased after the exercises in PFP patients but not in healthy participants. But, no cartilage CSA and EI differences between PFP patients and healthy individuals were identified. Though continuation of this investigation is needed to confirm our findings, preliminary analysis indicates there is no morphological difference in femoral cartilage between those with PFP and healthy adults despite pain level alterations.

Table 1. Femoral cartilage alteration following rehabilitations

		CSA			EI		
		PFP	Healthy	P	PFP	Healthy	P
Running	Medial 140°	-16.0±19.7	-19.1±9.8	0.82	-0.5±4.1	-5.5±4.9	0.21
	Lateral 140°	-9.9±8.8	-17.5±17.7	0.49	-3.1±5.9	-3.6±3.7	0.92
	Medial 110°	-14.1±12.9	-3.5±13.7	0.34	0.5±4.3	-5.3±4.1	0.13
	Lateral 110°	-6.8±17.1	-3.1±22.1	0.81	-2.5±3.0	-6.8±6.5	0.29
	Medial 90°	-24.2±8.7	-3.6±21.4	0.14	-1.5±7.5	-3.7±2.8	0.66
Strengthening	Lateral 90°	-16.3±9.1	-9.7±6.9	0.35	-0.4±5.2	-4.6±7.1	0.41
	Medial 140°	-14.3±13.8	-12.1±15.2	0.85	3.4±3.2	0.7±1.8	0.25
	Lateral 140°	-11.1±2.1	-9.1±10.2	0.70	-1.0±2.9	1.8±0.9	0.17
	Medial 110°	-8.3±14.2	-8.3±6.4	1.00	3.2±5.2	3.2±5.2	1.00
	Lateral 110°	-10.8±10.1	-1.1±10.3	0.27	-1.7±3.4	3.4±5.2	0.17
Plyometrics	Medial 90°	-4.1±7.3	-7.9±15.1	0.67	2.7±5.6	-1.0±7.2	0.47
	Lateral 90°	-7.1±13.1	-6.5±5.1	0.95	-0.2±3.1	-1.8±6.0	0.66
	Medial 140°	-13.4±13.7	-11.6±6.2	0.84	0.9±3.8	-2.4±3.0	0.27
	Lateral 140°	0.9±3.8	-8.4±3.2	0.92	0.5±2.6	0.6±3.9	0.97
	Medial 110°	-10.5±6.9	-17.8±7.3	0.23	-0.4±3.6	-4.0±9.3	0.49
	Lateral 110°	-11.7±15.2	-1.5±13.3	0.40	-3.8±3.4	-3.6±8.4	0.96
	Medial 90°	-19.2±11.1	-19.2±11.1	0.08	-1.6±5.5	-1.6±9.3	0.99
	Lateral 90°	-13.5±3.7	-6.9±15.1	0.43	-2.5±5.1	-2.4±4.6	0.98

CSA: Cross sectional area (mm²), EI: Echo intensity (Gray scale 0-255), Unit: ° (degrees)

- Negative value indicates greater cartilage deformation

Free Communications, Oral Presentations: Risk Factors for Shoulder and Elbow Injuries in Overhead Athletes

Thursday, June 27, 2019, 1:30PM-3:00PM, Mandalay Bay A; Moderator: Brett Pexa, MA, LAT, ATC

Predicting Injury History in High School Pitchers From Two- and Three-Dimensional Kinematics

Struminger AH, Atanda A Jr, Buckley TA, Richards JG, Swanik CB: Eastern Michigan University, Ypsilanti, MI; Nemours/Alfred I. Dupont Hospital for Children, Wilmington, DE; University of Delaware, Newark, DE

Context: Previous research has identified specific pitching kinematics associated with excessive upper extremity loading. Understanding which of these pathomechanics exist in pitchers who return from injury could create more efficient treatment techniques, but data comparing previously injured and uninjured athletes are lacking. Furthermore, most data on pitching mechanics are collected via three-dimensional analysis, which is prohibitively expensive for clinical use. Current advances in two-dimensional camera technology may produce kinematic variables that identify previous injury in pitchers. The purpose of this investigation was to determine the ability of two- or three-dimensional kinematic analyses to predict injury history in high school baseball pitchers. **Methods:** High school-aged, currently healthy, male baseball athletes ($n = 43$, age = 15.6 ± 1.3 years, height= 178.7 ± 6.1 cm, weight= 73.5 ± 12.4 kg) who had pitched for at least two consecutive seasons participated. Participants were grouped based on self-report of a previous throwing-related upper extremity injury that caused them to limit pitching activity for at least one week (previously injured: $n=16$, previously uninjured: $n=27$). Three-dimensional data were recorded using a 12-camera motion-capture system. Two-dimensional data were collected with two commercially available video cameras. Both systems collected pitching biomechanics at 240 Hz. Shoulder abduction, shoulder external rotation, shoulder horizontal abduction, lateral trunk tilt, and elbow flexion were measured by

three-dimensional analysis at three points of the pitching motion: stride foot contact (SFC), maximum external rotation (maxER), and ball release (BR). Only shoulder abduction at SFC, elbow flexion at SFC, and trunk lateral flexion at BR were valid compared to three-dimensional kinematics and used in the two-dimensional analysis. Logistic regressions were used to evaluate how well the dependent variables predicted injury history. **Results:** The three-dimensional logistic regression indicated statistically significant improvement over the constant-only model ($\chi^2=10.563$, $df=4$, $p=.032$). The variables accounted for 30.2% of the variance. In the three-dimensional model, only shoulder abduction at maxER was identified as a statistically significant predictor. Specifically, athletes who displayed less abduction at maxER were more likely to be placed in the injured group (Injured: $80.6 \pm 9.2^\circ$; Uninjured: $88.4 \pm 6.2^\circ$). Overall, the three-dimensional model correctly classified 78.6% of the athletes into the proper injured and uninjured groups. Analysis of the two-dimensional logistic regression did not indicate a statistically significant improvement over the constant-only model ($\chi^2=2.323$, $df=3$, $p=.508$), with the included variables only accounting for 8.1% of the variance between groups. **Conclusions:** Three-dimensional analysis of shoulder abduction at maxER successfully grouped high school pitchers with and without injury history. Analysis of two-dimensional angles does not identify previous injury status in high school pitchers. These data indicate that clinicians cannot rely on two-dimensional kinematic analysis to identify injury history. However, they should begin conversations high school pitchers who are visually identified to throw with a reduced shoulder abduction angle at maxER in an attempt to provide appropriate early intervention.

Preseason Neck Mobility Is Associated With Throwing-Related Shoulder and Elbow Injury, Pain and Disability in College Baseball Pitchers

Devaney LL, Denegar CR, Thigpen C, Lepley A, Edgar C, DiStefano L: University of Connecticut, Storrs, CT; University of South Carolina, Greenville, SC

Context: Shoulder and elbow injuries in baseball pitchers have been on the rise for three decades at all levels of play and result in significant pain and disability. Despite anatomical and neurophysiological relationships, neck mobility impairments have not been explored as contributors to shoulder and elbow injury in baseball pitchers. The purpose of this study was to investigate the relationship between cervical/thoracic spinal mobility and risk of shoulder and elbow pain and disability in college baseball pitchers. **Methods:** This was a prospective cohort study. Forty-nine healthy college baseball pitchers (19.92 ± 1.48 years, 187.04 ± 6.02 cm, 89.14 ± 12.08 kg) were enrolled prior to the 2018 college season. Posture, neck mobility, and glenohumeral passive range of motion were measured during preseason using the InclinoMetric Kyphosis Measure, Cervical Flexion Rotation Test, Cervical Active Range of Motion (CROM®), and digital inclinometry, respectively. Time-loss (days lost to shoulder or elbow injury) was recorded, and patient reported disability was captured bi-weekly using the Functional Arm Scale for Throwers (FAST). Pitchers were dichotomized into Injured and Uninjured groups based on time-loss (> 7 days) and cutoff scores for average FAST (> 10). Receiver Operating Characteristic curves were generated, and diagnostic accuracy values and risk ratios (RR) were calculated to assess the diagnostic utility of the physical measures. **Results:** Ten pitchers (20.4%) sustained a time-loss

injury (> 7 days) due to shoulder or elbow injury. A dominant side Cervical Flexion Rotation Test of <39° resulted in over 9 times increased risk of time-loss injury (RR=9.38, 95%CI 1.28-68.49, p=.028). Dominant side Cervical Flexion Rotation Test of <38°, Cervical Flexion Range of Motion < 64°, and mass > 86.86 kg were also associated with increased risk of patient reported pain and disability >10 on the FAST Pitcher Module ((RR=4.05, 95%CI 1.02-16.04, p=.030; RR=8.90, 95% CI 1.27-62.26, p=.014; and RR=10.42, 95%CI 1.14-213.70, p=.008, respectively). **Conclusions:** College baseball pitchers with less neck mobility during preseason had increased risk of both time-loss and patient reported shoulder and elbow pain and disability during the season. Predictive value of these measures as part of a risk screening profile should be further explored.

Relationship Between Spine and Hip Range of Motion, Hip Strength, and Injury Risk in Collegiate Baseball Athletes

Tucker WS, Laudner KG, Snyder Valier AR, Huxel Bliven KC: University of Central Arkansas, Conway, AR; Illinois State University, Normal, IL; A.T. Still University, Mesa, AZ

Context: Transfer of forces through the kinetic chain during the throwing motion requires requisite spine and hip range of motion (ROM) and strength for optimal performance. Research examining the impact of these variables on injury risk in baseball athletes is limited. The purpose of this study was to determine whether pre-season clinical measures of spine and hip ROM and hip strength are predictive of sport-related injuries during a collegiate baseball season. **Methods:** This prospective cohort study included 183 baseball athletes (73 pitchers, 110 position players, age: 20.1±1.5 years, height: 180.9±20.1cm, mass: 85.7±17.5kg, years of play: 13.4±3.2 years) from four inter-collegiate teams. Participants were tested in a single session during pre-season and tracked weekly during the concurrent competitive season for sport-related injuries. Bilateral pre-season measurements included: standing active-assisted spine rotation ROM (degrees) measured with two bubble inclinometers; passive hip internal rotation (IR), external rotation (ER), and total (IR+ER) ROM (degrees) measured using a digital inclinometer with participants prone and 90° knee flexion; and side-lying hip abduction strength (%BW) using a hand-held dynamometer. Four investigators with >0.75 intra-rater reliability for their assigned measurements performed the same measurements on all participants. Each team's athletic trainer provided weekly in-season injury reports that included: body part, diagnosis, time lost, participation status, and injury mechanism. Poisson regression with robust estimator analyses were performed to assess injury

risk ($p < 0.05$). **Results:** A total of 36 participants sustained a sport-related injury (9 pitchers, 27 position players) for a 20.0% injury risk. The majority of injuries were: to the trunk/lower limbs (55.5%, 20/36), a result of throwing (33.3%, 12/36), diagnosed as muscle strains (55.6%, 20/36), and time-loss (i.e., partial or complete) (61.1%, 22.36). Spine rotation to the throwing side was related to relative injury risk (Exp(B)=1.062, CI:1.024, 1.101, $p=0.001$) when controlling for spine rotation to the non-throwing side. Stance leg hip IR ROM was related to relative injury risk (Exp(B)=0.921 CI:0.871, 0.974, $p=0.004$) when controlling for stance hip ER and lead hip IR and ER. Stance hip ER ROM was not related to injury ($p=.057$). Stance leg hip total ROM was related to relative injury risk (Exp(B)=0.949, CI: 0.918, 0.982, $p=0.003$), when controlling for lead leg hip total ROM. Lead and stance leg hip abduction strength were not related to injury ($p=0.61$ and $p=0.23$, respectively). **Conclusions:** The results suggest spine rotation to the throwing side and stance leg hip IR and total ROM are independently related to relative risk of sport-related injury in collegiate baseball athletes, while hip strength is not. Our findings emphasize the importance of spine and hip rotation ROM, and their ability to alter injury risk in baseball athletes. Baseball athletes may benefit from injury prevention programs that focus on spine and hip rotation ROM.

Predictors of Shoulder Injuries in Female Collegiate Swimmers

Lippincott EL, Hellman MA, Michener LA, Shaw K: Lock Haven University, Lockhaven, PA; Nova Southeastern University, Fort Lauderdale, FL; University of Southern California, Los Angeles, CA

Context: As many as 90% of competitive swimmers will experience shoulder pain at some point in their career. Shoulder impairments and swim history, occurring singularly or in combination, may be risk factors for shoulder injury. The objective of this study was to determine if shoulder impairments and swim history are risk factors for shoulder injury in female collegiate swimmers. **Methods:** Study design and setting: prospective longitudinal cohort, multi-center collegiate teams. Patient population: Female collegiate swimmers from four NCAA Division II universities (n=53 swimmers/106 shoulders, mean age=19.3 +/- 1.2 yrs). **Intervention:** All participants provided consent and completed a preseason demographic and swimming-related questionnaire and underwent musculoskeletal impairment measures. Information gathered from the questionnaire included the participant's swim history (eg, age when starting competitive swimming, preferred swim stroke and distance) and shoulder injury history. Shoulder impairment measurements included scapular dyskinesis, glenohumeral range of motion and laxity, pectoralis minor length, and shoulder muscle strength and endurance. Shoulder injury data was collected over a 16-week season. A shoulder injury was defined as swimming-related shoulder pain that required medical attention and resulted in at least one modified or missed athlete exposure. Statistical analysis: Mann-Whitney U and Chi square tests were used to determine differences in pre-season shoulder impairments and swim characteristics between swimmers who did and did not develop a shoulder injury. Impairments found to be significant

were entered into a logistic regression to determine their ability to predict shoulder injury during the season. A priori significance was set at 0.05. **Results:** Fourteen new shoulder injuries were reported during the season. No differences were noted in preseason shoulder impairments between swimmers who did and did not develop shoulder pain. An injury was reported in 7 of the 18 shoulders with a history of shoulder pain, compared to 7 of the 88 shoulders with no history of shoulder pain (p=0.002). Previous shoulder injury was the sole predictor of an in-season shoulder injury (B=7.4; p=0.001; 95% CI 2.17, 25.00). **Conclusions:** Swimmers who sustained an injury during the season did not display any differences in pre-season shoulder impairments or swim characteristics, when compared to those swimmers who did not develop a shoulder injury. Swimming history did differentiate those who developed an injury. Swimmers with a history of shoulder injury are 7 times more likely to develop an in-season shoulder injury compared those without a history of shoulder injury. These results are similar to previous injury surveillance research that indicates previous injury is often a predictor of future injury. Limitations include the small number of new injuries and the measurement strategies for shoulder muscle endurance. Future research should include a larger sample size and further investigate shoulder impairments in swimmers with a history of shoulder pain.

The Acute:Chronic Workload Ratio is Associated With Injury in Adolescent Tennis Players

Mexicano G, Aguilar KV, Donaldson MJ, Aranda M, Knudson DV, Farnsworth JL, Myers NL: Texas State University, San Marcos, TX

Context: Tennis athletes are often exposed to rigorous training workloads. Recently, authors have used rate of perceived exertion (RPE) to track internal training load in athletes using a metric known as the acute to chronic workload ratio (ACWR). Research reported on team sports have determined that if the acute workload is higher than the chronic workload athletes are likely to sustain injury. No studies, however, have attempted to investigate internal workload and injury in a tennis population despite the rigorous training loads. Therefore, the purpose of this study was to determine if high chronic workloads compared to small spikes in acute workloads decrease the risk of injury in adolescent tennis players. **Methods:** Thirty-two junior tennis players (11 Female; 21 male, 15±2years) were recruited from one tennis academy to participate in a 23-week cohort study. Rate of perceived exertion workload data were collected every day after training/match sessions. Players were instructed to provide a subjective rating of RPE (range:0-10) as an estimate of training intensity. Session RPE (sRPE), a measure of internal workload was calculated by multiplying the training/match session RPE by the session duration in minutes. Players self-reported their injuries using AthleteMonitoring Software; however, the research team was actively involved in following up with all players in regard to any documented injuries. Injury was defined as any non-contact injury that resulted in 1 or more missed training sessions, or a loss of match time. The ACWR was the primary independent variable and was categorized into weekly blocks running from Monday to Sunday. Acute workload was determined as the total sRPE for one week, while a 4-week

rolling average sRPE represented chronic workload. A Cox proportional hazard model was used to determine if ACWR from the previous week was a significant predictor of injury the following week when controlling for age, sex, previous injury history, and years of experience. The SPSS complex sampling procedures was used to control for violations of independent observations that are unavoidable with longitudinal injury data. **Results:** Sixteen participants sustained injuries during the observation period. The model indicated that ACWR from the previous week and previous history of injury were significant predictors of injury the following week (Wald $F_{1,30} = 9.407$; $p < 0.01$ and Wald $F_{1,30} = 5.028$; $p = 0.03$, respectively). In the week preceding injury, the average ACWR was 1.57 ± 0.90 . **Conclusions:** Our study indicates that injured players did 1.5 times more work in the past week due to the previous 4 weeks. Thus, the players that went on to sustain an injury were not prepared for the workload endured. These results were similar to previous studies investigating ACWR where large change in workload were associated with increased injury risk.

The Acute:Chronic Internal Workload Ratio in Relation to Joint Pain in Adolescent Tennis Players

Aguilar KV, Mexicano G, Donaldson MJ, Aranda M, Knudson DV, Farnsworth JL, Myers NL: Texas State University, San Marcos, TX

Context: Tennis athletes are often exposed to rigorous training and competition schedules which may lead to increased joint pain if not managed appropriately. One method of managing training workload is to implement the acute to chronic workload ratio using internal workload metrics such as rate of perceived exertion (RPE). Previous research has determined that high chronic workloads relative to small spikes in acute workloads protect against injury. No studies, however, have attempted to investigate training workload and its relationship to joint pain. Therefore, the purpose of this study is to determine if high chronic workloads with limited spikes in acute workloads decrease self-perceived joint pain in adolescent tennis players. **Methods:** Thirty-two junior elite tennis players (15 ± 2 years; male=21) were followed for 23 consecutive weeks. Rate of perceived exertion workload data were collected every day after training/match sessions. Players were instructed to provide a subjective rating of RPE (range:0-10) as an estimate of training intensity. Session RPE (sRPE), a measure of internal workload was calculated by multiplying the training/match session RPE by the session duration in minutes. Players self-reported joint pain using AthleteMonitoring Software. Joint pain was recorded (range 0-4; where 4 indicates worst pain possible) based upon responses to the question “Was joint pain felt in any part of your body as a result of playing tennis today?” Session RPE data were organized into acute and chronic workloads in order to calculate the acute to chronic workload ratio (ACWR) which was the primary independent variable. Acute workload was determined as the total sRPE for one week, while a

4-week rolling average sRPE represented chronic workload. Joint pain was the dependent measure and expressed as a percentage of the total reported pain for that week. A multiple linear regression model was used to determine if ACWR from the previous week was a significant predictor of joint pain when controlling for the covariates age, sex, previous injury history, and years of experience. The SPSS complex sampling procedures was used to control for violations of independent observations that are unavoidable with longitudinal injury data. **Results:** The average ACWR for participants was 1.12 ± 0.66 . The average pain score for participants was 22% (95%CI 0.15-0.28). Linear regression analysis indicated that the ACWR from the previous week was associated with joint pain score the following week (Wald $F_{1,30} = 4.67$; $R^2 = 0.10$; $p = 0.04$). **Conclusions:** This study was the first to associate joint pain with the ACWR in tennis players. While results are significant the correlation is weak as 10% of the variation in joint pain scores are explained by the preceding week's ACWR. In this sample, the percentage of reported pain is relatively low and lacked variability which could be one reason why the model generated weak correlations.

Free Communications, Rapid Fire Oral Presentations: Nutrition-Related Screening

Thursday, June 27, 2019, 3:15PM-4:15PM, Mandalay Bay A; Moderator: Toni Torres-McGehee, PhD, ATC

Disordered Eating Risk and Body Image Dissatisfaction in Physically Active College-Aged Students

Bradley C, Torres-McGehee T, Smith A, Weber S, Dayton R: University of South Carolina, Columbia, SC

Context: The prevalence disordered eating (DE) behaviors and body image (BI) dissatisfaction are not confined to one specific population. Physically active college-aged students may be at an increased risk for developing DE behaviors or BI dissatisfaction. The purpose of this study was to examine DE risk and BI dissatisfaction among physically active college-aged students.

Methods: A cross-sectional study was conducted at a large southeastern public university. A total of 123 participants (males: $n=45$, ages: 21.2 ± 2.0 years, weight: 80.8 ± 13.0 kg, height: 179.3 ± 5.8 cm; females: $n=78$, ages: 20.2 ± 1.6 years, weight: 66.8 ± 13.7 kg, height: 165.5 ± 7.5 cm) completed an online survey. As part of a larger study, independent variable was gender and dependent variables were DE risk and BI dissatisfaction (perceived [PBI] and desired body image [DBI] in daily clothing and perceptions by others [peers, parents]). Participants completed a demographic section (e.g., height, weight, etc.) To screen for DE risk behaviors the Eating Attitudes Test-26 was used and BI dissatisfaction was assessed using sex-specific silhouettes (Likert scale). Basic descriptive statistics to examine demographic variables; and cross-tabulations and chi square analysis examined the distribution between DE risk and gender. Repeated measures ANOVA examined differences between gender and PBI and DBI in daily clothing and perceptions by others. **Results:** No significant differences were found across gender and DE risk; however, the overall prevalence for DE was 29.3% ($n=36$) for both males and females.

Within females and males respectively. 34.6% ($n=27/78$) and 20.2% ($n=9/45$) were at risk for DE. A perception by gender interaction ($F_{1,112} = 2842.4$; $P \leq 0.001$; $\eta^2 = .96$) was found for BI perception of students in daily clothing across gender (males vs. females) and perception. Females presented the largest discrepancy between PBI and DBI in daily clothing compared to males (PBI: 4.0 ± 1.1 , DBI: 3.0 ± 0.7 vs. PBI: 3.8 ± 0.9 , DBI: 3.8 ± 0.8). A perception by gender interaction ($F_{1,112} = 2400$; $P \leq 0.001$; $\eta^2 = .96$) for BI perception by friends across females and males (PBI: 3.8 ± 1.1 , DBI: 3.3 ± 0.6 vs. PBI: 3.7 ± 1.1 , DBI: 3.8 ± 0.7) and for parents across females and males ($F_{1,112} = 2363$; $P \leq 0.001$; $\eta^2 = .96$; PBI: 3.9 ± 1.1 , DBI: 3.4 ± 0.7 vs. PBI: 3.7 ± 1.1 , DBI: 3.8 ± 0.7). **Conclusions:** Almost a third of the college-aged students presented with risk for DE with males only representing a small portion of the total. Overall, DE risk was slightly higher than previously reported in collegiate populations. Body image dissatisfaction was present in both genders, but pressures from parents and friends were felt in opposite directions for males and females. Similar levels of body image dissatisfaction have been reported in previous studies conducted on collegiate students and student-athletes. Lifestyle stressors of college-aged students may contribute to their risk for DE and BI dissatisfaction.

Disordered Eating Behaviors and Body Image Factors Influencing Body Mass Index in Male High School Athletes

Tracey S, Garrett Z, Konz SM: Marshall University, Huntington, WV

Context: Disordered eating behaviors and how body image can influence body mass index is not frequently studied among the male population, especially not in the male high school athletic population. The purpose of this study was to assess how disordered eating and body image factors influence body mass index in male high school athletes. **Methods:** A cross-sectional study utilizing a convenient sample pool at a single sports medicine facility that provided free pre-participation physical exams. A participant pool of 408 was solicited to fill out a questionnaire; 43 males (15.42 ± 1.332 YO) agreed to participate. A modified survey of the Eating Disorder Examination Questionnaire was used. BMI for adolescents was calculated based upon height and weight measures. A Kruskal-Wallis ANOVA was used for analysis. The $p < .05$ significance level. **Results:** BMI distribution was as followed healthy weight ($n=25$), overweight ($n=7$), obese ($n=11$). A Kruskal-Wallis analysis indicated a statistical difference in BMI in athletes who deliberately limit food intake to influence their sport, $p=.009$, with 9 athletes (20.9%) reporting that they limit food intake every day. A Kruskal-Wallis analysis indicated a statistical difference in BMI in athletes who excluded food from their diet to influence sport, $p=.009$ with 8 athletes (18.6%) and 6 (14.0%) excluding food from their diet. A Kruskal-Wallis analysis indicated a statistical difference in BMI in athletes who limited calories, $p=.002$, 5 athletes for 1-5 days (11.6%) and 5 athletes for 16-22 days (11.6%) limiting calories to influence their sport. A Kruskal-Wallis analysis indicated a

statistical difference in BMI in athletes who felt fat, $p=.014$, 7 athletes (16.3%) and 5 athletes (11.6%) reported feeling fat in their sport. A Kruskal-Wallis analysis indicated a statistical difference in BMI in athletes who reported feeling a strong desire to lose weight, $p=.018$, 5 athletes (11.6%) for 1-5 days and 5 athletes (11.6%) for 23-27 days who felt a strong desire to lose weight for their sport. **Conclusions:** High school male athletes, in general, are an understudied population when it comes to disordered eating behaviors. Football is not considered a body-conscious sport; however 67.4% ($n=29$) of the participants played football in contrast to athletes (4.7%) who participated in cross country which is considered a body-conscious sport. Further research needs to be conducted, and better education on healthy eating behaviors needs to be directed toward high school male athletes.

Clinical Use of the EAT-26: Prevalence of Eating Disorder Risk in Male and Female Collegiate Student-Athletes During Non-Anonymous Screening

Crills J, Keenan L, Ingram Y, Daltry R: West Chester University of Pennsylvania, West Chester, PA; Lock Haven University of Pennsylvania, Lock Haven, PA

Context: With the recent shift in sports medicine culture around addressing mental health in student-athletes, it is imperative athletic trainers appropriately screen student-athletes for eating disorders (ED). The Eating Attitudes Test (EAT-26) is an ED screening tool appropriate for both sexes, as it does not focus on female-specific factors. Additionally, in clinical application of ED screening, athletic trainers must ask student-athletes to identify themselves in order to provide follow-up referrals; despite this, all previous studies examining ED screening in this population have utilized anonymous screening, which may play a role in reporting behavior. Therefore, the purpose of this study was to examine prevalence of ED risk

in both male and female collegiate-student athletes using the EAT-26, during non-anonymous screening. **Methods:** All 943 collegiate student-athletes from two NCAA Division II universities were invited to participate in this study; 877 (93%) consented including 420 (47.89%) males and 457 (52.1%) females, across 24 sports, with a mean age of 19.7±1.4 years. Participants completed a demographics survey and the EAT-26, as part of their pre-participation examination (PPE). A score of 20 or higher on the EAT-26 was used to classify a “red flag” for ED risk, with possible scores ranging from 0-75. Student-athletes were asked to include their name; identifiers were then removed for data analysis. Internal consistency was measured with Cronbach’s alpha and descriptive statistics were used to examine mean scores and at-risk prevalence. Independent t-tests were used to examine differences in mean scores between sexes and lean (aesthetic/weight-focused) sports and non-lean sports. **Results:** The Cronbach’s alpha for internal consistency was 0.792. The prevalence of ED risk was 0.71% (n = 3) in males and 3.06% (n = 14) in females, with an overall prevalence of

1.94% (n = 17) and a mean score of 3.93± 5.29. At-risk athletes represented a range of both lean and non-lean sports (Table 1). Female athletes had significantly higher EAT-26 total scores (M=4.20±5.45) compared to male athletes (M=3.45±3.73), t(875)=-2.36, p=0.019, but no significant difference in EAT-26 mean scores was found between non-lean (M=3.91±4.85) and lean sports (M=3.69±4.42), t(875)=0.64, p=5.24. **Conclusions:** In contrast to previous research utilizing anonymous screening, the lean sport athletes in this study did not have a higher ED risk, and the prevalence among all athletes was inconsistent with other literature, with reports above 20%¹. As student-athletes in this study were asked to include their name for clinical purposes, it is possible they underreported negative attitudes on the EAT-26. Athletic trainers should consider the possibility of underreporting, as clinical screenings are administered utilizing non-anonymous protocols. Further research is needed to examine the potential of underreporting and consider a lower cut-off score on the EAT-26 for identifying athletes at-risk for ED.

Table 1: EAT-26 Mean Scores and Red-flags Across Lean and Non-Lean Sports

Sport	N (%)	EAT-26 Mean Score± SD	EAT-26 Red-flag, n (%)
Women's Gymnastics	21 (2.4)	3.62±3.50	0 (0)
Women's Swimming & Diving	37 (4.2)	6.41±7.80	3 (0.3)
Men's Swimming & Diving	22 (2.5)	3.73±4.73	0 (0)
Men's Wrestling	25 (2.9)	3.4±2.02	0 (0)
Women's Cross Country	31 (3.5)	2.87±2.66	0 (0)
Men's Cross Country	25 (2.9)	3.16±2.13	0 (0)
Women's Track & Field	38 (4.3)	2.39±1.87	0 (0)
Men's Track & Field	27 (3.1)	2.04±2.07	0 (0)
Women's Volleyball	34 (3.9)	4.09±5.36	2 (0.2)
Cheerleading	15 (1.7)	5.53±4.93	0 (0)
Total Lean Sports	275 (31.4)	3.69±4.42	5 (0.6)
Football	165 (18.8)	3.28±3.55	2 (0.2)
Baseball	61 (7.0)	3.87±2.96	0 (0)
Softball	43 (4.9)	4.51±4.47	1 (0.1)
Field Hockey	51 (5.8)	3.24±4.36	1 (0.1)
Women's Lacrosse	53 (6.0)	3.92±5.96	3 (0.3)
Men's Soccer	53 (6.0)	2.83±2.92	0 (0)
Women's Soccer	62 (7.1)	4.27±5.41	2 (0.2)
Women's Golf	7 (0.8)	6.0±5.90	0 (0)
Men's Golf	7 (0.8)	6.0±6.08	0 (0)
Women's Tennis	9 (1.0)	4.33±3.84	0 (0)
Men's Tennis	6 (0.7)	2.17±2.64	0 (0)
Men's Basketball	28 (3.2)	5.5±7.15	1 (0.1)
Women's Basketball	23 (2.6)	4.04±4.06	0 (0)
Women's Rugby	34 (3.9)	6.26±9.26	2 (0.2)
Total Non-Lean Sports	602 (68.6)	3.91±4.85	12 (1.4)

Comparing Blood Serum Values of Vitamin D and Calcium in Division I Female Athletes

Lyman KJ, Schmidt AL, Christensen B, Hackney K, Hanson TA: North Dakota State University, Fargo, ND; Butler University, Indianapolis, IN

Context: Vitamin D and calcium are critically important to the development and function of the skeletal system as well as other processes throughout the body. Blood serum levels of vitamin D and calcium are a major concern for athletes who participate in indoor sports and outdoor athletes who participate in the Midwest, as the amount of sun exposure is limited. The objective of this study was to compare blood serum levels of vitamin D and calcium to bone mineral density and previous fracture of Division I female athletes who participate in basketball and soccer. **Methods:** Controlled laboratory study at a research and hospital laboratory. The study included thirty female adults (19.53 ± 1.105 years); NCAA Division I Soccer ($n=21$) and Basketball ($n=9$). Inclusion criteria required current eligibility on a Division I Women's basketball or soccer team. Exclusion criterion included pregnancy due to exposure to the Dual-Energy X-ray absorptiometry (DXA) scanner. To obtain blood serum values of vitamin D and calcium, participants had their blood drawn by a phlebotomist from a local hospital. The range for sufficient calcium was 8.4-10.5 mg/dL; range for sufficient vitamin D was 27 to 90 ng/mL. Independent t-tests for differences in four dependent variables: calcium, vitamin D, and total bone mineral density (BMD) were conducted using SPSS version 24 (IBM, Armonk, NY). **Results:** The average calcium level for soccer players was $9.61 \pm .39$ mg/dL and basketball calcium average were 10.01 ± 0.33 mg/dL. The vitamin D average for soccer was 44.48 ± 12.09 ng/DL and for basketball 52.00 ± 17.44 ng/dL. The two groups differed at a statistically significant level with a large effect size in terms of calcium ($t[18.28]$

$= 2.9, p = .009, g = 0.97$). For vitamin D, there was a medium effect size but the difference was not statistically significant ($t[11.44] = 1.18, p = .263, g = 0.54$). Total bone mineral density measurements for the two groups did not differ at a statistically significant level, and the effect size was small ($t[11.9] = 0.74, p = .472, g = 0.36$). The results also indicated bone mineral density and previous stress fractures were not statistically significant ($p = .663, g = 0.65$). **Conclusions:** Surprisingly, the results indicated participants in an indoor sport (basketball) reported higher levels of calcium and vitamin D when compared to participants in an outdoor sport (soccer). The results contradict the current literature on vitamin D in indoor sports, especially considering the geographical location in which this study was conducted. However, the sample size was small; a broader sample should be considered in future research.

Serum Vitamin D Levels Are Less Associated With Bone Mineral Density In Athletes Living in the Southern United States

Parr JJ: University of Southern Mississippi

Context: Vitamin D deficiency and insufficiency are being recognized as a widespread concern among athletes, especially in those with excess adipose tissue, which may put them at greater risk for fractures. Athletes who practice outdoors and below the 37th parallel may be at a decreased risk for vitamin D insufficiency due to greater absorption of ultraviolet B rays that supports vitamin D synthesis in the skin. The primary objective was to examine the relationship between body mass (BMI), body composition (% body fat), vitamin D status (25-hydroxyvitamin D [25(OH)D]), and bone mineral density (BMD) in a group of healthy athletes living in the southern United States. **Methods:** Thirty-one NCAA Division I athletes (19 females, mean age = $20.7 + 1.1$ years) participating in outdoor sports (baseball, softball, track & field) located along the 31st parallel were recruited to participate in this controlled laboratory study. Participants had height, weight, serum 25(OH)D levels, and BMD measured. Serum 25(OH)D was measured by liquid chromatography/tandem mass spectrometry following intravenous blood draw. Bone mineral density and body composition were measured using a dual-energy X-ray absorptiometry (DXA; GE Lunar-Prodigy; software version 7.51.008). Only 19 of 31 athletes obtained DXA measurements due to scheduling conflicts. Data were analyzed using SPSS Software (version 24.0). Pearson correlation coefficients were used to assess relationships between variables. One-way ANOVAs were used to assess differences between genders. **Results:** Vitamin D levels were similar between males and females ($31.4 + 12.4$ ng/mL; $34.6 + 8.3$ ng/mL). BMD was examined as total BMD and was significantly different between males and females

($1.49 + 0.08 \text{ g/cm}^2$; $1.32 + 0.13 \text{ g/cm}^2$; $p = 0.009$). BMI was not significantly different between genders, however, body composition was significantly different between males and females ($18.8 + 7.3 \text{ kg/m}^2$; $29.7 + 7.9 \text{ kg/m}^2$; $p = 0.01$). BMI had a significant positive correlation with BMD ($R = 0.685$; $p = 0.001$). Vitamin D levels had a significant negative correlation with BMD ($R = -0.538$; $p = 0.017$). There was no significant correlation between vitamin D levels and body composition ($p = 0.31$).

Conclusions: This study demonstrates an inverse correlation between vitamin D levels and BMD, but a direct correlation between BMI and BMD. Total BMD appears to be less associated with circulating vitamin D levels and more associated with stress placed upon the bones. This may be due to vitamin D actually reaching the bone and causing positive adaptations when placed under stress. While 39% of the participants in this study were defined as having sub-optimal vitamin D, it seems that does not significantly affect the bone mineral density content. However, vitamin D levels do have other negative health implications, so it may still need to be corrected and monitored.

Free Communications, Oral Presentations: Soft Tissue Mobilization and Myofascial Release

Tuesday, June 25, 2019, 7:30AM-9:00AM, Mandalay Bay B; Moderator: Mark Merrick, PhD, ATC

Treatment Order and Retention of Myofascial Release and Static Stretching on Hip Flexion Range of Motion

Long BC, Truxton TT, Miller KC:
Central Michigan University, Mt.
Pleasant, MI

Context: Foam rolling (FR) and static stretching (SS) are popular in sports medicine. Currently it is unknown if the order an individual performs FR and SS influences flexibility or whether flexibility is retained. The objective was to determine if FR prior to or following SS influences passive hip flexion range of motion (ROM) and if changes are retained. **Methods:** We used a 5x7x16 repeated measures for this controlled laboratory study. Independent variables were treatment [FR then SS (FR/SS), SS then FR (SS/FR), SS only, FR only, and nothing], day (1, 2, 3, 4, 5, 6, 14, and 21), and time (pretreatment and post-treatment). Dependent variable was passive hip flexion ROM from pretreatment on day 1 to posttreatment on day 6, 14, and 21. A calculated power analysis was computed prior to data collection indicating we needed 32 subjects. To ensure power, 35 subjects (n=16 female and n=19 males; age: 21.27±0.29yrs, height: 174.48 ± 12.82cm, mass: 76.15±10.95kg) with less than 90° of passive hip flexion ROM volunteered. Over 8 days, 6 separated by 24 hours and 1 week (day 14) and 2 weeks (day 21), hip flexion ROM was measured. On the first 6 days, these ROM measures were taken prior to and following each treatment. Using a bubble inclinometer, pretreatment ROM measures were taken by passively flexing the hip to the point of stretch discomfort. Subjects assigned to receive FR were instructed actively move a FR against their hamstring muscles 3 times for 1-minute with a 30-second rest period between each. Subjects receiving SS laid supine where 3 consecutive passive stretches were

performed. For each stretch, the subject's leg was moved to the point of discomfort and held for 1 minute with a 30 second rest between each. For those receiving FR/SS and SS/FR the same FR and SS protocols were used. Those assigned to receive nothing remained supine on the table. On days 14 and 21 subjects reported back to the laboratory for posttreatment ROM measures.

Results: A significant interaction between treatment and day ($F_{12,90}=4.60$, $P=.001$) and a significant difference in time ($F_{1,30}=18.31$, $P=.001$) occurred. There was no difference between pretreatment measures ($P>.05$). From day 6, ROM for the FR ($82.68\pm 15.90^\circ$) and SS/FR ($88.82\pm 6.10^\circ$) was retained to day 14 (FR: $79.06\pm 15.93^\circ$ and SS/FR: $82.46\pm 6.85^\circ$; $P<.05$) but not day 21 (FR: $76.67\pm 13.84^\circ$ and SS/FR: 79.02 ± 5.99 ; $P>.05$). On day 6, SS/FR produced greater ROM ($88.82\pm 6.10^\circ$) than FR ($82.68\pm 15.90^\circ$; $P<.05$). ROM with FR/SS and SS was not retained at day 14 or 21 ($P>.05$). No change in ROM occurred for those receiving nothing ($P<.05$). **Conclusions:** Clinically, when performing FR and SS on those who have limited ROM, the greatest gains and retention occur when SS is performed prior to FR.

Assessing the Effectiveness of Soft Tissue Mobilization on Pain, Point Tenderness, and ROM in Physically Active Individuals With Muscle Soreness

Harrison K, Carver M, McDevitt J:
East Stroudsburg University, East
Stroudsburg, PA; Temple University,
Philadelphia, PA

Context: Instrument assisted soft tissue mobilization (IASTM) and massage are interventions commonly used to address muscle soreness; however, the efficacies of these interventions have not been well established. **Objective:** The purpose of this study was to compare the immediate effects of IASTM, massage (MAS), or sham treatment (SHAM) on pain perception, range of motion, and point tenderness in an active population reporting muscle soreness. **Methods:** Double-blinded repeated measures design, where the intervention group allocation was randomized. **Setting:** University Athletic Training Center. **Patients or Other Participants:** Forty-four participants (14 males and 30 females; $21.0 + 2.26$) reporting localized point tenderness greater than a 5/10 on a numeric pain scale and ROM discomfort in either biceps brachii (n=18) or gastrocnemius (n=26) were included in the study. **Interventions:** Participants were randomly allocated to one of the 3 treatment groups IASTM (n=15), MAS (n=15), or SHAM (n=14). Participants and the assessor were blinded to the intervention. The most symptomatic limb was treated (Tx) and the contralateral limb was used as the control (NoTx). The IASTM was performed using the Técnica Gavilán Ala and Pico instruments as the subjects performed active ranging. The MAS treatment consisted of effleurage, petrissage, and compressive lengthening strokes. The SHAM treatment consisted of the application of light manual skin contact to the area of reported discomfort. All treatment interventions lasted 10

minutes. The authors measured pain levels via an electronic visual analog scale (EVAS), active elbow extension or ankle dorsiflexion (ROM), and pain pressure threshold (PPT) at baseline and immediately following treatment. **Main Outcome Measures:** Change scores were calculated for dependent variables (EVAS, ROM, and PPT). A one-way ANOVA was used to analyze between group differences. Differences in change scores between TxLimb and NoTxLimb were analyzed using a paired t-test. **Results:** Change scores (Posttest-pretest) were used to analyze differences between the treatment groups (IASTM, MAS, SHAM). A one-way ANOVA found no significant differences between groups for mean change scores for EVAS, ($F=.827$, $P=.444$), ROM ($F=1.00$, $P=.376$), PPT ($F=.247$, $P=.782$). The paired-samples t-test demonstrated significantly greater improvement in EVAS for the TxLimb ($M= -12.73$, $SD = 11.58$), than the ConLimb ($M =-3.32$, $SD = 6.44$), $t(43) = -5.68$, $p<.001$, $d =-1.53$. The TxLimb ROM changes scores demonstrated significant improvement ($M = 5.92$, $SD = 10.54$) compared to the ConLimb ($M = 2.43$, $SD = 6.54$), $t(43) = 2.39$, $p =.021$, $d =.73$. The PPT change scores were significantly higher for the TxLimb ($M= .476$ lbf, $SD = 1.43$) compared to the ConLimb ($M= -.396$ lbf, $SD = 1.34$), $t(43) = 3.43$, $p =.001$, $d =1.04$. **Conclusions:** IASTM, MAS, and SHAM treatments all yielded significant improvements in EVAS, ROM, and PPT in the Tx limb compared to the NoTx limb. No treatment (IASTM, MAS, or SHAM) was found to be superior in reducing symptoms of general muscle soreness. There is an inherent placebo effect that occurs with most soft tissue treatment. These data support the need for researchers to include methods to mediate potential placebo responses, such as the use of a sham group, in the research design when evaluating treatment efficacies.

Acute Effects of Instrument Assisted Soft Tissue Mobilization, Foam Rolling, and Static Stretching on Hamstring and Quadriceps Flexibility

Boucher T, Greenwood L, McConnell L, Mullinnix J: Texas A&M University, College Station, TX; University of Kansas, Lawrence, KS; James Earl Rudder High School, Bryan, TX

Context: Numerous techniques are used to improve soft tissue and joint mobility including instrument-assisted fascial abrasion technique (FAT), foam rolling (FR), and static stretching (SS). FAT, FR, and SS exhibit encouraging clinical applications but there is varying evidence on outcomes and comparisons. This study's objective examined the acute effects of FAT, FR, and SS on hamstrings and quadriceps flexibility.

Methods: The study was a randomized 3 (intervention group) x 3 (time points) x 5 (dependent variables) single-blinded crossover design in a university laboratory setting. Twenty healthy, recreationally active male and female (age 21.85 ± 2.21 years; height 172.60 ± 10.31 centimeters; weight 72.09 ± 16.68 kilograms) presented with limitations in hamstrings flexibility determined by lacking 20° of knee extension in the $90^\circ/90^\circ$ position. Subjects performed a five-minute bike warm up and were then assessed for active $90^\circ/90^\circ$ position hamstrings flexibility, hip flexion, knee flexion, knee extension, and hip extension ROM by goniometry. Subjects randomly received FAT, FR, or SS interventions on three separate test sessions. FAT intervention comprised of application to the hamstrings and the quadriceps for 2 minutes each. FR comprised of 2 sets of a 1 minute intervention with a 30 second rest to both hamstrings and quadriceps. SS comprised of 4 sets of 30 seconds of intervention with a 10 second rest to both hamstrings and quadriceps. The same variables were assessed using the exact procedure and order post intervention application. A two-way repeated measures

analysis of variance, with Greenhouse-Geisser correction and p set a priori at <0.05 , was used to analyze within-subject effects. If significance was found, a t-test was used to determine the difference between each intervention.

Results: Statistically significant differences were found between mean pre ($57.29^\circ \pm 9.22^\circ$) to post ($62.71^\circ \pm 9.0^\circ$) $90^\circ/90^\circ$ hamstring flexibility ($P < 0.001$, power = 0.975) for all three interventions. Statistically significant differences were also found between mean pre ($19.54^\circ \pm 5.83^\circ$) to post ($22.57^\circ \pm 5.48^\circ$) hip extension AROM ($P < 0.001$, power = 0.96) for all three interventions. Significant differences were found between mean pre ($58.10^\circ \pm 9.01^\circ$) and post ($66.25^\circ \pm 9.02^\circ$) FAT compared with both pre ($56.92^\circ \pm 11.31^\circ$) to post ($61.17^\circ \pm 9.99^\circ$) FR ($P < 0.001$) and pre ($56.87^\circ \pm 7.33^\circ$) to post ($60.70^\circ \pm 7.98^\circ$) SS ($P = 0.002$) for $90^\circ/90^\circ$ hamstring flexibility. Significant differences were found between mean pre ($19.77^\circ \pm 5.53^\circ$) and post ($24.30^\circ \pm 4.83^\circ$) FAT compared with both pre ($19.25^\circ \pm 5.86^\circ$) to post ($21.33^\circ \pm 5.98^\circ$) FR ($P = 0.002$) and pre ($19.60^\circ \pm 6.09^\circ$) to post ($22.07^\circ \pm 5.64^\circ$) SS ($P = 0.003$) for hip extension AROM. No significant differences were found between FR and SS interventions.

Conclusions: Results indicate a 2-minute FAT application to the quadriceps and hamstrings is an effective method for improving hamstrings flexibility and hip extension motion compared to FR and SS techniques in healthy individuals. Findings show no flexibility differences between the FR and SS applications.

Does a Light Pressure Instrument Assisted Soft Tissue Mobilization Technique Modulate Tactile Discrimination and Pressure Pain Threshold in Healthy Individuals With Delayed Onset of Muscle Soreness?

Cheatham SW, Kreiswirth E, Baker R: California State University Dominguez Hills, Carson, CA; Rocky Mountain University of Health Professions, Provo, UT; University of Idaho, Moscow, ID

Context: Instrument assisted soft-tissue mobilization (IASTM) has become a popular myofascial intervention utilized by allied health professionals. Of interest, are the therapeutic effects of IASTM as a posttreatment intervention after strenuous exercise. The purpose of the investigation was to measure the effects of a light pressure IASTM technique on two-point discrimination (TPD) and pressure pain threshold (PPT) in healthy individuals with delayed onset of muscle soreness (DOMS). **Methods:** This pretest, posttest clinical trial was conducted at the university kinesiology laboratory. Twenty-three healthy, recreationally active subjects (M=14, F=9; mean age= 24.22 ± 3.07 years; height= 172.08 ± 8.53 cm; body mass=80.43 ± 16.18 kg) underwent three different testing sessions: baseline measures and exercise, 24-hours (post) treatment and measures, and 48-hours (post) treatment and measures. At baseline, subjects underwent testing followed by a DOMS exercise protocol which included a five-minute treadmill warm-up followed by 100 drop jumps (5 sets of 20 repetitions) from a 0.5 m box. The follow-up visits at 24-hours and 48-hours included IASTM treatment and measures. The outcome measures were PPT to the dominant quadriceps measured with an algometer and TPD measured with a caliper on a pre-determined marked area. The primary investigator took measurements at all time points. A second investigator administered the IASTM intervention using

the following parameters: 90 second light pressure “feather stroke” using the tool weight (208 grams) in line with the rectus femoris fibers using a rate of 120 BPM with the instrument angled at 30°. The investigator used a metronome to ensure a consistent rate and calibrated the instrument angle with a digital goniometer prior to each subject’s treatment. Statistical analysis included the ANOVA for group comparisons at all time points. Post hoc testing was calculated using the Bonferroni statistic and effect size (ES) was calculated. Statistical significance was considered $p < .05$ using a conservative two-tailed test. **Results:** For TPD, there was a significant difference between all time points [F (1, 21) =30.50, $p < .001$, partial $\eta^2 = .744$]. Post-hoc testing revealed a significant difference from baseline to 24-hours post ($p < .001$, ES=1.12) and baseline to 48-hours post ($p < .001$, ES=1.10). There was no significant difference between 24 to 48 hours post ($p = 1.00$, ES=.10). For PPT, there was a significant difference between all time points [F (1, 21) =9.56, $p < .001$, partial $\eta^2 = .477$]. Post-hoc testing revealed a significant difference from baseline to 24- hours post ($p = .005$, ES=.33) and baseline to 48-hours post ($p = .004$, ES=.30). There was no significant difference between 24 to 48 hours post ($p = 1.00$, ES=.03). **Conclusions:** The results suggest that a light IASTM technique may produce a neuromodulation effect on local tactile discrimination and pain perception in individuals with delayed onset of muscle soreness.

The Acute and Residual Effects of IASTM and Roller Massage Stick on Hamstring Active Range of Motion

Lee J, Young A, Erb N, Herzog V: Weber State University, Ogden, UT

Context: Trauma can cause the fascia surrounding muscles to develop adhesions and reduce range of motion and cause pain. Different techniques have been studied and used to release these adhesions and restore normal ROM, but none have compared the (typically) more expensive instrument-assisted soft tissue mobilization (IASTM) with a less expensive roller massage stick, The Stick. Therefore, the objective of this study was to compare the acute and residual effects of IASTM and The Stick on active hamstring ROM after a single treatment. We hypothesized that IASTM would increase AROM more at both time points. **Methods:** This was a prospective cohort study and was performed in a university laboratory. Sixteen (8M, 8F) recreationally-active college-aged participants (age=23.38±2.446yrs, ht=171.38±9.135 cm, mass=70.94±11.108 kg) with a deficit in hamstring flexibility, but with no injuries or surgeries within the past six months. All participants participated in moderate to vigorous intensity exercise for at least 20-60 minutes, at least 3-5 times per week. The independent variables were IASTM using stainless-steel instruments and The Stick. Participants completed a five-minute warm-up on a stationary bike prior to each treatment. They were then randomly assigned to either IASTM or The Stick treatment on the hamstring of their dominant leg with the other intervention treated to the hamstring of their non-dominant leg. Active range of motion of knee extension in 90° of hip flexion was measured pre-treatment, immediately post-treatment, and 48hrs-post-treatment using an Acumar digital inclinometer. Both treatments were 3½ minutes, performed by an athletic training student with M1-level training in Graston Technique and with training on the use of The Stick.

Participants were then instructed to conduct their week as normal, including workouts, and intensity of workouts. Participants returned after 48 hours for final ROM measurements. Active range of motion of knee extension in 90° of hip flexion was measured as the dependent variable. Data were analyzed using a two-way repeated-measures ANOVA ($p < .05$). **Results:** There was no interaction effect between treatment and time ($F(2,14) = .728$, $p = .491$, $n2 = .046$, observed power = .162). There was a main effect for time ($F(2,14) = 10.553$, $p < .000$, $n2 = .413$, observed power = .981) showing a significant increase in AROM from pre-treatment to immediate post-treatment ($5.844 \pm 1.433^\circ$, $p = .003$) and from pre-treatment to 48hr post-treatment ($6.50 \pm 1.868^\circ$, $p = .01$). IASTM produced an acute increase in AROM of the hamstring (pre = $41.5 \pm 14.556^\circ$, post = $48.38 \pm 12.743^\circ$) and sustained the increase 48 hours later (48post = $48.69 \pm 8.428^\circ$). The Stick also resulted in an acute increase in AROM (pre = $44.0 \pm 13.332^\circ$, post = $48.81 \pm 11.374^\circ$) and sustained 48 hours later (48 post = $49.81 \pm 9.772^\circ$). **Conclusions:** Participants had increased AROM regardless of the treatment type and it was sustained 48 hours post-treatment. IASTM and The Stick were equally effective, but The Stick is more affordable.

Effects of Dynamic Warm-up Paired with IASTM Technique on Quadriceps ROM and Vertical Jump Performance

Popp ML, Wilburg CT, Wright CJ:
Whitworth University, Spokane, WA

Context: It is important to find the optimal technique to increase readiness and performance in athletes. One way that has been shown to increase range of motion (ROM) is instrument assisted soft tissue mobilization (IASTM), however it is unknown whether pairing a dynamic warm-up with IASTM could both increase ROM and improve muscular performance. The purpose of this study is to compare the effects of dynamic warm-up and an IASTM treatment versus dynamic warm-up alone on quadriceps ROM and muscle performance in a countermovement vertical jump (CMJ). **Methods:** Repeated measures; cross sectional study in a Human Performance Lab. A convenience sample of 30 healthy, physically active college students (19 women, 11 men) participated in this study (age= 20.23 ± 0.73 years, height = 170.52 ± 8.08 cm, weight= 69.25 ± 11.86 kg). In a single session, participants completed three baseline ROM measurements on the right leg using an inclinometer (Baseline® Digital; accuracy of $\pm 0.5^\circ$) and three baseline CMJs for jump height (JH) using a jump plate (Just Jump, Probotics, Inc.), followed by a 7-minute dynamic warm-up. Then, the participants completed either 10 minutes of supine rest or IASTM treatment (using a G-4 Graston® tool). Post-intervention, ROM and JH were reassessed. Participants performed the opposite intervention on their second visit. Subjects were asked before and after each visit how prepared for exercise they felt on a scale of 0-10. The dependent variables were right quadriceps ROM (degrees), JH (inches), and a patient readiness scale. Each pre- and post-intervention was measured 3 times, and the average of 3 measurements was used for analysis. Dependent variables were compared using separate

2 (conditions) by 2 (time) repeated measures ANOVAs. Alpha was set a priori at $p = 0.05$. **Results:** There was no significant interaction between intervention and time for JH or readiness scale (all $P > 0.05$) however there was a significant interaction for ROM ($F(1,29) = 22.718$, $P < 0.001$). Post hoc testing revealed that for both interventions ROM increased from pre- to post-intervention, however, the IASTM intervention increased at a greater rate (ROM: $t = 11.006$, $df = 29$, $p < 0.001$, mean increase = 5.1°) than the control (ROM: $t = 3.226$, $df = 29$, $P = 0.003$, mean increase = 1.8°). There was a significant main effect for intervention between IASTM and control for JH ($F(1,29) = 6.063$, $p = 0.02$) and readiness scale ($F(1,29) = 4.307$, $p = 0.047$). Tukey's post hoc revealed that IASTM increased JH (mean difference: 0.55 inches), and readiness compared to the control (mean difference: 0.50). Readiness also improved over time regardless of intervention type ($F(1,29) = 91.612$, $p < 0.001$, mean difference = 2.23). **Conclusions:** The use of an IASTM treatment paired with a dynamic warm-up is advised to prepare patients for rehabilitation and activity. The combination can not only increase ROM, but also muscular performance.

Free Communications, Oral Presentations: Effective Treatment and Rehab Approaches for Upper Extremity Conditions

Tuesday, June 25, 2019, 9:15AM-10:45AM, Mandalay Bay B; Moderator: Nicole Cascia, MAT, ATC, CES

Nonsurgical Management of UCL Injuries is Tentatively Successful in Overhead Athletes: A Critical Appraisal of Case Series

Oakes N, Medina McKeon JM:
Ithaca College, Ithaca, NY

Context: Since the inception of the “Tommy John”, surgical management of the ulnar collateral ligament(UCL) is fairly standard; however, the invasive, costly, time-and intensive nature of UCL surgery may be restrictive to some athletes. **Methods:** Electronic databases(PubMed and EbscoHost) were searched through September 2018. Search terms included iterations of “ulnar collateral ligament”, “elbow”, injury”, “nonsurgical” and “nonoperative”. A hand search was performed. Studies were limited to peer-reviewed articles, published in English after 2012. Selection criteria required that studies 1) included athletes; 2) investigated nonsurgical management of UCL injuries; 3) assessed outcomes associated with return-to-participation. Extracted data included frequencies of 1) return-to-play(RTP); 2) return-to-same level of play(RTSP); 3) athlete’s position; 4) complete reconstitution of the UCL; 5) the location of ligament rupture (proximal or distal).“RTP” was defined as any return to sporting activity. “RTSP” was the ability to return to the same level of play prior to injury. “Complete reconstitution” was defined as the lack of identifiable gaps in the UCL as visualized by MRI. Proportions of success/failure for selected outcomes were calculated. Additionally, odds ratios(OR) [95% CI] were used to determine the association between tear location(proximal v. distal) and nonsurgical success. A 10-question critical appraisal tool, the JBI Critical Appraisal Checklist for Case Series(JBI), was used to evaluate evidence quality. **Results:** Seven studies met eligibility criteria. All were case-series. A total of 169 athletes underwent nonsurgical management of

UCL injury in the 7 included studies. Sports included baseball, gymnastics, softball, hockey, volleyball, and tennis. A majority [n=71] were classified as “elite”. Overall, 83% (n=140) and 72% (n=121) were able to RTP or RTSP, respectively. For a proximal UCL tear, 82% (n=56) were able to RTSP, compared to 42% (n=13) for a distal UCL tear. For pitchers, 76% (n=38) were able to RTSP compared to 90% (n=9) of position players. For reconstitution of the UCL, 96% (n=23) were complete. For the effect of tear location, proximal tears were 650% (OR=6.5[2.5, 16.7], p<0.001) more associated with a successful outcome(RTSP or RTP). Included studies ranged from 5-10 on the JBI; 3 studies received a 10. “Failure to clearly describe clinic” was missed in 4 studies. “Consecutive patient inclusion” and “complete patient inclusion” in 2 studies. **Conclusions:** Based on the pooled outcomes of included studies, nonsurgical management of a UCL injury was reasonably successful RTP and RTSP rates in elite athletes, with better chance of success for proximal tears compared to distal. Although there was good success across outcomes, only case series studies were identified for inclusion. The exploratory nature of utilizing nonsurgical management for UCL sprains in athletes, by way of the case series, appears to be fairly well established. An upgrade in study design, perhaps to level of clinical trials, is warranted.

Use of a Motus Sleeve During the Care of a Medial Elbow Injury in the High School Baseball Athlete: Level 3 Case Report

Brodersen JM, Carlson MH, Govrik GL, Chmielewski TL: TRIA Orthopaedic Center, Bloomington, MN

Background: Incidence of medial elbow injuries among youth pitchers is increasing. Throwing mechanics including lower arm slot, faster arm speed, and higher maximal shoulder external rotation are associated with greater elbow varus torque and may contribute to medial elbow injury. Wearable technology allows objective measurement of throwing mechanics. No studies have reported on this technology in the injured high school athlete. **Patients or Other Participants:** The athlete is an 18 year old right-handed baseball pitcher. He presented to the Athletic Trainer after 3 weeks of competition and 4-days post pitching with medial elbow pain. Evaluation revealed tenderness at the medial epicondyle and flexor pronator mass, full active elbow ROM, 4+/5 forearm flexor strength, and no visible edema. Valgus stress test was negative while valgus extension overload and moving valgus stress tests were positive for pain. Referral to a physician confirmed a flexor-pronator mass strain by physical exam. Physical therapy followed including 2 visits consisting of dry needling to forearm flexors, and shoulder and elbow strengthening.

Treatment was also provided in the athletic training room consisting of performing the strengthening program and instrument assisted soft tissue mobilization. The medical team and athlete agreed that he would discontinue pitching but would continue playing in the field. Following 1 week of rest from throwing the athlete began infield play with some discomfort. He returned to pitching in a limited capacity after 3 weeks of treatment. **Intervention(s):** Prior to the season, the athlete completed a Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow questionnaire (KJOC) and was issued a motusBaseball system, a validated inertial measurement unit containing a triaxial accelerometer and gyroscope, held within a compression sleeve. He was instructed in proper sensor positioning on the arm (5cm distal to the medial epicondyle of the humerus). The sensor was to be worn during warm-up, long toss, bullpen, and live game activity. Variables collected for each throw included arm slot, maximal shoulder external rotation, arm speed, and elbow varus torque. Data was stored in the sensor until upload to an application via Bluetooth. The athlete was asked to upload data weekly. The sensor was worn for 9 weeks, from the first week of competition to the end of the season. KJOC and informed consent were completed post-season. In addition to traditional management of medial elbow injury, throwing metrics were quantified by the athletic trainer, providing additional insight to injury development. **Outcomes or Other**

Comparisons: High effort throws (52 to 67 N-m) were retrospectively analyzed. Sensor variables were averaged weekly, except during the week of rest (Table 1). The athlete showed variability in arm slot, the largest difference being a 22.8 degree decrease from week 1 to 2, one week before injury. Maximal shoulder external rotation increased 13.5 degrees over the 9 week period. Elbow varus torque was highest upon return to pitching (Week 7). Subsequently both arm speed and elbow varus torque decreased in the final 2 weeks of the season. KJOC score decreased from 69 at pre-season, to 60 at post season. **Conclusions:** Variability in throwing mechanics was evident, with demonstrated risk factors for medial elbow injury both acutely (arm slot), and cumulatively (shoulder external rotation). Poorer throwing mechanics at the end of the season agrees with decrease in KJOC score from pre-to post-season. Workload (throw counts) may not be accurate due to noncompliance with recording and upload, preventing analysis of workload during injury development and return to throwing. **Clinical Bottom Line:** Quantified throwing metrics during the season provided insight into medial elbow injury development and return to throwing. Use of a Motus sleeve may augment preventative and post injury care provided to the high school athlete.

Table 1. Motus sleeve variables collected during the high school season

Sensor Variables	Week								
	1	2	3	4	5	6	7	8	9
Arm Slot (°)	58.1	35.3	40	***	40	47.8	41.5	39.8	36.5
Arm Speed (rpm)	919.1	1018.2	919.7	***	854.2	844.9	903.6	738.9	759.1
Maximal Shoulder External Rotation (°)	153.2	159.5	160.7	***	162.9	165.3	161.2	161.9	166.7
Elbow Varus Torque (N-m)	45	44.3	38.9	***	40.2	42.0	54.5	26.7	31.9
High Effort Throw Count (n)	41	42	8	***	62	9	45	56	53
Total Throw Count (n)	112	251	207	***	378	34	154	108	207

Instrument Assisted Soft Tissue Mobilization to Improve Shoulder Joint Rotation Range of Motion

Mitchell R, Bradney DA, Bowman TG, Wesley C: University of Lynchburg, Lynchburg, VA

Context: Range of motion (ROM) deficits are common in the physically active following injury. A common goal of rehabilitation plans is to restore normal joint motion. Instrument-assisted soft tissue mobilization (IASTM) techniques have been reported to improve ROM in the lower extremities. However, there is limited evidence studying the effects of IASTM in the upper extremities. Therefore, the purpose of this study was to measure the effects of IASTM applied in two different degrees of shoulder abduction on shoulder internal rotation and external rotation ROM. **Methods:** Thirteen healthy participants (8 females, 5 males; age = 22.15 ± 2.38 years; height = 173.69 ± 9.74 cm; mass = 82.06 ± 18.62 kg) volunteered for our study. The independent variables were session (IASTM with 45 degrees of shoulder abduction, IASTM with 90 degrees of shoulder abduction, and control) and time (pre-intervention and post-intervention). Shoulder internal and external rotation ROM measurements served as dependent variables. Participants warmed up on an upper extremity ergometer for 5 minutes, then we measured participant's internal and external ROM three times with a goniometer and calculated the average. IASTM was applied to the anterior shoulder with the participant supine and posterior aspect of the shoulder with the participant prone for 5 minutes with the shoulder placed in 45 degrees of abduction and 90 degrees of abduction on 2 separate days. ROM measurements were repeated exactly the same following the intervention. Participants also completed a third session (control) where they sat for 10 minutes between pre and post measurements. Participants completed all 3 sessions in a counterbalanced order over 3 separate days separated by

approximately 48 hours between sessions. **Results:** For internal rotation, the interaction between time and session was significant ($F_{2,11}=6.26$, $P=.02$, $\eta^2=.53$). Post hoc results revealed significant improvement in internal rotation range of motion from pre to post time points during IASTM at 45 degrees ($P<.001$, mean difference= 7.69 degrees, $CI_{95}=5.24-10.14$ degrees) and IASTM at 90 degrees ($P<.01$, mean difference= 9.23 degrees, $CI_{95}=4.06-14.40$ degrees), but not during the control session ($P=.73$, mean difference= $.49$ degrees, $CI_{95}=-2.52-3.50$ degrees). The interaction between time and session was not significant ($F_{2,11}=3.17$, $P=.08$, $\eta^2=.37$, $1-\beta=.49$) for external rotation. **Conclusions:** Application of IASTM in 45 and 90 degrees of shoulder abduction was shown to be statistically significant and may lead to an improvement of shoulder internal rotation ROM. However, application of IASTM may not be the first modality of choice when looking to improve shoulder external rotation ROM.

Comparison of Instrument-Assisted Soft Tissue Mobilization and Passive Stretching to Improve Glenohumeral Range of Motion and Function

Mendenhall T, Harter RA, Myers NL, McCurdy K: Texas State University, San Marcos, TX

Context: Loss of glenohumeral internal rotation range of motion (ROM) is a common maladaptation that may predispose overhead sport athletes to injury. Instrument-assisted soft tissue mobilization (IASTM) has been suggested as an alternative to stretching exercises designed to restore normal ROM. The purpose of this study was to determine the extent to which a 4-week traditional stretching plus IASTM intervention improved glenohumeral ROM compared to a 4-week stretching program. A secondary purpose was to compare the effects these interventions had on 2 sport-specific patient reported outcome measures. **Methods:** Twenty intercollegiate baseball players participated in this study; 10 in the Stretching group (19.9 ± 1.4 yrs; 183.4 ± 7.4 cm; 87.1 ± 8.5 kg) and 10 in the Stretching + IASTM Group (20.9 ± 0.9 yrs; 180.8 ± 8.1 cm; 85.7 ± 7.2 kg). Participants in the Stretching group received a clinician-administered shoulder stretching program 5 days/week for 4 weeks. Participants assigned to the Stretching + IASTM group received an identical stretching program plus 2 IASTM treatments/week for 4 weeks. All participants completed the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow (KJOC) score and the Functional Arm Scale for Throwers (FAST) at the beginning and end of the study. Our main outcome measures were shoulder internal rotation and external rotation passive range of motion (PROM), glenohumeral total range of motion (TROM), and KJOC and FAST scores. We performed 5 Group (2) x Time (2) mixed-effects ANOVAs. **Results:** There were no significant Group x Time interactions for any of the outcome measures ($p > 0.05$). Stretching group mean internal rotation

PROM increased 6.3%, from 52.8° + 8.7° in Week 0 to 56.1° + 8.4° in Week 4 ($p = 0.005$), while Stretching + IASTM group internal rotation PROM improved 7.8%, from 52.6° + 7.2° in Week 0 to 56.7° + 4.5° in Week 4 ($p = 0.005$). Stretching group TROM improved 3.1%, from 145.2° + 17.0° to 149.7° + 18.4°, and 4.2% in the Stretching + IASTM group, from 143.0° + 8.4° to 149.0° + 10.6° between Week 0 and Week 4, respectively ($p = 0.005$). KJOC and FAST scores improved between Week 0 and Week 4 in both groups, and while these changes approached statistical significance (KJOC, $p = 0.097$; FAST, $p = 0.060$), they did not meet our criterion alpha (0.05). **Conclusions:** While both treatment protocols were effective in improving both disease-oriented and patient-oriented outcome measures over 4 weeks, the IASTM protocol we employed did not have a significant effect on glenohumeral internal rotation PROM or TROM. Future studies should compare the effects of multiple IASTM treatment frequencies and durations to more fully evaluate the capacity of IASTM to create long-term improvements in glenohumeral joint ROM and function.

Thoracic Outlet Syndrome in a College Volleyball Player

Roosta P, Felton SD: Florida International University, Miami, FL

Background: Thoracic outlet syndrome is a rare disorder that affects less than 200,000 people in the United States per year. This Level 4 Case study presented a 19-year-old (170cm, 61kg) NAIA college volleyball player with over 13 years of volleyball experience as a setter. The patient reported to the AT complaining of paresthesia and swelling in the hands, pain and tightness in the arm and neck, and states that symptoms would subside during times of rest and return during activity in sport. Upon examination post-practice, the patient demonstrated poor upper extremity posture, tenderness in upper extremity musculature, swelling and discoloration of the hands. The patient tested positive for a diminished radial pulse during the Adson's Test for TOS and was retested using an ultrasound doppler which confirmed a decreased pulse. The patient also displayed a weak pulse during the Allen Test for TOS but did not test positive during the Military Brace Test or Roos Test. When referred out for imaging, X-ray revealed a lack of cervical spine curvature but no displaced clavicle or rib. The patient described no previous history of any of these symptoms and stated that it did not start until her activity changed when she began to set long distances with a weighted volleyball. **Differential Diagnosis:** Nerve root impingement, Cervical spine stenosis, Carpal tunnel syndrome, Thoracic Outlet Syndrome **Treatment:** Patient was diagnosed with Vascular Thoracic Outlet Syndrome (VTOS) Patient began treatment immediately after the initial evaluation with the goals to correct posture, decrease pain and point tenderness and decrease paresthesia. The treatment plan for this athlete was comprised of Neurodynamics for the median and radial nerve, manual therapy which consisted of massage and instrument assisted soft tissue mobilization of the musculature of the arm and shoulder, stretching of the

neck and shoulder, corrective exercises to strengthen the posterior aspect of her shoulder to help with postural correction, and thermal modalities. In this particular case, this treatment plan helped reduce symptoms; she did not feel numbness during participation, no swelling, and no pain in arms. Minimized tightness in surrounding musculature was also noted after 2 weeks of therapeutic intervention.

Uniqueness: Thoracic Outlet Syndrome is a rare condition affecting less than 200,000 individuals yearly. TOS is categorized as vascular or neurogenic and the vascular cases are further subcategorized as arterial or venous. Of the limited reported cases, most cases present as neurogenic. This case is further unique since the patient was symptom free and participating fully in intercollegiate volleyball without incident until a weighted ball was introduced. **Conclusions:** This case highlighted the diagnosis and treatment of a patient suffering from Thoracic Outlet Syndrome. This case further highlighted the success of a conservative management plan addressing the patient's poor upright posture. The combination of the modalities, stretching exercises, manual therapy and Neurodynamics has improved the patient's symptoms and allowed her to continue participating in her sport almost completely symptom free. Athletic trainers need to be aware and recognize the early symptoms and ensure appropriate referrals are made to provide a positive clinical outcome and return to activity. Research has suggested that clinicians utilize the Halstead maneuver, Wright's test and Cyriax release test and due to the varied ranges of sensitivity and specificity evaluators should be cautious of the results when performing the Adson's and Roo's Tests. However, in this specific case, the Adson's Maneuver did assist in the proper clinical diagnosis but the Roo's test supported the current literature.

Use of Postural Restoration in Treating Chronic Rotator Cuff Pathology: A Level 3 CASE Study

Waldron JL, McKenney MA, Samuel MN, Turner CL, Girouard TJ, Radzak KN: University of Nevada, Las Vegas, Las Vegas, NV; Northeastern University, Boston, MA

Background: Many overhead athletes experience generalized shoulder pain due to repetitive terminal external rotation, with abduction and elevation. A study examining Division I athletes found roughly 30% of 371 overhead athletes developed a shoulder injury during their athletic career. Common rehabilitation programs for shoulder pain focuses on strengthening, mobility, and sport specific movements targeting the involved joint. Postural Restoration Institute® (PRI) theories and rehabilitation techniques focus on restoring balance to anatomical systems. Common postural asymmetries can present in athletes as dysfunctions and limitations. Once these dysfunctions and limitations are addressed, patients can perform activities with greater efficiency. This Level 3 CASE study examines the use of PRI exercises and theories to address pelvic alignment, along with core stabilization, to treat shoulder dysfunction in a collegiate volleyball player. **Patients or Other Participants:** 22-year-old female Division I volleyball player with 14 years of competitive experience seen for generalized right shoulder pain in August 2018. In August 2017, an Athletic Trainer

diagnosed her with rotator cuff tendinopathy. During the 2017-18 academic year, her rehabilitation program included shoulder mobility, strengthening, and ROM exercises. The rehabilitation program was supplemented with modalities for pain modulation. Prior to the 2018 season, while performing Theraband resisted standing shoulder flexion in the scapular plane, the athlete presented with bilateral rib cage flare and anterior pelvic tilt. ROM evaluation revealed bilateral differences for both hip and shoulder internal and external rotation (Table 1). PRI® recommended special test findings included a positive left and right Adduction Drop Test (ADT), positive left Extension Drop, and Hruska Adduction Lift test (left=2, right=3) indicating posterior exterior chain (PEC). PEC is theorized to cause the right and left hip to position in external rotation, abduction, and flexion resulting in bilateral rib cage flare and anterior pelvic tilt. **Intervention or Treatment:** Intervention exercises included the 90/90 hamstring hip lift, side-lying adductor pull back, and dead bug position. Exercises were performed as three sets of ten diaphragmatic breathing repetitions, a minimum of three times weekly prior to activity. The athlete’s former shoulder rehabilitation program was eliminated to isolate the effects of pelvic alignment on shoulder dysfunction. Patient-reported Likert 10-point pain scale rated shoulder pain/discomfort post-intervention. She was instructed and given direct feedback for two weeks. After this period, she was allowed to perform the program without direct supervision, while still reporting

completion. The ADT was performed post-intervention, ensuring that pelvic neutral was achieved. ADT was chosen because direct feedback about the exercises’ effect on pelvic alignment was obtained. Measures to evaluate progress over the treatment period included Likert pain scale ratings, hip and shoulder ROM, Extension Drop test, and Hruska Adduction Lift test. **Outcomes or Other Comparisons:** Pain scale ratings decreased from a six pre-intervention to a 0-2 range 65% of the time assessed. Progression of ROM is presented in Table 1. The left hip gained 10° of internal rotation and the right hip gained 14° of external rotation. The right shoulder increased in internal rotation by 15°. The Hruska adduction lift improved to a four bilaterally (right day 24, and left day 31). The left extension drop test progressed from positive to negative following day 17. **Conclusions:** This case suggests that PRI® exercises focusing on core and pelvic stability can translate to improved ROM and decreased shoulder pain associated with rotator cuff tendinopathy. PRI-based rehabilitation addresses postural asymmetries in the kinetic chain that present as movement dysfunction. By treating pelvic alignment with the PRI® exercises, the ROM imbalance and pain at the shoulder joint were subsequently treated. **Clinical Bottom Line:** Postural restoration exercises and theories should be incorporated into rehabilitation programs to address underlying imbalances throughout the kinetic chain.

	Pre-Intervention		Treatment Day 10		Treatment Day 17		Treatment Day 24		Treatment Day 31		Treatment Day 38	
	Left	Right										
Hip ROM												
Flexion (supine)	100°	110°	104°	110°	106°	111°	107°	112°	108°	112°	108°	111°
Extension (prone)	10°	6°	10°	8°	12°	11°	12°	13°	12°	14°	11°	14°
Adduction (supine)	18°	20°	20°	21°	21°	21°	22°	23°	22°	23°	23°	24°
Abduction (supine)	34°	29°	37°	30°	42°	36°	45°	42°	49°	47°	49°	48°
Internal Rotation (seated)	23°	38°	26°	36°	27°	35°	28°	34°	32°	33°	33°	35°
External Rotation (seated)	35°	20°	35°	22°	36°	25°	35°	27°	34°	32°	34°	34°
Shoulder ROM												
Extension (standing)	50°	47°	52°	50°	54°	52°	56°	56°	58°	56°	59°	58°
Internal Rotation (supine)	60°	50°	61°	55°	64°	58°	65°	60°	66°	62°	66°	65°
External Rotation (supine)	84°	95°	85°	95°	86°	96°	85°	96°	87°	95°	88°	94°

Free Communications, Oral Presentations: Clinical Education Techniques and Challenges

Tuesday, June 25, 2019, 11:00AM-12:00PM, Mandalay Bay B; Moderator: Ashley Thrasher, EdD, LAT, ATC

Challenges Associated With Clinical Immersion in Athletic Training Education: A Report From the Athletic Training Clinical Education Network

Myers SL, Campbell M, Mazerolle SM, Clements C, Eberman LE: University of Connecticut, Storrs, CT; Springfield College, Springfield, MA; Boston University, Boston, MA; Indiana State University, Terre Haute, IN; Athletic Training Clinical Education Network, Dallas, TX

Context: The Commission on Accreditation of Athletic Training Education (CAATE) will require professional masters programs to offer an immersive clinical experience starting in 2019. Clinical immersion is common in other healthcare fields; however little is understood about its implementation in athletic training. The purpose was to determine athletic training program administrators' perceived challenges of implementing immersive clinical experiences. **Methods:** In phase I participant and programmatic demographic data were collected and stored using Qualtrics online survey platform. Frequency and means were calculated for Phase I demographic data. To provide additional context to the survey responses, follow up phone interviews were conducted in phase II of the study and a general inductive lens was used to analyze these data. Pilot interviews, external review, and reaching data saturation were utilized to ensure content and to limit bias. 24 administrators from CAATE-accredited professional athletic training programs participated in phase I of the study, 15 from master's degree programs and 9 from programs offering both master's and bachelor's degrees. The respondents had 13 ± 6 years of experience in program administrative roles and 22 ± 7 years as credentialed athletic trainers. 17 administrators (12 PDs, 4 CECs, 1 Department Chair) completed one-on-one phone interviews in phase II. **Results:** 17 (71%) of the respondents currently include

immersive clinical experiences in their athletic training programs. 13 (76%) indicated their programs offered a minimum of one clinical immersive experience. Respondents identified three perceived challenges of immersive clinical experiences for the student: 1) isolation from peers and faculty, 2) financial burden due to off campus immersive placements, and 3) the amount of time a student may spend not engaged in quality learning experiences while still required to be physically present at their clinical site. Additionally, the respondents identified three challenges programmatically: 1) lack of a clear definition of the experience from the CAATE, as the 2020 CAATE standards at the time of data collection were not yet approved, 2) scheduling of immersive experiences, and 3) level of preceptor engagement with students. Program administrators believed that these factors greatly influenced 'buy in' from the students, faculty and preceptors. While programs acknowledge the benefits clinical immersion can provide in preparing students to transition to practice, challenges were still present in regards to the overall clinical immersion experience. **Conclusions:** Perceived challenges of immersive clinical experiences for both athletic training students and athletic training programs exist. PDs and CECs continue to seek clarity on beneficial practices for implementation of immersive experiences. If their perceived challenges are not addressed, buy in from faculty and preceptors could be influenced, thereby impacting the potential success of the student.

Student Burnout After a 15-Week Immersive Clinical Experience

Snyder MM: Western Carolina University, Cullowhee, NC

Context: All athletic training programs must include an immersion clinical experience as part of the curriculum starting in 2020. While several programs have used immersion clinical experiences, the student experience has not been explored. Burnout is defined as a state of prolonged physical and psychological exhaustion, and has been examined in athletic training clinical experiences. The purpose of this study is to describe the burnout of athletic training students who recently finished a 15-week full immersion clinical. **Methods:** A convenience sample of senior athletic training students at a southeastern public university completed a full immersive clinical during the fall semester where they completed 35-60 hours a week at various athletic training settings; this was their second immersive experience. Data collection occurred over two years; 35/45 (77.78%) of eligible subjects completed the study. Subject included 12 males and 23 females; average age was 21.6 ± 0.77 years. Subjects completed the Copenhagen Burnout Inventory (CBI) through Qualtrics during the last week of the clinical experience. The CBI is specific for health-related professions and has three scales with good reliability: 1) personal burnout ($\alpha=0.87$), 2) work-related burnout ($\alpha=0.87$), and 3) patient-related burnout ($\alpha=0.85$). Burnout scores were calculated for the three subscales and the total burnout score. Scores are on a 0-100 scale and a score of greater than 50 is considered high burnout. Means, standard deviations, and frequencies were calculated for total burnout and the three subscales. **Results:** Average scores for each subscale and total score were the following: total 35.15 ± 17.75 , personal 45 ± 21.38 , work-related 39.26 ± 19.54 , and patient-related 20.48 ± 17.13 . The

frequency (% , n=35) of subjects who score high were the following: total = 6(17.14%), personal = 15(42.86%), work-related = 9(25.71%), and patient-related = 3(8.57%). **Conclusions:** This is the first study exploring the burnout experienced by athletic training students during immersive clinical experiences. The results of the study indicate that athletic training student experience burnout. All areas of burnout were higher than previous research in athletic training (total=30.5±13.3; personal=41.3±17.3, work=31.6±16.3, and patient=18.8±15.4). When exploring the subscales, more subjects suffered from personal burnout, which is defined as a burnout related to self. This indicates that students during immersion clinicals could benefit from stress reduction exercises, time management skills, and other interventions that address exhaustion and burnout. The lowest frequency of burnout was patient-related, which is defined as burnout related to the person's work with patients. This is a positive result, meaning that the subjects did not relate their burnout to working with patients and is important for their longevity as professionals. Burnout and exhaustion should be a consideration when structuring and preparing students for immersive clinical experiences.

Athletic Training Students' Engagement in Interprofessional Education and Practice in the Classroom and During Clinical Education

Armstrong KJ, Walker SE, Feld SD, Weidner TG: James Madison University, Harrisonburg, VA; Ball State University, Muncie IN

Context: Healthcare education emphasizes the need for students to learn to practice collaboratively during patient care as they will when in clinical practice. Students need positive modeling and experiences of collaboration with other healthcare providers to understand how different disciplines work together to provide patient care through a network of practitioner connections. The purpose of this investigation was to identify the different healthcare students that athletic training students collaborate with in the classroom/laboratory and during clinical education.

Methods: We used a cross-sectional survey design including public and private institutions. Program directors of all accredited professional athletic training programs as of November 2015 (n = 372) were solicited. A total of 90 program directors (42 males, 48 females; 77 bachelor's level, 10 master's level, 3 both levels) completed the electronic survey consisting of 6 demographic questions and 2 questions regarding student engagement in interprofessional education. Cronbach's alpha determined internal consistency, alpha = 0.784. Descriptive statistics were computed for all items. An independent samples t-tests analyzed differences between demographic characteristics of the institution/programs and engagement with other healthcare students in the classroom/laboratory and during clinical education. The alpha level was set at .05. An interpretive coding method was used to analyze respondents' comments. **Results:** More than half of athletic training students collaborated with students from other healthcare professions in the classroom/laboratory and during clinical education. 58.9%

(n = 53) and 31.3% (n = 28) of respondents indicated that students interacted with physical therapy students during clinical education and in the classroom respectively. Additionally, athletic training students commonly engaged with students from nursing and physician assistant studies. Unfortunately, 27 (30%) and 34 (37.8%) respondents indicated no engagement with other healthcare professions students during clinical education and in the classroom respectively. No significant differences between respondent/program characteristics and athletic training student's engagement with students from other healthcare professions neither in the classroom nor during clinical education. Respondents' comments indicated that interprofessional education and engagement with other healthcare professions were connected to the teaching and evaluation of athletic training students' clinical skills. Regarding methods used to teach clinical skills, two categories emerged, including student-centered teaching methods (simulations, standardized patients, peer-assisted learning) and faculty-centered methods (eg, flipped classroom, audience response systems). Three categories emerged regarding methods used to evaluate clinical skills, including method emphasizing clinical application (eg, standardized patients), methods emphasizing foundational knowledge (eg, observations of clinicians), and methods emphasizing collaborative practice (eg, peer assessments, interprofessional case studies). **Conclusions:** Athletic training students need to learn with and beside students from other healthcare professions. Athletic training faculty need to be more intentional about providing exposure to a variety of healthcare students, as well as utilizing student-centered teaching strategies that foster interprofessional education and practice.

Free Communications, Oral Presentations: The Latest in Heat Illness Research

Wednesday, June 26, 2019, 7:30AM-9:00AM, Mandalay Bay B; Moderator: Susan Yeargin, PhD, ATC

Core Temperature and Environmental Factors Among University Marching Band Musicians

Emerson DM, Torres-McGehee TM, Yeargin SW, Kelly MR, Hirschhorn RM, Smith A, Weber SR, Uriegas N, Usuki H, Hatcher M: University of Kansas, Lawrence, KS; University of South Carolina, Columbia, SC

Context: Marching band (MB) requires individuals to perform physical activity outdoors for several hours a day and often in high environmental temperatures. Recent news indicates marching musicians experience exertional heat illnesses. However, no research has investigated thermoregulatory responses and potential influence of environmental and unique institutional factors in this population. This study sought to examine gastrointestinal temperature (TGI) in MB musicians during fall rehearsals and football performances. **Methods:** A cross-sectional study design examined TGI during 3 rehearsals and 2 football games. Nineteen MB musicians from 2 universities completed the study (MB1: n = 10; MB2: n = 9; female: n = 13; age = 20.5±0.9 yrs; weight = 73.3±18.9 kg; height = 164.9±6.8 cm; body fat = 27.5±11.4%). Participants ingested a thermistor to measure TGI and researchers recorded measures pre-, post-, and every 15 minutes during rehearsals and games. Wet-bulb globe temperature (WBGT) and relative humidity (RH) were recorded every 15 minutes during activity. Other measures included activity time and surface type (turf, concrete, or grass). Statistical analysis included descriptives (mean±standard deviation) for all variables. ANOVA and independent t-tests determined differences within and between MBs and day type (rehearsals and games). Backward step-wise multiple linear regression identified which variables significantly explained TGI. **Results:** Environmental measures were

not significantly different between institutions. Across all days, the mean max WBGT = 33.3±9.7°C and mean max RH = 70.1±17.2%. Mean rehearsal time was significantly longer for MB2 than MB1 (116.3±15.3 min vs 87.5±11.4 min, P<0.001). Game activity time was not significantly different (overall mean = 230.1±26.0 min). Mean TGI was significantly higher in MB2 than MB1 at pre- (38.4±1.3°C vs 37.6±0.4°C, P<0.001) and post-activity (38.8±1.1°C vs 37.9±0.4°C, P<0.001). Max TGI was also significantly higher in MB2 than MB1 (39.3±1.1°C vs 38.1±0.4°C, P<0.001). There were no significant differences in TGI between games and rehearsals within MB1. Contrastingly, within MB2, games elicited significantly higher TGI compared to rehearsals at post- (39.6±0.8°C vs 38.6±1.1°C, P=0.021). Maximum TGI was also significantly higher for games (39.9±1.1°C) compared to rehearsal (38.9±1.0°C, P=0.010). Activity minutes, ground surface, max WBGT, and max RH significantly predicted max TGI (adj. R² = 0.51, P<0.001). Six individuals in MB2 experienced TGI >40°C (without central nervous system dysfunction) for more than 60 minutes during games; MB2's game field is turf, which also corresponded to the highest recorded WBGTs of all data collection days (game 1 max = 42.9°C and game 2 max = 51°C). **Conclusions:** While environmental temperatures were similar, other institutional differences appear to influence physiological responses, with longer activity time and ground surface impacting TGI. Athletic trainers should be aware MB musicians experience high TGI during rehearsals and games, and clinicians should have appropriate preventative and management strategies for exertional hyperthermia.

Validity of Common Body Core Temperature Measurement Sites in Hyperthermic Humans Wearing American Football Uniforms

Miller KC, Adams WM: Central Michigan University, Mt. Pleasant, MI; University of North Carolina at Greensboro, Greensboro, NC

Context: Valid body core temperature measurements are essential for diagnosing and monitoring patients with exertional heat illness (EHI). American football uniforms put athletes at risk of EHI because they increase metabolic activity and decrease heat dissipation. No research has established the validity of common body temperature sites when American football uniforms are worn during clinically-applicable situations. Therefore, we determined the criterion-related validity of four body temperature measurement sites when participants wore an American football uniform during rest, exercise, cold water immersion (CWI), and post-immersion recovery. We hypothesized all body temperature sites would be considered invalid (i.e., all body sites would differ from rectal temperature [T_{rec}] by more than 0.27°C). **Methods:** Thirteen men (age=22±2 y, mass=77.5±8.8 kg, height=181.3±5.7 cm, body fat=6.9±2.9%, body surface area=1.98±.13 m²) completed this cross-sectional laboratory study. Participants donned a full American football uniform (shoes; socks; undergarments; athletic shorts; three-quarter length pants with hip, knee, tailbone, and thigh padding; t-shirt; shoulder pads; mesh jersey; helmet) and entered an environmental chamber (~39°C, 39% humidity). T_{rec} was compared to temperatures recorded from a liquid-crystal sticker placed over the forehead (FHD) and thermometers inserted in the axilla (AXL), mouth (ORL), and ear canal (EAR). Temperatures were recorded from each site during a 10-minute rest

period; exercise until T_{rec} reached 39.75°C ; CWI ($9.95\pm 0.12^{\circ}\text{C}$) until all thermometers read $\leq 38^{\circ}\text{C}$; and a 15-minute post-immersion recovery period. Overall, we compared 34 measurements (11 during rest, 10 during exercise, 10 during CWI, and 3 during recovery). We calculated temperature differences (i.e., bias) between sites and our criterion-gold standard, T_{rec} , for each experimental period. Repeated measures analyses of variance and Tukey-Kramer post-hoc tests assessed differences in bias between sites; similar statistics were used to compare raw temperatures between sites over time (NCSS v.2007, $\alpha=0.05$). **Results:** Total bias differed between sites ($F_{1,13}=75.7$, $P<0.001$). AXL bias (mean \pm SD, $4.66\pm 1.88^{\circ}\text{C}$) was higher than ORL ($1.04\pm 0.24^{\circ}\text{C}$), FHD ($-0.29\pm 0.39^{\circ}\text{C}$), and EAR ($0.47\pm 0.21^{\circ}\text{C}$; $P<0.05$). ORL also differed from FHD ($P<0.05$). No statistical differences occurred between EAR and FHD or ORL and EAR ($P>0.05$). For raw temperatures, AXL statistically differed from T_{rec} and exceeded our 0.27°C bias threshold at all times (34/34). FHD statistically differed from T_{rec} eight times during rest; eight times during exercise; 0 times during CWI; and twice during recovery (18/34, 53%). FHD exceeded our bias threshold 28 times during the study (82%). EAR statistically differed from T_{rec} five times during rest; 0 times during exercise; five times during CWI; and once during recovery (11/34, 32% overall). EAR exceeded our bias threshold 15 times during testing (44%). **Conclusions:** AXL, FHD, EAR, and ORL thermometers should not be used to diagnose or monitor body core temperature in American football players suffering from EHI. T_{rec} remains the clinical gold-standard body core temperature site.

Exertional Heat Stroke at the Falmouth Road Race: Incidence Rate and Survival

Katch RK, Huggins RA, Stearns RL, Jardine JF, Belval LN, Hosokawa Y, Casa DJ: Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; College of Sport and Health Science, Ritsumeikan University, Shiga, Japan

Context: Previous research examining exertional heat stroke (EHS) at the Falmouth Road Race (FRR) has reported 100% survival with prompt recognition via rectal thermometry and treatment via whole body cold water immersion (CWI). With increased participation rates in road races and marathons, it is imperative that medical personnel understand the updated incidence of EHS and effectiveness of CWI in EHS patients. Therefore, the objective is to determine the updated incidence rate (IR) and survival rate of EHS at the FRR where gold standard assessment and treatment via rectal thermometry and CWI were implemented. **Methods:** This is a descriptive study set at the FRR (Falmouth, MA; 11.3 km). Participants include 147 runners (male, $n=90$; female, $n=57$; age, 34 ± 13 y) with EHS from 75,749 FRR finishers between 2012-2018. Medical records of runners with EHS who were diagnosed on-site via rectal thermometry and treated via CWI in any of the FRR medical tents were retrospectively obtained and analyzed. IR of EHS cases per 1,000 finishers based on medical diagnosis was assessed and reported for all years. All descriptive variables are presented as mean \pm standard deviation. **Results:** Out of 147 patients, there was a 100% EHS survival rate. Annual IR of EHS was 1.94 ± 0.99 (95% CI = 1.65, 2.28) with the highest occurring in 2015 (IR = 3.93; ambient temperature [TAMB] = 25.7°C , relative humidity [RH] = 79%) and lowest in 2018 (IR = 0.89; TAMB = 19.9°C , RH = 82%). Average pre-CWI rectal temperature (T_{rec}) was $41.39\pm 0.60^{\circ}\text{C}$, and average

post-CWI T_{rec} was $38.95\pm 0.59^{\circ}\text{C}$, with an average ΔT_{rec} of $-2.44\pm 0.82^{\circ}\text{C}$. Average CWI treatment time was 14.18 ± 7.28 min, with an average cooling rate of $0.20\pm 0.09^{\circ}\text{C}/\text{min}$. Of the 147 EHS cases, only 16 (11%) were transported after lowering T_{rec} via CWI due to continuing medical complications. **Conclusions:** There was an annual IR of 1.94 ± 0.99 between 2012-2018 with 147 EHS cases. Out of these 147 cases there was a 100% survival rate when prompt recognition and treatment were implemented via rectal thermometry and CWI, regardless of initial T_{rec} . This is in line with previous research conducted at the FRR where IR was 2.13 ± 1.62 , and out of the 274 EHS cases over a preceding 18 years there was 100% survival utilizing the same recognition and treatment methodology. When the data is combined, the annual IR is 2.06 ± 1.39 for the 25 years. These results indicate that CWI, the gold standard treatment for EHS, remains effective when administered immediately. Clinicians should, without hesitation, continue to utilize T_{rec} and CWI in the case of EHS.

Exertional Heat Stroke Management Strategies: A Comparison of Practice and Intentions Between Athletic Trainers Who Did and Did Not Treat Cases During High School Football Preseason

Nedimyer AK, Chandran A, Hirschhorn RM, Adams WM, Pryor RR, Casa DJ, Register-Mihalik JK, Kerr ZY: University of North Carolina, Chapel Hill, NC; University of South Carolina, Columbia, SC; University of North Carolina at Greensboro, Greensboro, NC; California State University, Fresno, CA; Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT

Context: Although Athletic Trainers (ATs) are educated about appropriate exertional heat stroke (EHS) management strategies, there may be disparities between their reported management intentions and retrospectively-measured clinical practice. This study examined the implementation of management strategies for suspected EHS events in the 2017 high school (HS) football preseason. We were particularly interested in comparing management strategies used by ATs who managed suspected

EHS cases and the management strategies ATs who did not manage cases of EHS reported they would use. **Methods:** In this cross-sectional study, a questionnaire was developed and pre-tested with six ATs for face and content validity. ATs on the NATA membership list (n=7278) were invited to complete an online questionnaire. Responding ATs noted whether they had managed suspected EHS events during the 2017 HS football preseason. ATs who had managed suspected EHS reported the management strategies used, while ATs who had not managed suspected EHS reported their intended management strategies. Both question sets were provided similarly to both sub-samples to ensure comparability of responses. Of the 1023 ATs included in analyses (14.1% response rate), most were female (55.1%), aged <40 years (65.9%), and had <10 years of athletic training experience (50.9%). There were no demographic differences between groups. For each management strategy, z-tests compared proportions of actual use among ATs who managed suspected EHS versus intended use among ATs who did not manage suspected EHS. **Results:** Overall, 124 (12.2%) ATs treated suspected EHS cases during the 2017 football preseason. Generally, proportions of intended management

strategy use by ATs who did not treat EHS were higher than the actual use of those strategies by ATs who treated suspected EHS (Table 1). Particularly, significant differences were found for: took rectal temperature (19.6% versus 3.2%, P<0.001), and immersed athlete in ice water (90.1% versus 51.6%, P<0.001). Additionally, 46.7% of ATs who managed suspected EHS reported taking temperature by mouth, ear, axilla, or forehead. **Conclusions:** Inconsistencies were observed between groups in terms of reported intended use and actual use of management strategies for treating EHS. The standard of care for managing suspected EHS, including taking rectal temperature and cold water immersion, were not consistently used in clinical practice, although ATs who did not treat EHS stated they intend to use these management strategies. Nearly half of ATs who treated suspected EHS used a temperature assessment strategy outside the standard of care. It is important to emphasize that we analyzed data from suspected cases of EHS which later may not have been diagnosed as EHS. This may explain the lower actual use of appropriate management strategies. Nonetheless, further research should aim to identify factors that preclude ATs from applying the standard of care when treating suspected cases of EHS.

Table 1. Management strategies for suspected exertional heat stroke (EHS) that were used or would have been used by Athletic Trainers (ATs) during the 2017 high school football preseason

EHS management strategy	Used by ATs treating suspected EHS (n=124),	Would have been used by ATs who did not treat suspected EHS (n=892),	Z-score	P-value
	n (%)	n (%)		
Removed athlete's football equipment ^a	121 (97.6)	879 (98.5)	-0.75	0.45
Used wet ice towels	109 (87.9)	770 (86.3)	0.49	0.62
Moved athlete to shaded area	109 (87.9)	841 (94.3)	-2.71	0.007
Moved athlete indoors into air conditioning	89 (71.8)	714 (80.0)	-2.10	0.04
Removed athlete's clothing	69 (55.6)	692 (77.6)	-5.29	<0.001
Immersed athlete in ice water ^a	64 (51.6)	804 (90.1)	-11.38	<0.001
Cooled athlete with fan	38 (30.6)	362 (40.6)	-2.14	0.03
Called for emergency medical services	19 (15.3)	848 (95.1)	-23.55	<0.001
Called for clinical backup (i.e., physician)	7 (5.6)	175 (19.6)	-3.81	<0.001
Utilized portable air conditioning unit	6 (4.8)	90 (10.1)	-1.89	0.06
Took rectal temperature ^{a,b}	4 (3.2)	175 (19.6)	-4.49	<0.001

^aStandard of care for EHS

^bAn additional 46.7% of ATs that treated suspected cases of EHS reported taking temperature by other means inclusive of oral, forehead scanner, axilla, and aural.

Examining the Need to Develop School-Specific Environmental Activity Modification Guidelines: Preliminary Analysis

Hosokawa Y: Ritsumeikan University, Shiga, Japan

Context: Wet bulb globe temperature (WBGT) based activity modification guidelines have been used to assess environmental heat stress risk and optimize safety during exercise in the heat. Recent studies have suggested the need to normalize the WBGT thresholds according to the local climate; however, limited study exists that outlines the method in examining the need to develop school-specific heat activity modification guidelines. Therefore, the objective of this exploratory study was twofold: 1) to compare WBGT values measured on school campus against data from the nearest meteorological station, and 2) to examine the distribution of WBGT based heat risk category recorded on days when heat related illnesses (HRIs) were observed during school organized sports. **Methods:** This study was an observational study including two high schools in Tokyo (TKY, n=1) and Osaka (OSK, n=1), Japan. WBGT data were collected every 10-minute using Kestrel 5400 Heat Stress Tracker (Nielsen-Kellerman, PA) on days when athletic trainers (ATs) were present on campus between June to September, 2018 (TKY, 75 days; OSK, 48 days). The nearest meteorological station was located 1.83km south and 1.25km north-west from TKY and OSK, where WBGT were recorded every hour. HRIs included cases that exhibited signs and symptoms of heat exhaustion or heat syncope. WBGT based heat risk category by Japan Sport Association was used as the reference category thresholds: event cancellation, 31C; extremely dangerous, 28-<31C; dangerous, 25-<28C; caution, 21-<25C; and relatively safe, <21C. Bland-Altman analysis was used to compare WBGT values on school campus and meteorological station. **Results:** Total of 632 timepoint-pairs and 516 timepoint-pairs

from on-campus and meteorological station WBGT data were collected in TKY and OSK. The bias between two sites were -0.92.0C (95% limits of agreement [LoA][-4.8, 2.9]) in TKY and 1.83.4C (95%LoA[-4.9, 8.5]) in OSK. When values were compared in terms of heat risk category, there were disagreements between campus and meteorological station-based risk categories in 37% timepoints (n=236) in TKY and 65% timepoints (n= 335) in OSK. Thirty-seven HRIs were reported in TKY (outdoor sports, 20; indoor sports, 17) which occurred in 19 days of the 75-day data collection period. WBGT risk category reached event-cancellation on 18 days and dangerous on 1 day. Five HRIs (outdoor sports, 2; indoor sports, 3) were reported on five different days of the 48-day data collection period in OSK. WBGT risk category reached extremely dangerous 4 days and event cancellation on 1 day. **Conclusions:** WBGT values from the nearest meteorological station resulted in bias that yielded to inaccurate heat risk categories. WBGT risk category from on-campus measurement were classified as event cancellation in 79% of the HRI-days.

Cold Water Immersion Preparedness for Exertional Heat Stroke in United States High School Football Preseason

Kerr ZY, Scarneo SE, Yeargin SW, Grundstein AJ, Pryor RR, Casa DJ, Register-Mihalik JK: University of North Carolina, Chapel Hill, NC; Korey Stringer Institute, Department of Kinesiology, University of Connecticut, Storrs, CT; University of South Carolina, Columbia, SC; University of Georgia, Athens, GA; California State University, Fresno, CA

Context: Cold water immersion (CWI) is the gold standard for treating exertional heat stroke (EHS). However, previous research from the 2011 United States (US) high school (HS) football preseason found that only 44.8% of programs engaged in CWI preparedness (i.e., having a CWI tub filled with ice water prior to practice). This study aimed to estimate the prevalence of CWI preparedness in the 2017 HS football preseason and determine factors associated with CWI preparedness. **Methods:** This cross-sectional study examined the 2017 HS football preseason. Athletic trainers (ATs) on the NATA membership list (n=7278) were invited to complete an online questionnaire. Of the responding ATs (n=910, 12.5% response rate), most were female (54.1%), aged <40 years (64.0%), with 10+ years of AT experience (50.1%), and at HSs with >1000 students enrolled (55.7%) and a football squad size ≥60 players (52.8%). The questionnaire was developed and pretested with six ATs. Responding ATs assessed their HSs' use of EHS preventive measures in the 2017 football preseason. ATs also provided the zip code of the HS, which were subsequently categorized into three geographical regions based on warm season wet bulb globe temperature (WBGT) generated by previous research. The mild Region 1 included the Pacific Coast and northern portions of the US; the moderate Region 2 included the midsection of the US; and

the hot Region 3 included the Southern US. The main outcome measure was reporting CWI preparedness (i.e., having a CWI tub filled with ice water prior to practice). A multivariable binomial regression model estimated the prevalence of CWI preparedness; prevalence ratios (PR) with 95% confidence intervals (CI) excluding 1.00 were deemed significant. AT demographics (sex, age, years of experience) and HS characteristics (student enrollment, student-athlete size, football squad size) were included in the model as covariates. **Results:** The largest proportion of ATs worked with HSs in Region 3 (44.4%). Over half (57.1%) reported CWI preparedness. Controlling for AT demographic and HS characteristic covariates, the prevalence of CWI preparedness was higher in Region 3 than Region 1 (PR=1.47; 95%CI: 1.25-1.72) and Region 2 (PR=1.16; 95%CI: 1.02-1.31), and in Region 2 than Region 1 (PR=1.27; 95%CI: 1.07-1.51). The prevalence of CWI preparedness was higher in HSs with a football squad size ≥ 60 players versus < 60 players (PR=1.23; 95%CI: 1.07-1.40). **Conclusions:** Findings suggest greater compliance with CWI preparedness compared to previous research. Our definition of CWI preparedness is a best practice and may be more stringent than what is feasible in some settings (e.g., only adding ice to the CWI tub when suspected EHS occur). Still, future research should aim to identify factors influencing CWI preparedness, particularly in Regions 1 and 2 and schools with smaller football squad sizes.

Free Communications, Oral Presentations: Perceptions of and Strategies for Caring for LGBTQ Student-Athletes

Wednesday, June 26, 2019, 9:15AM-10:15AM, Mandalay Bay B; Moderator: Pat Aronson, PhD, LAT, ATC

Athletic Trainers' Perceptions About Collegiate Transgender Student-Athletes' Unfair Advantage in Sport Participation

Nye EA, Walen DR, Rogers SM, Crossway AK, Winkelmann ZK, Walker SE, Eberman LE: Drake University, Des Moines, IA; Select Medical, Des Moines, IA; Indiana State University, Terre Haute IN; Select Medical, Des Moines, IA; Drake University, Des Moines, IA; California State University, Northridge, Los Angeles, CA; Nazareth College, Rochester, NY; Ball State University, Muncie, IN

Context: Transgender student-athletes are participating in sport at an increased rate, which calls for an evaluation of athletic trainers' (AT) preparedness to care for their needs. Part of that care includes understanding the physiology of those transitioning. The objective was to investigate ATs perceptions regarding collegiate transgender student-athletes' unfair advantage when competing in sport. **Methods:** We used a web-based survey that was distributed to 5503 college/university ATs. 894 ATs started the survey (response rate=16.2%) and 601 ATs completed the survey (completion rate=67.2%). Based on previous literature and in consultation with an Ally trainer, we developed, validated (content and face), and piloted the tool. The tool included 2 items for participants to indicate whether they believe student-athletes assigned male/female at birth and identify and compete as a female/male had a competitive advantage (yes, no, or unsure). We calculated frequencies of participant responses. The participants (n=457) that selected yes or unsure to unfair advantage were asked to explain their selected perceptions as an open-ended response. We used the consensual qualitative research tradition to analyze the qualitative data. The data analysis process included a 3-person coding team that used a multi-phase process to identify themes.

Trustworthiness was achieved through multi-analyst triangulation and internal auditing. **Results:** Just less than half (45.4%, n=278/613) of ATs believed that student-athletes assigned male at birth but identifying and competing as a female (transgender female) have a competitive advantage. About a third of ATs (35.2%, n=216/613) were unsure, while 19.4% (n=119/613) did not believe transgender females had a competitive advantage. Contrastingly, only 7.2% (n=44/613) of respondents indicated that student-athletes assigned female at birth but identifying and competing as a male (transgender male) had a competitive advantage, while 39.0% (n=239/613) were unsure and 53.8% (n=330/613) did not believe transgender males had a competitive advantage. Three themes emerged from the qualitative analysis including participants believed (1) transgender females had a competitive advantage because of the physical attributes of cisgender males, (2) participants felt that the competitive advantage was dependent upon the sport, and (3) the unfair advantage of transgender student-athletes hinged on where the individual was in the transition, specifically the influence of hormone-related therapy. **Conclusions:** Most collegiate ATs believed that transgender female student-athletes have an unfair advantage in sport when competing against cisgender female student-athletes. Transgender females may not compete on a women's team until they complete one year of estrogen and antiandrogen hormone-related therapy that dissipates prior testosterone levels and prevents increased musculature development. Transgender males will take a life-long dose of testosterone, which is a NCAA banned substance and requires a medical exception prior to competition. Regardless of perceived unfair advantage, athletic trainers must be aware of regulations and therapeutic effects associated with hormone-related therapy for transgender student-athletes.

Athletic Trainers' Perceived Competence and Educational Influences in Their Ability to Care for Collegiate Transgender Student-Athletes

Walen DR, Nye EA, Rogers SM, Crossway AK, Winkelmann ZK, Walker SE, Eberman LE: Indiana State University, Terre Haute IN; Select Medical, Des Moines, IA; Drake University, Des Moines, IA; California State University, Northridge, Los Angeles, CA; Nazareth College, Rochester, NY; Ball State University, Muncie, IN

Context: Patient-centered care requires that athletic trainers (AT) address the potential healthcare disparities and all dimensions of health-related quality of life, specifically in marginalized populations like transgender student-athletes. Currently, transgender student-athletes are participating in sport at increased rates, calling for an evaluation of ATs' preparedness to care for their needs. The purpose of this study was to measure perceived competence and educational influences in caring for collegiate transgender student-athletes. **Methods:** We used a web-based survey distributed to 5503 college/university ATs; 894 ATs started the survey (response rate=16.2%) and 601 ATs completed the survey (completion rate=67.2%). Based upon previous literature, and in consultation with an Ally educator, we developed, validated (content and face), and piloted a 43-item questionnaire. The tool included 8 items for participants to indicate their competence in caring for transgender patients (4-point Likert scale, strongly disagree=1 to strongly agree=4). Participants indicated where they received education on transgender patients (formal education, reading journal articles, reading media outlets, religious teachings, personal experiences through family/friends, personal experiences [self], no learning, other). Participants identified the influence of any methods of education that

they selected (5=extremely influential to 1=not at all influential). Frequencies and modes were analyzed using SPSS® software. **Results:** Just over half (51.4%, n=321/625, mode=3) of respondents agreed that they were competent treating transgender patients in comparison to cisgender patients. 55.4% (n=343/619, mode=3) of respondents agreed that they were competent in counseling transgender patients on sexually transmitted infections, and 39.2% (n=240/613, mode=3) of respondents agreed that they were competent in collaboratively practicing with an endocrinologist about the drug-screening processes. About half (48.9%, n=304/622, mode=3) of respondents also agreed that they were competent in using appropriate terminology relating to transgender patients. Many respondents disagreed that they were competent regarding counseling transgender patients about the impact of hormone treatments on sport participation (52.2%, n=321/615, mode=2), adjusting exercise prescription based on hormonal differences (51.6%, n=318/616, mode=2), counseling transgender patients on mental health concerns (43.5%, n=269/618, mode=2), and counseling transgender patients about how hormone levels can affect NCAA, NAIA, or other sport regulatory bodies' drug-screening processes (42.9%, n=263/613, mode=2). Participants indicated that they had learned most frequently from media outlets (35.4%, n=235/663, mode=somewhat influential), personal experiences through family/friends/self (33.9%, n=225/663, mode=very influential), formal education (29%, n=192/663, mode=somewhat influential), but 36.7% (n=243/663) received no education. **Conclusions:** While collegiate ATs generally feel competent at treating transgender patients, ATs disagreed that they were competent in addressing specific aspects of transgender patient healthcare needs. With over a third of participants indicating a lack of any education, there is a need for professional and continuing education to meet the knowledge gaps of ATs through formal workshops and programming for transgender patient healthcare.

Gender and Sexual Minority Athletes Willingness to Seek Medical Advice and Come Out to Athletic Trainers

Ensign KE, Munson E, Nance S:
Ohio University, Athens, OH

Context: Athletic trainers (ATs) treat a wide variety of patients including those who are of a sexual and/or gender minority. It is unclear how lesbian, gay, bisexual, transgender, and queer (LGBTQ) patients experience care with athletic trainers. The purpose of this study was to investigate the experiences of LGBTQ athletes with ATs. **Methods:** The study utilized a cross-sectional design. Participants completed an on-line survey which was distributed via various social media platforms, emailed to LGBTQ organizations, and sent to sports medicine departments at every National Collegiate Athletic Association institution. The survey included a demographics section and a modified LGB healthcare satisfaction instrument. A total of 121 LGBTQ athletes completed the survey. LGBTQ athletes who have or are currently participating in high school (N=29), collegiate (N=66), club (N=20), semi-professional (N=5), or professional (N=1) athletics and had access to an athletic trainer were included. Average age was 21.74±3.55 years (male N=10, female N=77, and transgender N=34; lesbian N=28, gay N=10, bisexual N=32, queer N=36, and other N=15). Dependent variables included willingness to seek medical advice and coming out to their AT. Independent variables were gender identity, sexual orientation, and level of sport. Chi-square tests compared between groups. Using a MANOVA, responses to seeking medical advice from ATs and feeling treated differently after coming out was compared by sport level with follow up ANOVA's if the overall MANOVA was significant. Alpha level was set a priori at p<0.05 for all analyses. **Results:** Chi-square test for association showed significance between whether an athlete came out to their AT and level of sport ($\chi^2(1)=11.445$,

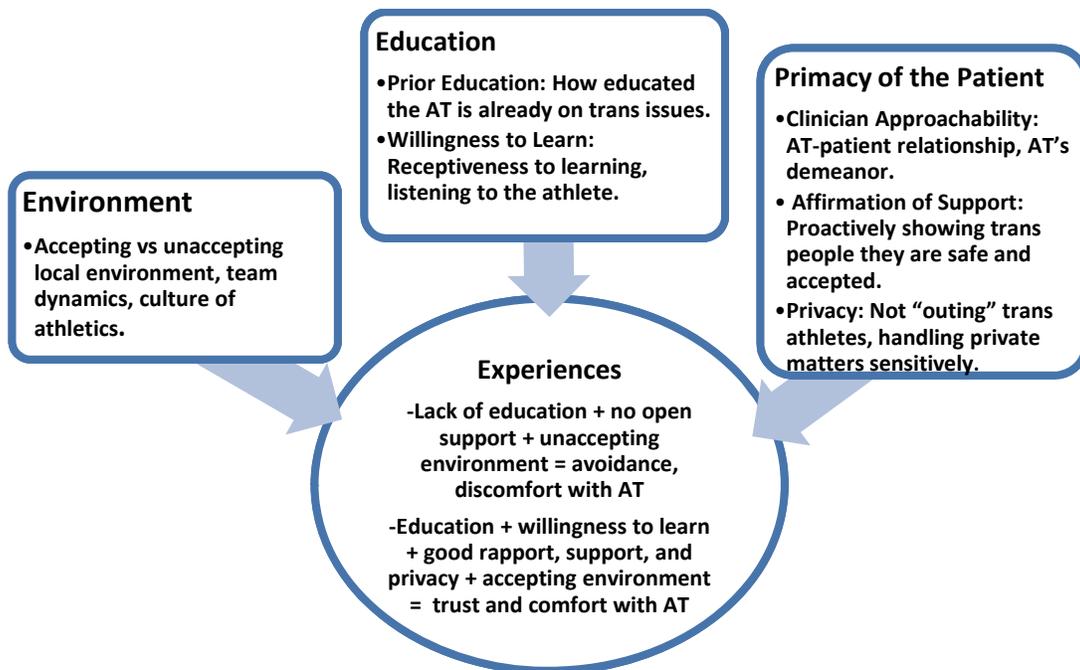
p=0.022, $\phi=0.308$). Only 24% (N=7) high school and 30% (N=6) of club sport athletes came out to their AT compared to 56% (N=37) collegiate athletes. A chi-square test for association showed no significance between whether an athlete came out to their AT and their sexual orientation ($\chi^2(1)=2.369$, p=0.668; $\phi=0.140$). A chi-square test for association showed no significance between whether an athlete came out to their AT and their gender identity ($\chi^2(1)=.239$, p=0.887, $\phi=0.044$). There was a significant difference between high school ($2.6 \pm .19$), club ($3.2 \pm .22$), and collegiate ($1.8 \pm .12$) LGBTQ athletes on willingness to seek medical advice from an AT (F(4, 107) = 8.312, p < .001; partial $\eta^2 = .237$). **Conclusions:** LGBTQ athletes have varying level of experiences with ATs depending on their level of sport. LGBTQ athletes at the lower levels of sport are less likely to come out to their AT and less likely to seek medical advice. However there does not seem to be a difference in coming out between the different sexual orientations and gender minorities. The data suggests that LGBTQ experiences can be improved in the high school and club settings.

Experiences of Transgender Athletes in the Athletic Training Setting: A Qualitative Study
 Munson E, Ensign KE: Ohio University, Athens, OH

Context: Transgender (“Trans”) is a term which means identifying as a different gender than you were assigned at birth. Transgender people often report negative healthcare experiences, including harassment and denial of care, leading many transgender people to avoid seeking healthcare. Little is known about transgender athletes’ experiences in the athletic healthcare setting and their experiences of with athletic trainers are currently unknown. The objectives of this study were to identify barriers transgender athletes may experience when seeking healthcare and to describe common experiences transgender athletes have with athletic trainers. **Methods:** A phenomenological qualitative design was chosen, consisting of semi-structured phone interviews. Interview questions addressed positive and negative experiences, avoidance, and perceived athletic trainer knowledge on transgender issues. Transgender participants were

sampled from participants who completed a lesbian, gay, bisexual, and transgender healthcare satisfaction survey and agreed to complete a follow up interview. Additional participants were added to the study from previous participants’ referrals. Participants needed to be 18 or older, transgender, an athlete within the past 5 years, and had access to an athletic trainer. Interviews were conducted until data saturation was reached. Nine participants (n=9) from high school (n=2), college (n=4), club (n=2), and semi-professional (n=1) athletics were interviewed. Mean age was 23.56±5.32. Participants included trans men (n=3), trans women (n=3), and non-binary/genderqueer people (those who do not identify as solely male or female) (n=4), with one participant identifying as both “trans man” and “non-binary”. Interviews were recorded, transcribed and analyzed for themes. Themes were checked with a peer reviewer and member checking was completed to validate findings. **Results:** Three themes emerged: Education, Primacy of the Patient, and Environment. Education includes the sub-themes Prior Education and Willingness to Learn, and describes athletic trainers’ knowledge on transgender

issues and their receptiveness to learning about these issues. Primacy of the Patient describes athletic trainers’ behaviors when interacting with transgender patients; including the sub-themes Clinician Approachability, Affirmation of Support, and Privacy. Environment describes how social environment impacts transgender athletes’ comfort with athletic trainers. Participants commonly perceived a lack of clinician education on transgender issues. When combined with unwillingness to learn, lack of support, or a hostile environment, this lead to discomfort and avoidance. Positive experiences were described when patient privacy was respected, support was demonstrated, and athletic trainers “learned with the athlete.” Figure 1 shows the relationship between the themes. **Conclusions:** Athletic trainers can improve their care of transgender patients in several areas. Information about transgender people should be included in professional athletic training curriculums, and athletic trainers should seek out continuing education on transgender topics. Athletic trainers can also use inclusive language, visually signal (posters, symbols) their facilities are safe for all people, and be aware of resources for transgender athletes.



Free Communications, Oral Presentations: The Effects of Cupping on Patient Outcomes

Wednesday, June 26, 2019, 10:30AM-11:15AM, Mandalay Bay B; Moderator: Colby Mangum, PhD, ATC

Cupping Therapy Does Not Influence Hamstring Range of Motion Compared to Control or Sham Conditions

Schafer MD, Tom JC, Girouard TJ, Navalta JW, Turner CL, Radzak KN: University of Nevada, Las Vegas, NV

Context: Flexibility is an essential aspect of physical performance, and when deficient increased likelihood of injury could result. Cupping therapy, or myofascial decompression, has gained popularity amongst athletic trainers as a modality to increase ROM. The purpose of the current study was to evaluate if cupping therapy applied passively for 10 minutes increases hamstring ROM compared to sham treatment or control conditions. **Methods:** A double-blinded, repeated measures, randomized control trial was conducted to evaluate the effectiveness of cupping therapy on hamstring ROM in a laboratory setting. Thirty-five individuals, ages 18-30 years old, were recruited. Inclusion criteria included being semi-active (exercising \geq twice weekly) and having active straight leg raise (ASLR) ROM $\geq 80^\circ$. Exclusion criteria included previous cupping therapy experience.

Twenty-five participants (10 females, 15 males) met inclusion and exclusion criteria, and subsequently completed the study (age: 23.52 ± 3.50 years, height: 171.89 ± 9.23 cm, body mass: 72.86 ± 14.90 kg, exercise: 4.22 ± 0.31 hours per week). Independent variables were treatment conditions and time. Treatment conditions were cupping therapy, sham cupping, and control. Timing of hamstring ROM measurements included pre-treatment, immediately post-treatment, and 10 minutes post-treatment. The dependent variable was hamstring ROM measured via a digital inclinometer during an ASLR with the pelvis and contralateral limb stabilized. Participants performed four ASLRs, with the mean of the final two trials used for analysis. Two certified athletic trainer investigators were utilized to maintain blinding. The primary investigator, with formal cupping therapy training, performed treatments. The secondary investigator collected ROM. Participants were randomly assigned treatment condition order, with one week's time between conditions. Cupping therapy was performed prone and four cups were placed along the biceps femoris, from gluteal fold to medial femoral condyle, for 10 minutes.

The largest cups that maintained contact with the posterior thigh before depressurization were utilized. The sham cupping treatment was identical, but sham cups had a 0.325mm hole and adhesive to maintain skin contact. The control condition required the participant to lay prone for 10 minutes. A 3x3 (condition x time) repeated measures analysis of variance was performed. **Results:** ROM means and standard deviations are presented in Table 1. There was no interaction between condition and time ($p=0.78$). The within-subjects main effect for time was not significant ($p=0.76$). Pairwise comparisons for time found no difference between pre-treatment and post-treatment ($p=0.48$), pre-treatment and 10 minutes post-treatment ($p=0.80$), and post-treatment and 10 minutes post-treatment ($p=0.61$). The main effect for condition was also not significant ($p=0.56$). Pairwise comparison of conditions found no difference between control and cupping ($p=0.36$), cupping and sham ($p=0.35$), or control and sham ($p=0.98$). **Conclusions:** Cupping therapy applied to a healthy individual for 10 minutes does not result in increased hamstring flexibility compared to a sham treatment or control conditions.

Table 1. Hamstring Range of Motion (mean \pm standard deviation)

	Baseline ($^\circ$)	Immediately Post- Intervention ($^\circ$)	10 Minutes Post- Intervention ($^\circ$)
Cupping	69.38 \pm 11.36	70.88 \pm 12.64	70.40 \pm 12.62
Sham	67.08 \pm 13.95	66.51 \pm 14.68	67.05 \pm 15.52
Control	66.83 \pm 10.63	67.57 \pm 12.67	66.47 \pm 13.21

The Effects of Dry Cupping Massage Therapy on Delayed Onset Muscle Soreness

Mueller CV, Evans TA, Majewski-Schrage TL, Snyder KR:
University of Northern Iowa,
Cedar Falls, IA

Context: Dry cupping massage has been suggested as a beneficial therapy for modulating pain associated with DOMS. Although research supports traditional massage for DOMS, there is limited research on the effect of dry cupping massage on DOMS. The purpose of this study is to compare the effects of dry cupping massage to petrissage on the pain associated with DOMS in otherwise healthy participants. **Methods:** Experimental, single blinded study with stratification for gender in a controlled laboratory study. Thirty-two healthy participants (13 males, 19 females, 20.25 ± 1.11 yrs, 172.78 ± 11.03 cm, 73.95 ± 15.42 kg) underwent a DOMS

induction protocol to the biceps brachii. They were then assigned to two stratified treatment groups accounting for gender; petrissage and dry cupping massage. The outcome was pain reported on an 11-point numeric rating scale (NRS). Participants then received treatment 48 hours post-induction, and every 24 hours subsequently until they reported no pain (zero out of ten). A 2 (session) x 2 (group) repeated measures ANOVA was used to determine if DOMS was induced and if the two groups reported different levels of pain, prior to beginning the first session. Independent t-tests were used to determine differences between massage conditions: prior to, during, and immediately following each session. Significance levels were set at p < .05, with a Bonferroni adjustment (alpha = 0.05/4 = 0.0125) when appropriate. At the conclusion of the study, participants were also asked if they perceived their treatment as effective. **Results:** Participants reported a

significant increase in pain 48 hours after the induction of DOMS (F (1, 30) = 140.90, p < 0.001), however there was no difference between the petrissage (3.84 ± 1.77) and cupping groups (3.5 ± 1.71) prior to the first intervention (1, 30) = 0.31, p = 0.58). Pain reported by the cupping and the massage groups were not different immediately before (p > 0.05), during (p > 0.05), and immediately after treatment sessions (p > 0.05). Mean pain scores and t-test values are reported in Table 1. Thirty-one (97%) of participants perceived their treatment as effective in managing their pain. **Conclusions:** Our results suggest that there is no difference in pain reduction between dry cupping massage and petrissage during DOMS recovery, although some in the cupping group did report increased pain following the first two cupping sessions. Relative to petrissage, dry cupping massage does not provide greater relief for DOMS recovery.

Table 1. Mean pain scores and t-test value for each measurement..

Time - Session	Pain Scores		Independent t-test results
	Petrissage $\bar{x} \pm SD$ (N)	Cupping $\bar{x} \pm SD$ (N)	
Pre - 1	3.84 ± 1.77 (16)	3.5 ± 1.71 (16)	t(30) = -0.56, p = 0.58
Pre - 2	2.44 ± 1.59 (16)	2.13 ± 1.41 (15)	t(29) = -0.56, p = 0.58
Pre - 3	0.93 ± 1.39 (15)	0.97 ± 1.08 (15)	t(28) = 0.07, p = 0.94
Pre - 4	0.67 ± 1.21 (6)	0.11 ± 0.33 (9)	t(13) = -1.33, p = 0.21
During - 1	2.13 ± 1.67 (16)	2.38 ± 1.63 (16)	t(30) = 0.43, p = 0.62
During - 2	1.63 ± 1.59 (15)	2.29 ± 1.59 (14)	t(27) = -1.12, p = 0.69
During - 3	2.33 ± 1.21 (6)	1.50 ± 1.33 (10)	t(14) = 0.25, p = 0.76
During - 4	*	3.0 (1)	*
Post - 1	1.78 ± 1.25 (16)	1.84 ± 1.48 (16)	t(30) = 1.29, p = 0.47
Post - 2	1.00 ± 1.13 (15)	1.39 ± 1.16 (14)	t(27) = 0.92, p = 0.29
Post - 3	0.67 ± 0.82 (6)	0.78 ± 0.83 (9)	t(13) = 0.26, p = 0.91
Post - 4	*	0.0 (1)	*

*Values could not be calculated because at least one group had complete DOMS recovery.

The Influence of Dry Cupping Therapy on Collegiate Musicians with Chronic Neck Pain

Ngor AS, Simon JE, Law TD, Russell JA: Ohio University, Athens, OH

Context: Non-specific chronic neck pain can inhibit optimal performance in musicians. Cupping therapy has emerged as a viable treatment alternative to traditional Western medicine for chronic neck pain. The objectives of this study were to determine the effect of retained, dry cupping therapy treatments on collegiate musicians' perception of pain and upper extremity function outcome scores. **Methods:** This exploratory laboratory study was conducted at a University clinical setting that serves performing artists. Five collegiate musicians (19±2 years, 170±9 cm, 82.1±21.8 kg) with chronic non-specific neck pain were enrolled and received a total of five dry cupping treatments (Hansol Medical Seoul, Korea) on the neck over the course of 4 weeks. Based on previous studies of cupping therapy, 3 acupuncture points on the posterior, bilateral paraspinal areas of the neck (EX-HN15, SI-15, and GB-21) were used. Data collection time points included baseline, immediately after the first treatment, and before and immediately after the fifth (last) treatment. Patient pain perception at rest and while playing his/her instrument were assessed by visual analog scale (VAS). The Neck Disability Index (NDI) and Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) were used to assess function. As this study was exploratory in nature, descriptive statistics [mean, standard deviation, and 95% confidence intervals (95%CI)] were calculated for each dependent variable for the entire group across time. Additionally, minimal clinically important differences (MCIDs) were calculated at the individual level. **Results:** Group baseline VAS scores indicated a score of 40±14 (95%CI: 27, 61). Immediately after the first treatment, VAS decreased 11

mm, 33±29 (95%CI: -4, 69). At rest 4 days after the initial treatment, VAS score decreased to 29±18 (95%CI: 7, 52), and continued to decrease through immediately after the final fifth treatment, 24±31 (95%CI: -14, 62). At the 25-day follow-up VAS at rest was 40±32 (95%CI: 0, 86). NDI scores were 13.6±5.4 (95%CI: 6.9, 20.2) at baseline. NDI scores four days after the initial intervention decreased to 11±7 (95%CI: 2, 20). At the 25-day follow-up post intervention, NDI scores decreased to 6±7 (95%CI: -2, 15). The QuickDASH baseline score was 27±9 (95%CI: 16, 38). QuickDASH four days after the initial intervention decreased to 18±12 (95%CI: 3, 32). At the 25-day follow-up post-intervention, QuickDASH decreased to 13±16 (95%CI: -6, 38). At the individual level, 4 out of 5 participants met the MCID of ±14 mm for pain; however, of those 4 participants, 3 subjects reported decreased pain, while 1 subject experienced increased pain. **Conclusions:** Dry cupping therapy is a safe and effective therapeutic modality for musicians with chronic neck pain. Musicians with increased perceived stress levels and heightened sensitivity toward pain may not respond to dry cupping treatments; therefore, further assessment and treatments may be warranted.

Free Communications, Rapid Fire Poster Presentations: Biomechanical and Neuromuscular Considerations for ACL Reconstruction Rehabilitation

Wednesday, June 26, 2019, 5:15PM-6:45PM, Mandalay Bay B; Moderator: Grant Norte, PhD, ATC, CSCS

Systemic Quadriceps Muscle Failure Following ACL Reconstruction: Neural and Morphological Considerations

Lepley AS, Grooms DR, Burland JP, Davi SM, Kinsella-Shaw JM, Lepley LK: University of Connecticut, Storrs, CT; Ohio University, Athens, OH

Context: Quadriceps muscle dysfunction is common following anterior cruciate ligament reconstruction (ACLR). Neural and morphological alterations have separately been identified to contribute to this clinical impairment, however a comprehensive assessment of these multifaceted origins of muscle dysfunction remains undefined. The primary aim of this study was to comprehensively investigate alterations in neural and morphological characteristics of the quadriceps muscle in patients with ACLR.

Methods: A cross-sectional case-control study design was used to evaluate bilateral differences in quadriceps neural and morphological function between patients with a history of ACLR and healthy-matched controls. Quadriceps strength was assessed via maximal voluntary isometric contractions (MVIC) normalized to body mass at 90° of

knee flexion. To evaluate neural function, spinal-reflex excitability (Hoffmann reflexes), corticospinal excitability (active motor thresholds [AMT] and motor evoked potentials [MEP] elicited via transcranial magnetic stimulation), and cortical activation during a knee motor task (functional magnetic resonance imaging [fMRI]) were assessed. Muscle volume of the rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL), vastus intermedius (VI) and total quadriceps (TQ) were derived using MRI to quantify morphological adaptations. 2x2 repeated measures analyses of variance (ANOVA) and post-hoc pairwise comparisons were used to evaluate group (ACLR, controls) and limb (injured, contralateral) differences. fMRI data were analyzed using group-wise paired contrast between ACLR patients and controls with group z-statistic images set at $z > 3.5$ threshold. All alpha levels were set a priori at $P < 0.05$. **Results:** Twenty-two participants volunteered (11 ACLR [6F/5M]: age: 22.6 ± 1.8 yrs, height: 167.4 ± 7.9 cm, mass: 66.2 ± 12.2 kg, months post-surgery: 69.4 ± 22.4 ; 11 Control [6F/5M]: age: 23.2 ± 1.6 yrs, height: 168.5 ± 10.3 cm, mass: 66.2 ± 12.7 kg). Means \pm standard deviations for outcomes and ANOVA statistics can be found in Table 1. MVICs were significantly lower in the ACLR injured limb, denoting

injured limb weakness. No differences in Hoffmann reflexes were detected. AMT was bilaterally higher in ACLR participants, demonstrating a reduced ability to excite descending corticospinal neurons. The ACLR injured limb exhibited smaller MEPs compared to the contralateral and control limbs, indicating that a smaller percentage of corticospinal signals reach the quadriceps muscle. Muscle volumes of the RF, VM, VI and TQ were lower in the ACLR injured limb compared to the contralateral and control limbs, indicating quadriceps muscle atrophy of the injured limb. fMRI analysis revealed that ACLR participants had greater activation (ACLR: $0.81 \pm 0.32\%$; Control: $0.30 \pm 0.49\%$; $P < 0.001$) in frontal lobe areas responsible for pain processing and motor error detection. **Conclusions:** ACLR patients demonstrated altered neural responses capable of influencing motor function, specifically a decreased ability to generate descending action potentials from the motor cortex (higher AMT), decreased motor output (lower MEP), and increased activation to frontal lobe areas of the brain responsible for motor processing. These systemic neural changes are observed concurrently with reduced quadriceps muscle volume of the injured limb and clinical measures of muscle weakness.

Table 1. Means \pm SD for neural and morphological variables by group and limb.

	ACLR		Healthy Control		$F_{(1,20)}$; P-value
	Injured	Contralateral	Injured Matched	Contralateral	
MVIC (Nm/Kg)	$2.95 \pm 0.56^*$	3.27 ± 0.70	3.52 ± 0.61	3.23 ± 0.71	2.92, $P=0.05$
H:M (%)	0.310 ± 0.172	0.256 ± 0.155	0.304 ± 0.204	0.288 ± 0.177	0.42, $P=0.52$
AMT (%2T)	$49.8 \pm 9.6^\dagger$	$45.1 \pm 9.4^\dagger$	37.6 ± 5.3	37.8 ± 5.2	14.12, $P < 0.01$
MEP (%)	$0.013 \pm 0.007^*$	0.037 ± 0.051	0.022 ± 0.012	0.043 ± 0.03	9.04, $P < 0.01$
RF volume (cm ³)	$143.2 \pm 67.2^*$	151.5 ± 72.2	153.7 ± 61.5	149.0 ± 62.5	4.83, $P=0.04$
VM volume (cm ³)	$313.1 \pm 151.8^*$	329.2 ± 151.4	340.7 ± 116.3	330.8 ± 105.1	7.32, $P=0.01$
VL volume (cm ³)	433.5 ± 158.0	443.0 ± 140.3	424.1 ± 137.5	418.8 ± 128.2	1.21, $P=0.28$
VI volume (cm ³)	$351.0 \pm 118.9^*$	359.3 ± 113.7	404.0 ± 150.1	393.5 ± 138.5	4.26, $P=0.05$
TQ volume (cm ³)	$1241.0 \pm 463.6^*$	1283.3 ± 450.9	1322.6 ± 444.5	1292.3 ± 419.6	11.82, $P < 0.01$

* Significantly different from ACLR contralateral and both healthy control limbs ($P < 0.05$)

† Significant group main effect. Regardless of limb, both limbs of ACLR group significantly different than healthy controls (pairwise comparisons, $P < 0.05$)

Abbreviations: ACLR, anterior cruciate ligament reconstruction; MVIC, maximal voluntary isometric contraction; H:M, Hoffmann reflex normalized to muscle response; AMT, active motor threshold; MEP, motor evoked potential; RF, rectus femoris; VM, vastus medialis; VL, vastus lateralis; VI, vastus intermedius; TQ, total quadriceps

How Much Time is Needed Between Serial “Return to Play” Assessments to Achieve Clinically Important Strength Gains in Patients Recovering From ACL Reconstruction?

Bodkin SG, Rutherford MH, Brockmeier SF, Diduch DR, Hart JM: Exercise and Sport Injury Laboratory, University of Virginia, Charlottesville VA

Context: Pass rates for return to play evaluations are alarmingly low for patients with anterior cruciate ligament reconstructions (ACLR). Patients that fail testing are often prescribed additional rehabilitation with follow-up testing at various time points after the original test. Since timing of return to play after ACLR is a complicated decision, it is important that patients are given optimal time to realize meaningful improvements in strength that warrants additional testing. The purpose of this study was to (1) determine strength gains indicative of improvements in subjective function and to (2) determine the amount of time between assessments necessary to achieve those meaningful strength gains. **Methods:** We collected data from 40 patients (20 Female, 20.4±7.1 years, 173.9±10.2 cm, 78.1±20.1 kg) during routine testing at approximately 6 months(5.97±.45-mo.) post-primary, unilateral and uncomplicated ACLR. Patients completed isokinetic knee extension at 90°/sec and patient reported outcomes through the International Knee Documentation Committee (IKDC) subjective knee evaluation form. All participants failed (operationally defined as 90% strength symmetry) initial assessment and were referred for subsequent testing at a time deemed appropriate by their treating clinician (2.14±.78 mo. post-initial visit, range [1-4-mo.]). A previously defined minimally clinically important difference (MCID) of 9-points on the IKDC was used to establish improvement in subjective function between visits. A receiver operator characteristic (ROC) curve was used to calculate

a threshold of mass-normalized knee extensor strength and a limb symmetry index indicative of subjective function improvement exceeding the MCID. A second ROC curve was calculated determine the time between assessments needed to achieve the strength gains determined in the previous analysis. **Results:** Knee extension strength gain of 0.219Nm/kg and increased knee extension peak torque symmetry of 5.75% were thresholds calculated that discriminated patients achieving a MCID in IKDC score. (Table 1). We next calculated that 1.97-months between assessments could discriminate those that achieved both previously calculated changes in knee extension strength and symmetry (Table 1). **Conclusions:** We established a threshold of time between return to play assessments in ACLR patients around the time when return to play decisions are being made. When patients fail testing and are referred for additional testing, approximately 2 months may be the minimum time needed for patients to achieve clinically meaningful improvements in patient reported outcomes, strength and symmetry.

Personalized Sensor-Based Classification of ACL Reconstructed Patients Using Machine Learning is Affected by Muscle Strength and Symmetry

Hart JM, Mandalapu V, Bodkin S, Lach J, Homdee N, Gong J: University of Virginia, Charlottesville, VA; University of Maryland, Baltimore, MD

Context: Early identification of subtle, sub-clinical, aberrant motion characteristics in patients with ACL reconstructed knees can inform rehabilitation and return to sports decision making. Wearable sensors enable characterization of movement in native sport and activity environment. Personalized injury classification may be helpful in making objective healthcare decisions regarding return to physical activity after injury or surgery to optimize patient safety. The ability to accurately classify patients with ACL reconstructed knees (ACLR) is not perfect and may be affected by strength recovery over the course of rehabilitation. For example, ACLR patients may be less accurately classified as strength and symmetry recover during rehabilitation thereby indicating good outcomes and healthy lower extremities. The purpose of the study to use a machine learning algorithm to classify patients with ACL reconstructions using inter-limb movement variability from sensor data during walking and jogging and to compare knee extension strength and symmetry between those patients who were accurately classified and those who were not. Our hypothesis is that patients who are accurately classified will be weaker and less symmetric. **Methods:** We evaluated 84 patients (23.5±10.2Yr, 172.6±9.6cm, 73.4±16.7kg, IKDC=79.7±13.2) with primary, unilateral and uncomplicated ACLR at approximately 6 months from index surgery. All participants walked for 5 minutes at 3 mph and jogged for 3 minutes at 6mph on a treadmill. Subjects were fitted with 5 wireless sensors (Shimmer3 IMU Unit, Dublin, Ireland) secured bilaterally on the

wrists and ankles and around the waist at the sacrum. Accelerations from the sensors were continuously monitored during the walking and jogging trials. The multi-dimensional time-varying biomechanical data captured by the sensors were processed to generate a graphical model and matrices to represent the cause-and-effect relationship in inter-limb movement. The matrices extracted from the sensor data were used to train machine-learning algorithms and then these trained algorithms were used to classify participants as ACLR. We then measured normalized peak isokinetic torque (90deg/s) using a dynamometer (Biodex System 4, Shirley NY) bilaterally and calculated limb symmetry and compared those patients who were correctly classified with those who were not using t-tests **Results:** Patients who were correctly classified during walking were weaker ($1.6 \pm .46 \text{ Nm/kg}$ vs. $1.45 \pm .44$, $P=.006$) and less symmetric ($66.1 \pm 19.4\%$ vs. $74.5 \pm 16.8\%$, $P=.048$) than those who were incorrectly classified. However, during jogging there were no differences in strength ($1.61 \pm .46 \text{ Nm/kg}$ vs. $1.45 \pm .44 \text{ Nm/kg}$, $P=.15$) or symmetry ($65.7 \pm 16.3\%$ vs. $72.1 \pm 19.6\%$, $P=.13$) between groups. **Conclusions:** Personalized classification of patients with ACL reconstruction using wearable sensor-based movement variability during walking only is affected by quadriceps strength and strength symmetry. This study is an initial step in laying the framework for the clinical use of instrumented measures of movement variability and machine-learning algorithms to better understand recovery from ACL reconstruction and making informed return to activity decisions.

Time Course of the Effects of Vibration on Quadriceps Function in Individuals With Anterior Cruciate Ligament Reconstruction

Johnston CD, Pietrosimone B, Blackburn JT: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Diminished quadriceps function is common following anterior cruciate ligament reconstruction (ACLR), and results in altered capacity to attenuate loading at the knee during tasks such as gait. This potentially results in aberrant loading of articular cartilage and development of post-traumatic osteoarthritis (PTOA). Local muscle (LMV) and whole body (WBV) vibration have been demonstrated to acutely improve quadriceps function in individuals with ACLR. However, it remains unclear how long these effects last. The purpose of this study was to determine the time course of the effects of LMV and WBV on quadriceps function in individuals with ACLR. This information is critical for determining how vibration could be integrated into ACLR rehabilitation. **Methods:** Twenty-four individuals (15 females; 9 males) with unilateral ACLR (50 ± 40 months post-ACLR) completed 3 testing sessions separated by at least 48 hours during which quadriceps function was assessed at 7 time points: baseline, immediately post (IMM), and 10, 20, 30, 45, and 60 minutes post-intervention. The interventions consisted of 6, 1-minute isometric squats while being exposed to WBV, LMV, or no vibration (CON) with 2 minutes' rest between exposures. The order of the interventions was determined using a Latin square. Peak torque (PT) and rate of torque development (RTD; slope of torque vs. time curve), were averaged across 3 maximal voluntary knee extension trials at each time point and expressed as a percentage of baseline values. Outcomes were compared across sessions via one-way repeated measures ANOVA, with significant time main effects evaluated via paired

t-tests to compare each post-intervention time point to baseline. Outcomes were also compared between groups at each time point via one-way repeated measures ANOVA with significant condition main effects evaluated by paired t-tests. **Results:** WBV improved PT at all time points post-intervention compared to baseline (IMM $105.2 \pm 8\%$, 10min $107.5 \pm 10\%$, 20min $109.7 \pm 10\%$, 30min $107.4 \pm 10\%$, 45min $105.8 \pm 11\%$, and 60min $107.2 \pm 12\%$; all $p < .05$). LMV had a significant effect on PT, but post hoc analysis only identified a significant difference from baseline at 10min post ($105.9 \pm 2.5\%$; $p=0.02$). CON had no effect on PT. Between groups analysis revealed that PT was greater following WBV than CON at all post-intervention time points (all $p < 0.05$). PT was greater with LMV than CON IMM and 20 min (both $p < .05$) and approached significance at 10 min ($p=0.051$). WBV PT was greater than LMV PT at 20, 45 and 60min ($p < 0.05$). No improvements in RTD were observed. **Conclusions:** WBV improved PT for up to an hour. While LMV had some effect on PT, WBV was consistently superior, having a greater magnitude impact and longer duration. Vibration improves quadriceps function for up to an hour and may enhance rehabilitation following ACLR with the aim of reducing PTOA risk.

Knee Loading Following ACL-R is Related to Quadriceps Strength and Knee Extension Difference Across the Continuum of Care

Garrison JC, Hannon JP, Goto S, Kosmopoulos V, Aryal S, Bush CA, Bothwell JM, Singleton SB: Texas Health Sports Medicine, Fort Worth, TX; University of North Texas Health Science Center, Fort Worth, TX; Orthopedic Specialty Associates, Fort Worth, TX; Fort Worth Orthopedics, Fort Worth, TX

Context: Quadriceps strength and knee extension are two variables believed to be important in the ability to effectively load the knee after ACL reconstruction (ACL-R). The aim of this study was to compare quadriceps strength (QUADS), side-to-side knee extension difference (ExtDiff), and knee energy absorption contribution (EAC) in patients with an ACL injury across the continuum of care. A secondary aim was to determine how QUADS and ExtDiff contributed to knee EAC at each time point. **Methods:** Repeated measures study design within a health-system based outpatient sports medicine center. Forty-three individuals (16.0 ± 1.6 y/o) were enrolled prior to their surgical procedure for ACL-R. QUADS, ExtDiff, and knee EAC during a double limb squat (DLS) were collected at pre-operative ACL-R (Pre-), 12 weeks post-operative ACL-R (12 weeks), and time of return to sport (RTS) following ACL-R. Knee EAC was calculated during DLS descent. Isokinetic QUADS was collected at 60 deg/sec., normalized to body weight, and averaged across 5 trials. Knee extension was measured with a goniometer and ExtDiff was calculated for analyses. Observations were obtained from both the surgical and non-surgical limbs at three time points. A mixed regression model with random-intercept to compare change over the three time points was used and a model selection was conducted using Akaike Information Criteria. Alpha level was set at $p < 0.05$. **Results:** Pre- and 12 week findings

were both compared to RTS in the results that follow. Surgical QUADS was significantly lower at Pre- ($p < 0.0015$) and 12 weeks ($p < 0.0001$) compared to RTS. Non-surgical QUADS was also significantly lower at Pre- ($p < 0.0329$) and 12 weeks ($p < 0.0148$) compared to RTS. No significant surgical knee EAC differences were observed between Pre- and RTS ($p = 0.2530$). Surgical knee EAC at 12 weeks was significantly lower than knee EAC at RTS ($p < 0.0033$). No significant differences were found between Pre- and RTS ($p = 0.1501$) and 12 weeks and RTS ($p = 0.0784$) for the non-surgical knee EAC. Although ExtDiff between 12 weeks and RTS was not significant ($p = 0.1264$), ExtDiff was significantly greater at Pre- than RTS ($p < 0.0001$). QUADS for both the surgical ($p < 0.0003$) and non-surgical ($p = 0.0019$) limbs were significant predictors of surgical limb knee EAC at Pre- explaining 33.59% of the variance. At 12 weeks, surgical QUADS was a significant ($p < 0.0255$) predictor for surgical limb knee EAC explaining 18.25% of the variance. ExtDiff at RTS was a significant ($p = 0.0201$) predictor of surgical limb knee EAC at RTS explaining 10.59% of the variance. **Conclusions:** The ability to load the knee following ACL injury changes across the continuum of care and is related to QUADS and ExtDiff. These results provide clinicians with insight into potential contributing factors that may limit knee loading during the rehabilitation process.

How Does It All Measure Up? Interrelationships Between Biomechanical, Clinical Symmetry and Self-Reported Function After ACLR

Burland JP, Lepley AS, Davi SM, Arciero RA, DiStefano LJ, Lepley LK: University of Connecticut, Storrs, CT

Context: Clinical hop tasks after anterior cruciate ligament reconstruction (ACLR) are often used as criteria to predict safe return-to-sport. However, inclusion of numerous tests limits clinical adoption. Simplifying return-to-sport testing may help with clinical adherence. In order to justify reducing the number of clinical tasks during the return-to-sport phase, we seek to understand if there is overlap between return-to-sport measures in patients with a history of ACLR who presently would pass physical return-to-sport criteria. Hence, the purpose of this study was to 1) determine whether knee biomechanical symmetry is associated with distance hopped during the triple hop task and 2) whether objective biomechanical and clinical performance is associated with an individual's perceived knee function and readiness to return-to-sport. **Methods:** Sixteen individuals with a history of unilateral ACLR participated (age: 22 ± 2 y; height: 1.71 ± 0.11 m; mass: 68.94 ± 13.06 kg; gender: 8 males, 8 females; years' post-surgery: 4 ± 3 y) in a single, cross-sectional controlled laboratory study. All individuals had previously been cleared to return to all functional sporting activities. Knee kinematics and kinetics (average and peak knee flexion angle and knee extension moment) were measured using 3D motion analysis during the triple hop for distance (TrH) task. Self-reported function was measured using the International Knee Documentation Committee (IKDC), Knee Injury and Osteoarthritis Outcomes Score (KOOS), ACL-Return-to-Sport after Injury (ACL-RSI) and the Tampa Scale of Kinesiophobia (TSK). Percent limb differences (%LD) were calculated to quantify distance hopped limb

symmetry and knee biomechanical symmetry. Pearson product moment correlations were used to determine associations between knee biomechanical variables, clinical TrH task, and self-reported function. An alpha level was set a priori at $P < 0.05$. **Results:** No significant associations were found between %LD and knee biomechanics during the TrH (Table 1). Self-reported function was not significantly associated with TrH %LD. **Conclusions:** Understanding the associations between clinical hop tasks, biomechanical performance and self-reported function may help bolster clinical adoption of return-to-sport criteria as it may reduce the number of tasks needed to determine readiness to return-to-sport. The lack of agreement between the TrH distance, biomechanical and self-reported function after ACLR emphasizes the need to continue to comprehensively evaluate all measures of physical function.

The Effects of Transcranial Direct Current Stimulation on Quadriceps Neural Activity After Anterior Cruciate Ligament Reconstruction

Rush JL, Lepley LK, Davi SM, Lepley AS: University of Connecticut, Storrs, CT

Context: Altered quadriceps activation is common following anterior cruciate ligament reconstruction (ACLR), and can persist for years after surgery. These neural deficits are due, in part, to chronic central nervous system alterations. Transcranial direct current stimulation (tDCS) is a non-invasive modality that is believed to immediately increase motor neuron activity by stimulating the primary motor cortex, making it a promising modality to use during ACLR rehabilitation. The aim of this study was preliminarily to determine if a single treatment of tDCS would result in increased quadriceps electromyographic (EMG) neural activity. **Methods:** A crossover randomized controlled study design was used, where patients completed a single familiarization session and two testing sessions separated by

at least three days. During testing, baseline measures of bilateral vastus lateralis (VL) EMG activation were measured during three trials of maximum voluntary isometric contractions at 90° of knee flexion. Immediately following baseline assessments, patients completed a tDCS intervention in which they walked on a treadmill for 20-minutes at a self-selected pace. During walking, a portable tDCS unit (Halo Neuroscience, Halo Sport) was positioned over the motor cortex and patients received either tDCS stimulation (average intensity: 9.40±1.34), or a Sham condition with no stimulation. Sham and treatment conditions were randomized. Post-intervention testing was performed in the same manner as baseline. EMG signals from each trial were filtered, rectified, processed with a root mean square algorithm, and then normalized to the largest of the peak muscle activity during maximal voluntary isometric contractions to represent percent maximum. Separate repeated measures analysis of variance by limb were performed to explain the differences between time points (pre, post) and condition (tDCS and Sham). Post hoc t-tests were performed in the

presence of significance. Alpha level was set a priori at P<0.05. **Results:** Five individuals with unilateral ACLR participated (3F/2M; 20.80 ± 3.03 yrs; 176.88 ± 5.11 cm; 79.37 ± 14.06 kg; months post-surgery: 44.00 ± 27.41). Means and standard deviations are depicted in Table 1. No significant interaction was observed with percent-maximum EMG activity for the uninjured VL (F(3,1)=0.26, P=0.64). A significant interaction was discovered for the injured VL for percent-maximum EMG (F(3,1)=7.70, P=0.05). Post-hoc analysis revealed a significant decrease in VL EMG activity of the injured limb during the Sham condition only (P=0.02). **Conclusions:** tDCS resulted in maintenance of muscle activity in the VL injured limb during treatment, whereas during the Sham condition EMG activity decreased. tDCS had no effect on the uninjured limb. tDCS may be effective at targeting altered quadriceps activation in patients with a history of ACLR. Longer treatment durations and larger sample sizes are warranted to understand the true therapeutic efficacy of tDCS in patients with ACLR.

Condition		Injured VL EMG	Uninjured VL EMG
tDCS	Pre	0.776±0.317	0.89±0.073
	Post	0.714±0.171	0.73±0.204
Sham	Pre	0.917±0.049*	0.938±0.030
	Post	0.640±0.165*	0.720±0.090

Abbreviations: VL, vastus lateralis
 *significant decrease in VL EMG activity of the injured limb during the Sham condition (P=0.02)

A Novel Test of Trunk Control Identifies Deficits in ACL Reconstructed Patients

Roe C, Pollen T, Silfies S, Johnson D, Noehren B: University of Kentucky, Lexington, KY; Drexel University, Philadelphia, PA; University of South Carolina, Columbia, SC

Context: Poor neuromuscular control of the trunk has been identified as a significant risk factor for anterior cruciate ligament (ACL) injuries in female athletes. To date, few clinical tests have been developed to capture trunk neuromuscular control following ACL reconstruction (ACLR). Twenty-nine percent of younger patients sustain a subsequent ACL injury suggesting the need for comprehensive evaluation prior to return to sport (RTS). Identifying patients with trunk control deficits may allow for a safer RTS following ACLR.

Objective: To determine if a novel test of trunk control can identify ACLR subjects with neuromuscular control deficits. **Methods: Design:** Cohort study.

Setting: University research laboratory.

Subjects: 15 females (age 19.25 ± 4.67 , BMI 23.51 ± 2.59) 3-months (105.81 ± 10.49 days) and 6-months (189.62 ± 8.87 days) following ACLR and 20 healthy females (age 21.95 ± 2.46 , BMI 21.84 ± 2.87) with no history of lower extremity injury. Intervention: Subjects were asked to sit on a wobble board placed on a hard surface with their feet approximately 0.1m off the ground with their eyes closed. Subjects were given one minute of eyes open practice to become acquainted with the board. The subjects were then asked to complete three eyes closed warm-up trials followed by two 30 second test trials. If an error did occur, subjects were instructed to resume the test position as quickly as possible. Errors were counted and averaged between the two eyes closed trials. Errors included uncrossing the arms, opening eyes, or touching the plinth with the edge of the wobble board.

Main Outcome Measures: Descriptive statistics were calculated for ACL and

healthy subjects. An independent samples t-test ($p < 0.05$) and ROC curve analysis were performed to compare between groups. **Results:** ACLR subjects had significantly more errors on average at three (6.18 ± 3.29) and six months (4.71 ± 1.18) while healthy subjects had 0.98 ± 1.13 ($p < 0.001$) errors. There was no significant difference between three and six month errors ($p = 0.11$). At three months, the sensitivity (93%) and specificity (95%) was high, with a cutoff score of 3.38 errors (AUC: 0.99). The sensitivity and specificity were 87% and 95% at six months, with a cutoff score of 3 errors (AUC: 0.94). **Conclusions:** The novel trunk test can differentiate between females with ACLR and healthy subjects with a cutoff score of three errors. The lack of change from 3 to 6-months may indicate substantial deficits that may not be addressed in rehabilitation. The truck test allows for an early, safe, and clinically applicable assessment of young active females with control deficits. Additionally, it can be completed with little evaluator training and minimal equipment. The errors are speculated to be due to the body's inability to recover the displacement of the center of mass when it shifts from equilibrium with the balance point on the board. As trunk neuromuscular control deficits have been linked to knee injuries, the trunk test may be utilized within a test battery to assess RTS readiness. Future analysis is necessary to determine if the deficits decrease over time and prior to RTS.

Relationship Between Patient-Reported Outcome Measures and Sample Entropy During Dual-Task Balance Following Anterior Cruciate Ligament Reconstruction

Simon JE, Miko SC, Grooms DR, Monfort SM: Ohio University, Athens, OH; Montana State University, Bozeman, MT

Context: Anterior cruciate ligament injury and surgical reconstruction (ACLR) has been shown to alter balance during various tasks. Additionally, following ACLR, individuals demonstrate deficits in region specific patient-reported outcome measures of the knee. However, few studies to date have investigated the relationship between patient-reported outcome measures and postural control measures. Thus, the purpose of this study was to understand the relationship between postural control measures and patient-reported outcome measures in ACLR individuals in the presence of sensory, motor, and cognitive challenges. **Methods:** Fourteen ACLR individuals (20.7 ± 2.0 years, 76.9 ± 19.1 kg, 1.7 ± 1.4 m, 6.7 ± 1.9 Tegner) were recruited for this biomechanics laboratory based cross-sectional study. The participants were 6 months to 7 years post-operative (3.89 ± 2.26 years) and cleared to return to full function by their physician. Participants were excluded if they had pain and/or joint effusion at the time of testing. Three 20-second trials of single-leg balance (ACLR limb) were performed under the following conditions: eyes open, eyes closed, dual cognitive, and dual motor. The dual cognitive condition involved mental addition every two seconds and the dual motor condition required participants to catch a ball from a ball machine every 2 seconds. Participants' center of pressure (CoP) was measured throughout the duration of each trial. Individuals also completed the Knee Injury and Osteoarthritis Outcome Score (KOOS), ACL-Return to Sport Index (ACL-RSI), and the International Knee Documentation Committee Subjective

Knee Form (IKDC-SKF). Sample entropy (SEn, unitless) was also calculated for increment resultant CoP data after downsampling to 50Hz, without filtering. Increased SEn indicates less regularity in CoP control, which is representative of healthier, more automatic postural control. Pearson correlations were used to assess associations between patient-reported outcomes and SEn for each of the balance conditions. Alpha was set a priori at 0.05. **Results:** Descriptive statistics for the measures variables were ACL-RSI (63.22±18.11), IKDC-SKF (77.42±10.56), KOOS-Pain (84.57 ± 11.79), KOOS-Symptom (73.5±16.71), KOOS-Sport (73.92±20.21), KOOS-ADL (94.64±5.46), KOOS-QOL (69.29±20.54), and SEn (eyes open: 0.95±0.17; eyes closed: 0.71±0.15; dual cognitive: 0.83±0.16; dual motor: 0.61±0.17). Significant associations were only observed for the dual cognitive condition. All other balance conditions had non-significant correlations with the patient-reported outcomes ($p>0.05$). For the dual cognitive condition, increased regularity (i.e., decreased SEn) was associated with lower scores on ACL-RSI ($r=0.53$, $p=0.049$), IKDC-SKF ($r=0.619$, $p=0.018$), KOOS-Pain ($r=0.574$, $p=0.032$), KOOS-Symptom ($r=0.57$, $p=0.033$), and KOOS-Sport ($r=0.755$, $p=0.002$). **Conclusions:** ACLR individuals who scored lower on the ACL-RSI, IKDC-SKF, and KOOS-Pain, Symptom, and Sport scales had lower sample entropy during the dual cognitive task, which is consistent with less automatic postural control. This finding is indicative of ACLR individuals who have lower confidence in their knee or more self-reported symptoms demonstrating a more attentionally-focused approach to balance control in the presence of cognitively challenging dual tasks.

Altered Gait Patterns in Patients With ACL Reconstructed Knees Performing Multiple Tasks

Twait K, Chang M, Hertel J, Hart JM: University of Virginia, Charlottesville, VA

Context: Altered movement patterns are common in patients with ACL reconstructed knees (ACLR). Many studies identifying changes in walking gait use tasks that poorly simulate real world environments. Evaluating gait while performing cognitive tasks and while looking different directions may better simulate the demands of activity and sport. The purpose of this study was to compare gait kinematics and spatiotemporal measures while performing multiple tasks between patients with ACLR and healthy controls.

Methods: Nineteen total subjects 9 ACLR (26.49±7.34yrs, 73.06±17.69kg, 167.44±7.76cm) and 10 healthy subjects (25.03±4.20yrs, 68.51±9.81kg, 169.07±9.12cm) participated in this study. Participants walked on a treadmill at 120% of comfortable walking speed while looking in 3 different directions (forward, toward involved/non-dominant side, toward uninvolved/dominant side) and performing a cognitive task (Stroop Test). We compared step length and step width as well as frontal and sagittal plane kinematics of the hip and knee between ACLR and healthy subjects during 6 total walking trials consisting of 2 cognitive task conditions and 3 visual gaze directions. Kinematic data from 10 consecutive strides were ensemble averaged over 100 percentiles of the gait cycle with associated 90% confidence intervals. Areas where confidence intervals did not overlap were considered statistically different. We used a 3X3X2 factorial ANOVA with post hoc tests where appropriate to compare average step length and width from 10 consecutive strides among groups and conditions. **Results:** Regardless of group or cognitive task, participants exhibited shorter step lengths when looking toward the involved (0.461 ± 0.04 m) and uninvolved sides

(0.464±0.04m) versus looking forward (0.475 ± 0.04m, $P = 0.005$). Participants also exhibited wider step widths when looking toward the involved (0.254 ± 0.04m) and uninvolved sides (0.262 ± 0.04m) versus looking forward (0.236 ± 0.04m, $P = 0.005$). Regardless of group or gaze direction, participants walked with wider step widths when performing the Stroop test (Stroop = 0.257 ± 0.04m, No-Stroop = 0.244 ± 0.03m, $P < 0.001$). There was a group by gaze direction interaction ($P = 0.014$) where patients with ACLR exhibited greater step widths when looking toward the uninvolved (non-reconstructed/dominant) side than healthy controls (ACLR = 0.27±0.05m, Healthy = 0.255±0.04m, Effect Size=0.29). There was no difference between groups while looking forward or towards the reconstructed/non-dominant limb. Patients with ACLR exhibited greater hip adduction during mid-late stance phase (range of differences: 3.2-3.8°) compared to healthy controls when looking forward and toward the involved side with and without performing the Stroop test. There were no other significant differences in hip or knee sagittal or frontal plane kinematics between groups across cognitive task or gaze direction conditions. **Conclusions:** Gait adaptations exits during over-speed walking with altered gaze direction or while performing a cognitive task. Patients with ACLR adapt gait during altered gaze direction by increasing step width.

Free Communications, Rapid Fire Poster Presentations: Hip Muscle Function and Lower Extremity Mechanics

Thursday, June 27, 2019, 7:45AM-9:00AM, Mandalay Bay B; Moderator: Yum Nguyen, PhD, ATC

Influence of Hip Strength Testing Position on Lower Extremity Muscle Activity

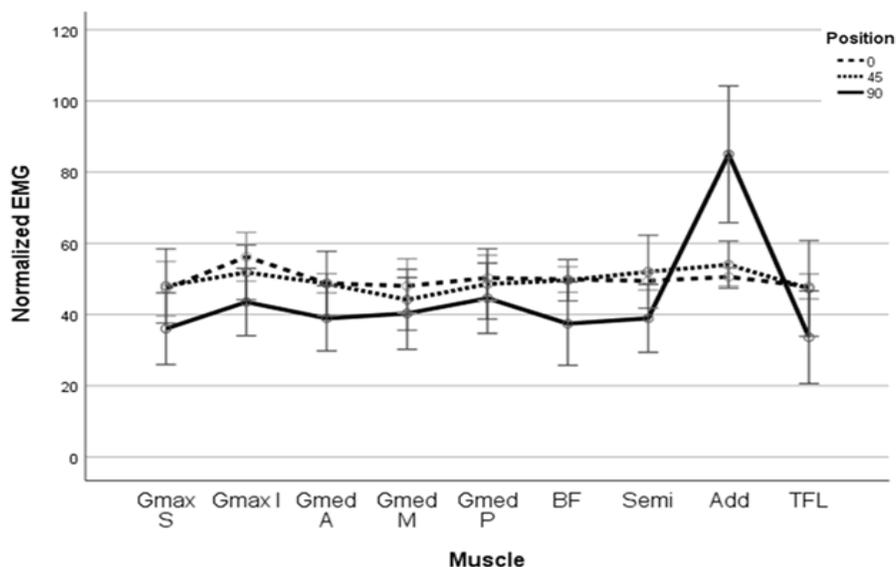
Glaviano NR, Bazett-Jones DM:
The University of Toledo, Toledo, OH

Context: Hip strength is a common objective assessment for both healthy and pathological patients. Hip extension, abduction, and external rotation have been used to evaluate relationships with both subjective function, pain, and lower extremity kinematics during functional tasks. Altering patient position during testing has been identified to influence force output for the hip muscles. However, it is unknown how altering patient positioning during hip muscle strength assessment influences lower extremity muscle activity. Therefore, the purpose of this study is to measure lower extremity muscle activity during hip strength testing in different patient positions. **Methods:** Twenty healthy female participants (age: 22.3±1.1years, height 168.4±6.4cm, mass 63.1±11.7kg) were recruited from the local university and completed this descriptive laboratory study. Testing positions for hip

strength was as follows: hip extension (0, 45, and 90° of hip flexion); hip abduction (-5, 0, and 45° of hip flexion); and hip external rotation (0, 45 and 90° of hip flexion). All testing was conducted for 5-second maximal voluntary isometric contractions (MVIC) in each testing position. Surface electromyography (EMG) was recorded for the superior and inferior gluteus maximus (GMaxS, GMaxI), anterior, middle, and posterior fibers of the gluteus medius (GMedA, GMedM, GMedP), Biceps Femoris (BF), Semimembranosus (Semi), Adductor Longus (Add), and Tensor Fascia Latae (TFL). The mean EMG activity for the middle three second of the MVIC of each muscle was normalized to the peak activity during the respective testing positions at 0° of hip flexion. MANOVAs were conducted to identify position by muscle interactions. Significance was set to where 95% confidence intervals did not overlap. **Results:** Add (0°: 52.46±1.54, 45°: 57.33 ± 3.57, 90°: 41.52±3.19, p<.038) and TFL (0°: 53.12 ± 2.54, 45°: 58.97±4.22, 90°: 36.98±3.97, p<.038) had significantly lower muscle activity when hip extension was assessed in the 90° testing position. Hip abduction at 45°

resulted in significantly greater GMaxS muscle activity (-5°: 42.28±2.35, 0°: 49.40±1.51, 45°: 69.05±6.11, p<.001), and significantly less activity in the GMedA (-5°: 50.74±2.99, 0°: 55.94 ± 1.33, 45°: 35.48±3.69, p<.001) and Semi (-5°: 45.88±4.68, 0°: 45.90±1.80, 45°: 28.23±2.92, p<.001). Testing hip external rotation at 90° resulting in a significantly greater activity of the Add compared to the other testing positions (0°: 50.59 ± 1.23, 45°: 53.99 ± 3.15, 90°: 84.99 ± 9.14, p < .001). (Figure 1) **Conclusions:** Patient positioning during strength testing influences lower extremity muscle activity. Significantly greater adductor activity was seen during the hip external rotation test at 90°. Increased adductor activity may be a compensation strategy to increase force production during seated hip external rotation testing. Clinicians should be aware that testing the hip external rotators in a seated position may be confounded by role of the adductors and their contribution to this strength assessment. A prone testing position for external rotation removes the adductor influence.

Figure 1: Lower Extremity Muscle Activity during Hip External Rotation Testing



EMG and Force Analysis of a Weightbearing Squat-Hold Position Compared to Traditional Hip Strength Assessment Positions

Sigmund KJ, Earl-Boehm JE:
University of Wisconsin,
Milwaukee, WI

Context: Altered hip strength is a risk factor for lower extremity injury, but methods of hip strength assessment vary. One criticism of current hip strength measurements is that testing positions are non-weightbearing with movements occurring in a single plane which is not functional. A weightbearing measurement may offer a better strategy to assess muscle strength, but no such measure currently exists. The purpose of this study was to determine whether differences exist in force output and selected hip muscle activity between a weightbearing squat-hold (S-H) task and standardized non-weightbearing maximal voluntary contractions (MVCs). **Methods:** We used repeated measures design in a laboratory setting. Twenty-nine healthy individuals volunteered for the study (23 female, 6 male, age 23.3±5.8years, height 170.8±7.3cm, weight= 64.9±9.7kg). A

handheld dynamometer (HHD) measured force output (kg) while surface EMG simultaneously collected muscle activity of the gluteus medius (GMed), tensor fascia lata (TFL), and gluteus maximus (GMax). All participants performed sidelying hip abduction MVCs, prone extension MVCs, and the S-H. MVCs were performed in standard positions with the HHD secured to the distal thigh by a rigid strap. The S-H was performed in a standing semi-squatted position. A rigid strap encircling both knees secured the HHD just above the right lateral femoral condyle while participants exerted a maximal bilateral force against the band. A repeated-measures ANOVA compared peak activity for each muscle between respective MVCs and the S-H. Paired t-tests compared force differences between respective MVCs and the S-H. Significance levels were set at p<0.05 for all analyses. **Results:** A significant interaction (F2,56=15.662, p<0.0001) indicated that peak muscle activity differed by task (Table 1). Follow-up paired t-tests indicated higher peak activity for the TFL during the abduction MVC than the S-H (t28= 4.537, p<0.0001), but peak GMed activity did not differ between the abduction MVC and

S-H (t28= -1.89, p=0.081), and peak GMax activity did not differ between extension MVC and S-H (t28=0.602, p=0.552). Greater force production occurred during the extension MVC compared to the S-H (t28=5.087, p<0.0001), which was also true for the abduction MVC compared to the S-H (t28=7.371, p<0.0001). **Conclusions:** While the S-H yielded similar peak activity of the GMax and GMed compared to traditional MVCs, less force was produced during the S-H. A possible explanation for reduced force output during the S-H is a change to an internal rotation moment arm of these muscles during hip flexion. While the position should not have affected the GMax moment arm, the GMax may be sensitive to changes in pelvic alignment, which was not controlled. Hip flexion during the S-H was standardized to 30° to mimic common rehabilitation exercises. Future research should continue to compare positions that optimize torque production in weightbearing positions to standard strength assessment positions.

Table 1. Peak Muscle Activation and Peak Force Output (Mean ± SD)

Position	Peak Activation, μV			Force, kg
	GMed	TFL	GMax	
Sidelying Abduction MVC	13.1 ± 0.15	36.6 ^a ± 0.57	---	24.9 ± 6.05 ^a
Squat-Hold	19.2 ± 0.38	15.4 ^a ± 0.31	19.7 ± 0.62	16.8 ± 6.53 ^{a,b}
Prone Extension MVC	---	---	20.9 ± 0.12	23.73 ± 8.7 ^b

Abbreviations: MVC= Maximal Voluntary Contraction

^a significant difference between sidelying abduction and S-H at the p<0.0001 level

^b significant difference between extension and S-H at the p<0.0001 level.

Relationships Among Knee, Hip, & Trunk 2-Dimensional Angles and Gluteal Muscle Activity During Squatting

Bazett-Jones DM, Glaviano NR:
The University of Toledo, Toledo,
OH

Context: Knee valgus is thought to be related to knee injury. A common measurement of knee valgus is the Frontal Plane Projection Angle for the knee (FPPA-K). However, other measures of hip, pelvis, or trunk motion might provide more valuable information. Large frontal plane motion during dynamic tasks during a squat is thought to be related to poor hip muscle function, often measured as strength. However, no study has yet determined if motion of the knee, hip, or trunk is related to muscle activity during a squat. Therefore, the purpose of this study was to measure the relationships among knee, hip, and trunk 2-dimensional angles and muscle activity of the gluteus medius and maximus. **Methods:** Twenty healthy female participants (age: 22.3 ± 1.1 years, height 168.4 ± 6.4 cm, mass 63.1 ± 11.7 kg) were recruited from the local university and completed this descriptive laboratory study. Surface electromyography (EMG) was recorded for maximal contractions of the gluteus maximus (superior [GMaxS] and inferior [GMaxI] fibers) and gluteus medius (anterior [GMedA], middle [GMedM], posterior [GMedP] fibers). Participants completed 3 single-leg squats with EMG and were required to keep pace with a metronome (2s down, 2s up). Frontal and sagittal plane video was recorded during the squats and images at peak knee flexion was exported for analysis. The angle, averaged over 3 trials, at peak knee flexion was measured for FPPA-K, hip adduction, pelvic drop, lateral trunk motion (LTM), hip flexion, and trunk flexion. The mean EMG activity during the eccentric and concentric phases of the squat, as well as over the total squat, was normalized to the peak EMG activity for each maximal contraction. Pearson correlations

were conducted to identify relationships among 2-dimensional angles and EMG during squatting. Significance was set to $p < 0.05$. **Results:** GMaxI was significantly and positively correlated to LTM during the eccentric phase ($r = 0.495$, $p = 0.027$), concentric phase ($r = 0.543$, $p = 0.013$), and total ($r = 0.545$, $p = 0.013$) squat. GMedM was significantly and positively correlated to LTM during the concentric phase ($r = 0.483$, $p = 0.031$) and total ($r = 0.462$, $p = 0.040$) squat. All other relationships were non-significant ($p > 0.05$). **Conclusions:** Previous research has reported a relationship between hip muscle strength and 2-dimensional measurements of knee and hip motion, reporting that those with weakness demonstrate more movement. However, the current results indicate that hip muscle function, as measured by EMG, are only related to LTM, not knee or hip motion. One factor to consider is that the squat may not have enough of a loading effect on the muscle to provide differentiation. In conclusion, 2-dimensional angles of the knee and hip measured during squatting are not related to hip muscle function in healthy females. Increased lateral trunk motion away from the stance limb is related to gluteal muscle activity.

The Relationship Between Hip Strength and Multiplanar Running Kinematics at the Hip and Knee

Holmes VC, Simon JE, Yom J, Starkey C, Wayner R: Ohio University, Athens, OH

Context: Female runners display high rates of lower extremity overuse injuries, due in part to abnormal running kinematics and insufficient hip strength. However, less is known about highly trained collegiate cross-country runners impeding the development of preventative and treatment interventions. The purpose of this study was to evaluate the relationship between hip strength and lower extremity running kinematics in the frontal and transverse planes in collegiate cross-country runners. **Methods:** A cross sectional study was conducted on a convenience sample of nineteen female collegiate cross-country runners with no current lower extremity injury (19.5 ± 1.17 years, 163.3 ± 6.57 cm, 53.3 ± 6.23 kg) in a gait laboratory. Participants completed a four-phase treadmill running protocol and had frontal and transverse plane kinematic data recorded via motion analysis. The frontal plane kinematic measures were knee abduction excursion, peak knee abduction angle, and peak hip adduction angle. The transverse plane kinematic measure was hip internal rotation excursion. Hip strength was measured for hip external rotation and hip abduction and was quantified by maximal voluntary isometric contraction (MVIC) and rate of force development (RFD) during static maximal effort muscle contractions. For the main analysis, three correlations were calculated for hip abduction MVIC and the three frontal plane kinematic variables, and one correlation was calculated for hip external rotation MVIC and the transverse plane kinematic variable. In a supplemental analysis using data from seven participants, three correlations were calculated for hip abduction RFD and the three frontal plane kinematic variables, and one correlation

was calculated for hip external rotation RFD and the transverse plane kinematic variable. Alpha level was set a priori at 0.006 to account for multiple correlations. **Results:** Weak and non-significant correlations were found for the main analysis between hip abduction MVIC and frontal plane lower extremity running kinematics, and between hip external rotation MVIC and transverse plane lower extremity running kinematics (-0.11 to 0.17; $p > 0.006$). The supplemental analysis found weak to moderate and non-significant correlations between hip abduction RFD and frontal plane lower extremity running kinematics, and between hip external rotation RFD and transverse plane lower extremity running kinematics (-0.38 to 0.41; $p > 0.006$). **Conclusions:** Caution should be used when correlating clinical measures of hip strength and observations of running gait analysis for this population. Additional research is needed to identify the role of RFD on lower extremity running kinematics due to the small sample size.

Gluteal Muscle Activation in Participants With and Without Low Back Pain During a Dynamic Balance Task

Dembeck AF, DeJong AF, Hertel J, Saliba SA: Exercise and Sport Injury Lab, University of Virginia, Charlottesville, VA

Context: Chronic Non-Specific Low Back Pain (LBP) is a prevalent pathology shown to impact activities of daily living, with specific insufficiencies in dynamic activities requiring postural control. Muscles of the lumbopelvic hip complex have been shown to have altered activation patterns in patients with LBP, however less is known on the role of the gluteal muscles in dynamic balance in LBP. Ultrasound imaging (USI) has been proven to be a reliable way to determine muscle thickness changes throughout a variety of activities including postural control and dynamic balance tasks. Therefore, the purpose of the study was to compare gluteal muscle activation and reach distance during a dynamic balance task between individuals with and without LBP. **Methods:** USI was used to determine differences in gluteal muscle activity in individuals with and without LBP during the Y-Balance Test (YBT) using a cross-sectional design. 44 total participants, 22 healthy (9 males, 13 females; Height [Ht] = 173.02 cm, Weight [Wt] = 71.70 kg, Tegner = 5.7) and 22 LBP participants (9 males, 13 females; Ht = 169.70 cm, Wt = 73.74 kg, Tegner = 6.0) reported to the research laboratory for a single testing session. Bilateral B-mode USI was used to obtain muscle thickness measures for the gluteus maximus and medius muscles during anterior, posteromedial and posterolateral reach directions of the YBT. Thickness measures were normalized to quiet standing images to calculate functional activation ratios. Gluteus maximus thickness during activity was compared to gluteus medius measures to determine preferential activation ratios. Normalized reach distances were measured for YBT performance in all

directions. 2x2 analyses of variance (ANOVA) with significance levels set a priori to 0.05 were used to determine between-group and between-limb differences for the functional activation ratios, preferential activation ratios, and reach distances. Cohen's d effect sizes with 95% confidence intervals were used to determine the magnitude of differences for each comparison. **Results:** There were no significant differences between groups for the gluteus maximus and medius functional activation ratios, preferential activation ratios, or any reach distances. Cohen's effect sizes were small ($d \leq 0.3$) for all comparisons. **Conclusions:** In this study cohort, there were no differences between groups or between limbs for USI gluteal muscle thickness measures or YBT performance between those with and without LBP. This sample of active individuals did not appear to be limited during this dynamic postural control test and were found to activate their gluteal muscles similarly to healthy individuals. Previous investigations have found altered lumbar and abdominal muscle activation patterns in those with LBP suggesting that there are many ways that the lumbopelvic hip complex functions during activity between populations. Future investigations of muscles throughout the lumbopelvic hip complex are warranted during dynamic postural control tasks.

Assessment of Gluteal Neuromuscular Function With the Central Activation Ratio

Gilfeather D, Norte GE, Ingersoll CD, Glaviano NR: The University of Toledo, Toledo, OH

Context: Hip weakness is a common consequence of many lower extremity injuries and may contribute to altered frontal plane motion. Strength is the traditional method to measure gluteal function; however, other measurements may provide unique information about gluteal muscle activation. The central activation ratio (CAR) is commonly used to assess gross neuromuscular function, but has primarily only been studied on the quadriceps. Therefore, the purpose of this study is to quantify the CAR of the gluteus medius (GMed) and gluteus maximus (GMax) in a healthy population. Additionally, we assessed the reliability of this measure over a one-week period. **Methods:** Twenty healthy participants (9 male and 11 females (age: 22.2 ± 1.4 years, height 173.4 ± 11.1 cm, mass 84.8 ± 25.8 kg) were recruited from the university and completed this descriptive laboratory study. Hip abduction and extension at progressive intensities (25%, 50%, 75%) and maximal voluntary isometric contraction (MVIC) were assessed using a stationary dynamometer. Gluteal activation was assessed with the superimposed burst (SIB) technique, with GMed assessed in standing hip abduction and GMax during prone hip extension. Measures were repeated one-week later. Primary outcome measures included (1) GMed and GMax central activation ratio (CAR) (2) normalized hip abduction and extension MVIC and SIB (Nm/kg), and (3) relationship between CAR and hip abduction and extension torque output at progressive contractions with maximal stimulus. Paired t-tests were used to compare differences in outcome measures between the two testing sessions. Interclass correlated coefficients (ICC) were used to quantify test-retest reliability. A line of best fit was used to evaluate the relationship between CAR

and varying progressive contractions for both hip abduction and extension, and coefficient of determination (r^2) were used with a regression analysis.

Results: There were no differences in GMed CAR (Day 1: 96.1 ± 3.37 , Day 2: 96.6 ± 3.16 , $p=0.59$), hip abduction MVIC (Day 1: 1.56 ± 0.29 Nm/kg, Day 2: 1.57 ± 0.51 Nm/kg, $p=0.87$) or SIB (Day 1: 1.59 ± 0.31 Nm/kg, Day 2: 1.60 ± 0.51 , $p=0.89$). There were also no differences in GMax CAR (Day 1: 86.5 ± 7.5 , Day 2: 87.2 ± 10.7 , $p=0.73$), hip extension MVIC (Day 1: 2.54 ± 0.69 Nm/kg, Day 2: 2.64 ± 1.15 Nm/kg, $p=0.69$) or SIB (Day 1: 2.88 ± 0.70 Nm/kg, Day 2: 2.91 ± 1.01 , $p=0.89$). GMed CAR exhibited excellent reliability (ICC $[-3,1] = .911$) while GMax CAR was moderately reliable (ICC $[-3,1] = .704$). A linear relationship demonstrated the line of best fit for both GMed CAR during hip abduction ($r^2=0.409$) and GMax CAR during hip extension ($r^2=0.639$).

Conclusions: The SIB technique appears to be an acceptable method to stimulate the gluteal muscles and assess gross neuromuscular function of the GMed and GMax. CAR is a reliable method to assess gluteal neuromuscular function in a healthy population within a one-week period. Gluteal CAR should be measured within a pathological population to assess potential neuromuscular impairments.

Examining the Relationship Between Hip Strength and Time to Stabilization in Collegiate Volleyball Players

Skammer S, Nakajima M, Wu W, Becker J: Montana State University, Bozeman, MT; California State University, Long Beach, CA

Context: Dynamic postural stability is important for performance and injury prevention in sports with a high frequency of repeated jump landings. One method for assessing dynamic postural stability is by calculating the time to stabilization (TTS), or how quickly an individual can stabilize following a jump landing. Numerous studies have reported increased TTS in individuals with unstable joints. However, relatively few studies have examined factors influencing TTS performance in healthy individuals. Weakness of the hip musculature is one factor which has been associated with numerous lower extremity injuries and could influence TTS performance. The purpose

of this study was to evaluate the relationship between hip strength and TTS performance in healthy collegiate athletes. **Methods:** Sixteen male collegiate volleyball players (age: 20.6 ± 1.4 years; playing experience: 8.3 ± 3.2 years) participated in this study. Muscle strength for the hip abductors, adductors, internal and external rotators, flexors, and extensors was measured using hand held dynamometry. Participants performed a standing long jump onto a force plate sampling at 1000 Hz, landing on one foot. Jump distance was set to 70 cm and jump height to 50% of maximal vertical jump height. TTS was calculated in the anterior-posterior (AP), medial-lateral (ML), and vertical directions using a sequential averaging method generated from a custom Matlab code. A resultant TTS was also calculated from AP, ML, and vertical values. TTS values were calculated for both the right and the left legs and multiple linear regression was used to evaluate relationships between hip strength values and TTS measures. **Results:** Mean TTS values were $3.21 (\pm 0.52)$,

$3.87 (\pm 0.91)$, $3.06 (\pm 0.66)$, and $5.93 (\pm 1.06)$ seconds in the anterior-posterior, mediolateral, vertical, and resultant directions, respectively. Muscle strength did not predict TTS in the anterior-posterior ($R^2 = 0.126$, $P = 0.591$), medio-lateral ($R^2 = 0.072$, $P = 0.841$), or vertical ($R^2 = 0.295$, $P = 0.087$) directions. In the vertical direction, the only significant muscle group were the extensors, with a p-value of .04. Regression coefficients and confidence intervals for each muscle are shown in Table 1. Muscle strength also did not predict resultant TTS ($R^2 = 0.106$, $P = 0.685$). **Conclusions:** Hip muscle strength did not predict TTS in this cohort of healthy individuals. However, previous studies report that hip muscle strength does influence TTS in athletes with a lateral ankle sprain. Thus, the relationship between hip strength and TTS performance appears to change with occurrence of injury. Further research is required to clarify the mechanisms responsible for this changing relationship.

Table 1. Regression results for the individual muscles in the anterior-posterior (AP), mediolateral (ML), and vertical directions.

Direction	Muscle Group	<i>p</i>	β	95% CI
AP	Abductors	0.482	-2.16	-8.40 – 4.07
	Adductors	0.188	-4.07	-10.26 – 2.13
	Extensors	0.761	0.55	-3.13 – 4.23
	Ext. rotators	0.671	1.58	-5.98 – 9.14
	Int. rotators	0.780	0.66	-4.18 – 5.52
ML	Abductors	0.822	1.23	-9.91 – 12.36
	Adductors	0.492	-3.74	-14.79 – 7.31
	Extensors	0.665	-1.39	-7.96 – 5.17
	Ext. rotators	0.653	-2.97	-16.47 – 10.51
	Int. rotators	0.785	-1.16	-9.81 – 7.50
Vertical	Abductors	0.260	-3.92	-10.94 – 3.08
	Adductors	0.817	-0.79	-7.75 – 6.17
	Extensors	0.04	4.30	0.16 – 8.44
	Ext. rotators	0.13	-6.48	-14.97 – 2.02
	Int. rotators	0.95	-0.17	-5.63 – 5.28

Relationship Between Hip Strength and LESS Scores in Youth Athletes Across Stages of Maturation

Crisafulli GA, Osbourne MK, Boling MC, Trigsted SM, Frank BS, Bailey J, Nguyen A: The University of Alabama, Tuscaloosa, AL; High Point University, High Point, NC; University of North Florida, Jacksonville, FL; University of Wisconsin Madison, Madison, WI; Utah Jazz, Salt Lake City, Utah; North Carolina FC Youth, Cary, NC

Context: The Landing Error Scoring System (LESS) is a valid clinical screening tool, shown to identify ACL injury risk in youth athletes. Strength of the hip musculature has been suggested to influence landing patterns. However, the influence of hip muscle strength on LESS scores in youth athletes is unknown. Understanding how hip strength is related to LESS scores, particularly how it may differ across maturation, could help clinicians develop the most appropriate and effective intervention programs to reduce the risk of ACL injuries in youth athletes. Therefore, the purpose of this study was to identify the differences in hip strength and LESS scores, and their relationship, across stages of maturation in youth athletes. **Methods:** A descriptive laboratory study design was used, during a field-based screening, to assess 307 youth male and female soccer athletes (12.1±1.1 yrs, 44.0±9.0 kg, 153.5±14.3 cm). Isometric strength of the hip extensors (HEXT) and abductors (HABD) was assessed bilaterally using hand-held dynamometry. Two-dimensional kinematics were collected during three trials of a jump landing task from a 30 cm high box and scored using an automated LESS scoring system (PhysiMax Technologies Ltd, Tel Aviv, Israel). Percent of adult stature (%AS), using the Khamis-Roche method, classified participants into pre-pubertal (PRE, less than 80%AS, N=119), pubertal (PUB, 80-92%AS, N=115), and post-pubertal (POST, greater than

92%AS, N=73) maturation groups. Normalized peak isometric hip strength (%BW), right and left LESS scores, and a calculated strength and LESS limb symmetry index (LSI) were used for analyses. One-way ANOVA, with Bonferroni's correction, determined differences ($P < 0.05$) in hip strength, LESS score, and LSI between maturation groups. Separate Pearson correlations (r) determined the relationship between hip strength and LESS scores, between strength LSI and LESS LSI, for each maturation group ($P < 0.05$). **Results:** Right HEXT strength in PRE was greater than POST (mean difference = 6.68%, $P = 0.008$). The PUB group had greater left LESS score (mean difference = 0.663, $P = 0.035$) and right LESS score (mean difference = 0.761, $P = 0.013$) compared to POST. Left HABD strength was negatively correlated with left LESS score in the PRE group ($r = -0.184$, $P = 0.046$). Showing an increase in left HABD strength leading to a decrease in left LESS score. **Conclusions:** The observation that PRE had greater strength and greater LESS score compared to POST, in addition to no observed relationship between HEXT strength and landing errors, suggests that measures of isometric strength alone may not contribute to altered landing patterns in youth athletes. While a weak correlation was observed between HABD strength and landing errors, it is unknown whether youth athletes utilize hip strength during dynamic activity. Further research is needed to understand the neuromuscular influences on jump-landing technique across stages of maturation.

Relationship Between Hip Strength, Lower Extremity Movement During a Single-Leg Step-Down Task and Upper Extremity Injury in Professional Baseball Players

Dove H, Michener LA, Brice T, Curran J, Li B, Hostetter G, Chien A, Plummer HA: University of Southern California, Los Angeles, CA; Los Angeles Angels of Anaheim, Anaheim, CA; Andrews Research & Education Foundation, Gulf Breeze, FL; Shirley Ryan Ability Lab, Chicago, IL

Context: Baseball is a dynamic activity that requires strength and control of the lower extremity. Deficits in hip strength and lower extremity movement quality can impact performance and may lead to upper extremity injuries. The purpose of this study was to determine the relationship between hip abductor strength, and hip and knee movement quality during a Single-Leg Step-Down (SLSD) test, on the incidence of upper extremity injuries in professional baseball players. It was hypothesized that players who did not sustain an upper extremity injury would have greater hip abductor strength and better

movement quality during the SLSD test. **Methods:** This was a prospective cohort study performed in an athletic training room. Minor League baseball players (n=130; age=22.10±2.07 years) competing in the 2017-8 season volunteered. Outcome measures were assessed during the pre-season. Hip abduction strength was assessed side lying using a handheld dynamometer (HHD). Data were normalized to body weight. The SLSD test was performed with participants standing on one leg while lowering their contralateral heel to the floor from an 8" step. The SLSD was filmed in the frontal and sagittal planes. Dartfish was used to calculate hip flexion, hip adduction, and knee valgus. All measurements were collected bilaterally. Injuries were tracked during the season. Injury was defined as any overuse or non-traumatic injury to the shoulder, elbow, forearm or wrist. Players were divided into pitchers and position players. A one-way ANOVA was used to compare hip strength measurements and SLSD hip and knee angles between injured and non-injured groups, within pitchers and position players. Binary regression analysis determined the ability of hip abduction strength and SLSD hip and knee angles to predict injury.

Results: There were 24 injured (INJ) and 106 non-injured (non-INJ) players during the season; n=17 injuries were to pitchers, n=7 were to position players. Data are presented in Table 1. Hip abduction strength was significantly greater in non-INJ position players compared to injured position players (mean difference = 13.2kg; 95% CI: 94.2,101.7; p = 0.018). There were no differences between INJ or Non-INJ groups in SLSD hip and knee angles. SLSD measures and hip strength did not predict the development of injury. **Conclusions:** Hip strength may contribute to upper extremity injuries in position players. Position players with lower hip strength measures were more likely to sustain an overuse upper extremity injury. A deficit in hip abduction strength may alter throwing mechanics and increase stresses on the upper extremity. Despite the difference in hip strength between INJ or non-INJ players, lower extremity movement patterns during the SLSD were similar. A deficit in hip abduction strength may alter throwing mechanics and increase stresses at the shoulder and elbow. Pre-season identification of hip strength could assist in the development of injury prevention programs.

	Pitchers				Position Players			
	Total (n = 70)	Injured (n = 17)	Non-injured (n = 53)	Mean difference (95%CI) p - value	Total (n = 60)	Injured (n = 7)	Non-injured (n = 53)	Mean difference (95%CI) p - value
Hip Abduction Strength (kg)*	96.8 ± 12.5	97.0 ± 12.6	96.7 ± 12.6	0.3 kg (93.7 to 99.8) p = 0.920	97.9 ± 14.0	86.4 ± 10.5	99.6 ± 13.7	13.2 kg (94.2 to 101.7) p = 0.018
Lead Leg								
SLSD: Hip Adduction (°)	86.3 ± 3.3	86.2 ± 2.8	86.3 ± 3.5	0.1° (85.5 to 87.1) p = 0.923	87.4 ± 3.5	87.0 ± 2.3	87.4 ± 3.6	.4° (86.4 to 88.3) p = 0.793
SLSD: Hip Flexion Angle (°)	60.1 ± 13.8	60.3 ± 14.7	60.0 ± 13.6	0.3° (56.7 to 63.5) p = 0.927	70.1 ± 17.4	60.1 ± 9.4	71.4 ± 17.8	11.3° (65.2 to 75.0) p = 0.137
SLSD: Knee Valgus Angle (°)	169.9 ± 5.8	170.4 ± 5.6	169.8 ± 5.9	1.5° (168.5 to 171.3) p = 0.689	171.5 ± 4.9	171.2 ± 3.3	171.6 ± 5.1	.4° (170.1 to 172.9) p = 0.877
Trail Leg								
SLSD: Hip Adduction (°)	85.1 ± 2.7	85.5 ± 2.1	85.0 ± 2.9	0.5° (84.5 to 85.8) p = 0.488	85.8 ± 3.6	85.9 ± 2.3	85.8 ± 3.8	.1° (84.8 to 86.9) p = 0.936
SLSD: Hip Flexion Angle (°)	60.5 ± 15.1	58.1 ± 14.4	61.3 ± 15.4	3.2° (56.8 to 64.2) p = 0.454	65.7 ± 16.4	62.2 ± 8.0	66.2 ± 17.2	4.0° (61.1 to 70.3) p = 0.588
SLSD: Knee Valgus Angle (°)	168.9 ± 5.3	169.2 ± 5.2	168.8 ± 5.3	0.4° (167.6 to 170.3) p = 0.806	168.9 ± 5.9	169.5 ± 6.5	168.9 ± 5.9	.6° (167.3 to 170.6) p = 0.790

*Hip Abduction Strength was measured as the lead leg hip abduction strength as a percentage of trail leg hip abduction strength. This value was normalized to the body weight in kg of the player.

Free Communications, Oral Presentations: Concussion Reporting Behaviors and Intentions

Thursday, June 27, 2019, 10:45AM-12:00PM, Mandalay Bay B; Moderator: Megan Houston, PhD, ATC

Examining the Relationship Between Coping Strategies and Intentions to Report Concussion Among Intercollegiate Athletes

Le RK, Anderson MN, Miller LS, Weber ML, Schmidt JD: University of Georgia, Athens, GA

Context: Alarming, approximately 50% of all sport-related concussions are unreported among college and high school student-athletes. Student-athletes will manage behavioral and psychological stressors from concussions using various coping strategies to eliminate the effects of stress. The different types of strategies for coping with a sport-related concussion and its mental outcomes include approach (active, planning, positive reinforcement, humor, and religion), social (emotional support, instrumental support), and avoidance (denial, venting, behavioral disengagement, and self-blame). Therefore, understanding a student-athlete's coping strategy type could aid healthcare professionals in identifying factors influencing intentions to report concussion in collegiate student-athletes. The objective of this study is to examine the relationship between coping responses and intentions to report concussion in student-athletes. **Methods:** A cross-sectional design was used for this study. Collegiate student-athletes ($n=105$, response rate=21.08%, 71 males, 94 females; age=20 +/- 1 year) from three universities in the state of Georgia completed the Brief COPE assessment survey, which consists of 28-items, with each item stating a short description about a particular way of coping with a stressor. For example, "I've been turning to work or other activities to take my mind off things." Participants were instructed to rate each item or description on a 4-point Likert scale (1=I haven't been doing this at all; 4=I have been doing this a lot). The Brief COPE is then assembled into three subcategories: approach (10

items), avoidance (8 items), and social (4 items). Each subscore is computed by summing of two items resulting in a range between 10 and 40. Indirect (8 items) and direct (3 items) intentions were captured using a 7-point Likert scale where student-athletes rated their agreement with statements regarding concussion reporting (1=strongly disagree; 7=strongly agree). A higher score is indicative of greater intentions to report. Responses were averaged across items separately for the three coping subscores: approach, social, and avoidance. Indirect and direct intentions were averaged separately across response items. Spearman's rank-order correlations were used to determine the relationship between coping categories and indirect and direct intentions. The α value was set to $P=.05$ a priori. **Results:** We observed a significant negative correlation, such that student-athletes with higher avoidance coping had lower direct intentions to report concussion, ($r_s=-.212$, $P=.038$). No other correlations were significant. **Conclusions:** Overall, coping type was only modestly associated with intentions to report concussion. Specifically, collegiate student-athletes that use an avoidance coping strategy may also exhibit an avoidance behavior when it comes to reporting a concussion. However, this correlation was weak and should be considered amongst the many other factors that influence concussion reporting. Results of this study suggest to further investigate factors beyond coping type that influence student-athletes' intentions to report.

Sport-Related Concussion Education, Concussion History, and Chronic Traumatic Encephalopathy Beliefs of Collegiate Student-Athletes

Beidler E, McAllister-Deitrick J, Wallace J, Bogar K, Anderson M, Schatz P: Duquesne University, Pittsburgh, PA; Coastal Carolina University, Conway, SC; Youngstown State University, Youngstown, OH; Saint Joseph's University, Philadelphia, PA; Michigan State University, East Lansing, MI

Context: It is mandatory for collegiate student-athletes to receive sport-related concussion (SRC) education. Questions surrounding long-term brain health, specifically chronic traumatic encephalopathy (CTE), have emerged as SRC diagnoses become more frequent. It is unclear how SRC education and concussion history may influence collegiate student-athletes thoughts about CTE, as it is currently a topic that lacks solid research evidence. The purpose of this study was to determine the association between CTE beliefs and SRC education and concussion history of collegiate student-athletes. **Methods:** This cross-sectional study included collegiate student-athletes from all sports at 6 institutions. A convenient sample of 1125 collegiate student-athletes initiated the survey, and 838 [age = 19.68 (1.40) years; 61.9% male; 38.1% female] SRC high-risk sport participants met the inclusion criteria, completed enough usable survey items, and were included in analyses. Concussion history was captured as the self-reported number of diagnosed concussions. SRC education was assessed by asking participants if they had ever received SRC education. An additional list of resources was also included to gauge where participants have gotten SRC information from. CTE exploratory items were added to a validated SRC knowledge scale, and asked participants if CTE was a consequence

of sustaining multiple concussions or returning prematurely to participation while still concussed. The 10-minute survey was distributed in paper/pencil or as an online Qualtrics survey in athletic training clinics or at team practices/meetings. Frequencies were completed for all variables. Chi-square analyses were used to determine the likelihood of CTE belief responses based upon both SRC education and concussion history. Significance was set at $P < .05$. **Results:** Only 49.4% ($n=414$) of the sample reported receiving SRC education. Those who reported receiving concussion education were significantly more likely to believe that premature return to play [$\chi^2(2)=8.41; P=.004$] led to CTE. The majority of the sample (69.5%, $n=580$) reported no diagnosed concussion history, 19.6% ($n=164$) reported 1, and 10.9% ($n=91$) reported 2+. Those with a history of concussion(s) were significantly more likely to believe that a history of multiple concussions [$\chi^2(2)=11.62; P=.003$] and premature return to play [$\chi^2(2)=15.82; P<.001$] led to CTE. Participants who reported beliefs that multiple concussions led to CTE, and those who reported beliefs that premature return to play led to CTE were significantly more likely ($P<.001$) to report getting SRC information from non-reputable resources (movies and books, social media, sports media, general news, online medical sources). **Conclusions:** SRC education and concussion history are associated with CTE beliefs in collegiate student-athletes. It is concerning that only half of the sample recognized that they received SRC education, which may lead them to non-reputable resources that provide them with incorrect information. SRC education initiatives should be revised to focus on topics that are relevant to collegiate student-athletes and actively engage them in the material.

Influence of Developmental and Sociological Factors on Concussion Knowledge, Attitudes, and Self-Reporting Intentions

Chandran A, Kerr ZY, Nedimyer AK, O'Neal C, Mensch J, Yeargin SW: The University of North Carolina at Chapel Hill, Chapel Hill, NC; University of South Carolina, Columbia, SC

Context: Although developmental and sociological factors have been determined to play a role in concussion-related reporting, empirical evidence is limited. We examined the influence of sex, grade-level, school location, concussion reporting history, and socio-economic status (SES) on concussion-related knowledge, attitudes, and reporting intentions among middle school (MS) and high school (HS) athletes. **Methods:** In a cross-sectional design, HS and MS athletes ($n=1461$) attending pre-participation examinations (PPEs) completed a paper survey. Overall, 541 athletes from 18 sports completed surveys (37% completion). Most respondents were boys (62.5%), enrolled in HS (60.8%), and of low SES (64.3%). Our main outcomes originated from validated instruments and measured concussion-related knowledge (range:0-18), perceived seriousness (range:1-21), positive feelings about reporting (range:1-49), and self-reporting intentions (range:1-20). We examined group-differences in these scores across levels of the explanatory variables of sex, grade-level (MS vs. HS), school location (urban vs. rural), concussion [self] reporting history (history vs. no history) and SES [on free/reduced lunch (FRL) vs. not on free/reduced lunch (NFRL)] using Wilcoxon rank-sum tests. Then, we categorized scores for each outcome into 3 ordinal levels using ~33% increments in each score to determine the relative cut-points (e.g., for knowledge; 0-6, 7-12, 13-18). Multivariable ordinal logistic regression models identified predictors of higher score levels for each outcome. All models met proportional

odds assumptions. Odds Ratio (OR) estimates with 95% confidence intervals (CI) excluding 1.00 were deemed significant. **Results:** We observed average scores of 11.0 ± 2.4 , 16.6 ± 3.7 , 39.2 ± 8.9 , and 13.5 ± 3.8 for knowledge, perceived seriousness, positive feelings about reporting, and self-reporting intentions, respectively. Knowledge scores differed between: MS and HS athletes (10.7 ± 2.3 vs. 11.2 ± 2.4 ; $p=0.02$); urban and rural school athletes (11.2 ± 2.4 vs. 10.0 ± 2.1 ; $p<0.001$); and FRL and NFRL athletes (10.7 ± 2.3 vs. 11.5 ± 2.4 ; $p<0.001$). Odds of higher levels of knowledge were higher in urban vs. rural school athletes [OR_{Adjusted}=1.81; 95%CI=1.03-3.17], and lower in FRL vs. NFRL athletes [OR_{Adjusted}=0.52; 95% CI = 0.36-0.77]. We observed differences in seriousness scores between: male and female athletes (16.1 ± 3.8 vs. 17.4 ± 3.4 ; $p<0.001$); and MS and HS athletes (16.1 ± 4.0 vs. 16.9 ± 3.4 ; $p=0.02$). Odds of higher levels of seriousness were lower in male vs. female athletes [OR_{Adjusted}=0.41; 95% CI = 0.26-0.65]. While we found no group differences in positive feelings scores within bivariate analyses, odds of higher positive feeling scores were higher in urban vs. rural school athletes [OR_{Adjusted} = 1.79; 95% CI = 1.05-3.04]. We found differences in self-reporting intention scores between male and female athletes (13.1 ± 3.9 vs. 14.3 ± 3.5 ; $p < 0.001$). Odds of higher levels of self-reporting intentions were lower among male vs. female athletes [OR_{Adjusted} = 0.52; 95% CI = 0.37-0.74]. **Conclusions:** Developmental and sociological factors are associated with concussion-related knowledge, attitudes, and self-reporting intentions. These results can better inform medical providers, parents, and coaches of context-specific clinical assessment of concussion symptoms, as well as initiate targeted interventions aimed at improving reporting behaviors in young athletes.

The Influence of Concussion Knowledge and Years of Clinical Experience on Athletic Trainers' Concussion Healthcare Practices
Lempke LB, Schmidt JD, Lynall RC:
University of Georgia, Athens, GA

Context: Athletic Trainers (ATs) are among the first healthcare providers conducting concussion assessments and implementing return to play (RTP) procedures. Despite ATs vital concussion management role, limited reports have examined factors influencing concussion assessment and RTP practices. Therefore, our purpose was to examine the role of concussion knowledge and clinical experience on concussion assessment and management tool use among ATs. **Methods:** A web-based survey was sent via email with two follow-ups to a random convenience sample of 8,777 ATs (15.0% response rate [1,307/8,777]; certified 15.0±10.6 years; clinical experience 12.7±9.5 years) from the National Athletic Trainers' Association membership in January 2018. The survey collected AT demographic information, number of concussions assessed annually, assessment and RTP tools used, and concussion knowledge using a modified, previously validated survey. Concussion

knowledge consisted of 20 (8 true, 12 false) signs and symptoms recognition questions scored as total correct. Multidimensional assessment batteries were examined based on at least two and three of the recommended battery domains (symptoms, balance, neurocognitive) being utilized. Numerous, multiple logit models determined the odds ratios (OR) with 95% confidence intervals (CI) to examine how knowledge and clinical experience influence the odds of using assessment and management tools. All CI not containing 1.0 were considered statistically significant. **Results:** ATs correctly identified 15.6±3.0 concussion knowledge questions. The number of concussions assessed annually (median:12.0, range:0-218) was not influenced by knowledge or clinical experience ($p \geq 0.12$). When assessing concussion, a one-point increase in knowledge was significantly associated with increased odds for using a clinical examination, symptom checklist, standardized sideline tool, computerized neurocognitive test, and balance test (statistical outcomes presented in Table). A one-point increase in knowledge was significantly associated with increased odds for a two-domain (OR:1.22; 95% CI: 1.16-1.30) and three-domain (OR:1.23; 95% CI: 1.16-1.30) multidimensional

assessment battery. When determining RTP, a one-point increase in knowledge was significantly associated with increased odds of using a clinical examination, symptom checklist, standardized sideline tool, computerized neurocognitive test, and balance test (Table). Every additional year of clinical experience decreased the odds of using standardized sideline tools for assessment (OR: 0.98; 95%CI:0.96-0.99) and RTP (OR:0.98; 95%CI:0.96-0.99), and a symptom checklist for RTP (OR:0.98; 95%CI:0.97-0.99). Clinical experience did not significantly influence use of the remaining assessment and RTP tools. **Conclusions:** ATs displayed less concussion knowledge than anticipated. Better concussion knowledge significantly contributed to increased concussion assessment and management tool use, while more clinical experience contributed to decreased tool use. Decreased standardized tool use with more years of clinical experience is concerning, but should serve as a reminder to experienced clinicians to continue learning and implementing best practices in sports medicine. All ATs should strive to frequently review concussion signs and symptoms and recommended assessment and RTP protocols to ensure optimal patient healthcare and safety.

Table. Influence of Concussion Knowledge on Concussion Assessment and Return to Play Tool Use

	Assessment Odds Ratio (95% CI)	Return to Play (RTP) Odds Ratio (95% CI)
Clinical Examination	1.47 (1.36 - 1.63)	1.35 (1.27 - 1.44)
Symptom Checklist	1.20 (1.13 - 1.27)	1.18 (1.13 - 1.24)
Standardized Sideline Tools	1.21 (1.15 - 1.29)	1.11 (1.07 - 1.17)
Computerized Neurocognitive Testing	1.12 (1.07 - 1.18)	1.16 (1.11 - 1.22)
Balance Testing	1.20 (1.14 - 1.28)	1.12 (1.07 - 1.17)

Odds ratios (OR) and 95% confidence intervals (CI) not containing 1.0 were considered statistically significant. All OR are presented as the odds of performing a task for every 1-point increase in concussion knowledge.

The Influence of Attitudes, Social Pressure, and Perceived Control on Intention to Report Concussion Symptoms in Collegiate Athletes

Baer DJ, Anderson JA, Vaccaro C, Curtis N: West Chester University of Pennsylvania, Chester County, PA; Indiana University of Pennsylvania, Indiana County, PA

Context: Underreporting of concussion symptoms in college athletics presents a challenge for athletic trainers in evaluating and diagnosing such injuries. Some athletes do not report symptoms because they do not recognize that they have a brain injury, however many athletes intentionally withhold symptoms to avoid removal from sport participation. Therefore, the purpose of this study was to quantify individual factors that influence college athletes' intentions to report concussion symptoms to a coach or athletic trainer. **Methods:** In this cross-sectional study, an anonymous online survey was emailed to 8,769 NCAA student-athletes in Pennsylvania. 2,965 respondents from 23 sports, across 22 colleges/universities completed the survey (completion rate = 33.81%). 35% of respondents were male and 65% were female, with a mean age of 20.02 years old. 46% participated in limited/non-contact sports, 37% in contact sports, and 16% in collision sports. 48% of the sample reported a previous history of at least one concussion. Independent variables included athletic identity (AI), attitudes towards symptom reporting, perceived social pressure (PSP), and perceived behavioral control (PBC). AI was measured using the Athletic Identity Measurement Scale, PBC was measured using a self-efficacy scale validated by Kroshus et al., and the remaining independent variables were measured using previously validated scales developed by Register-Mihalik. Factor analysis and reliability testing revealed that attitude (Cronbach's alpha = 0.90) and AI (Cronbach's alpha = 0.77) were unidimensional, while PSP and PBC

were each two-dimensional. PSP included injunctive norms (Cronbach's alpha = 0.79) and descriptive norms (Cronbach's alpha = 0.83), while PBC included capacity (Cronbach's alpha = 0.94) and autonomy (Cronbach's alpha = 0.80). To measure the dependent variable, concussion reporting intention, a mean multi-item scale was developed to capture various reporting conditions, with each item measured on a 7-point scale (Cronbach's alpha = 0.93). Data were analyzed using hierarchical OLS regression. **Results:** Hierarchical regression revealed positive effects of attitude ($b^* = .063$; $p = .005$), descriptive norms ($b^* = .131$; $p < .001$), injunctive norms ($b^* = .107$; $p < .001$), and capacity ($b^* = .196$; $p < .001$) on intention to report symptoms. AI and participation in collision sports had small negative indirect effects on intention, while perceived concussion knowledge had a small positive indirect effect. The full regression model explained 14.24% of variance in reporting intention. **Conclusions:** These findings may help clinicians develop more focused interventions that address key social and individual determinants of underreporting, including attitude, injunctive and descriptive norms, and capacity to report. AI, sport type, and perceived understanding of concussion symptoms also influence reporting intention to a lesser extent. Previous research in this area has failed to address a diverse population of athletes from different sports, and few studies have specifically targeted a college-age population.

Free Communications, Oral Presentations: Role and Hiring of DAT-Credentialed Athletic Trainers

Thursday, June 27, 2019, 12:15PM-1:00PM, Mandalay Bay B;

Moderator: Gary Wilkerson, EdD, ATC, FNATA

Academic Employers' Impressions Regarding the Qualifications of Athletic Trainers With the Doctor of Athletic Training Degree

Welch Bacon CE, Clines SH, Van Lunen BL, Eberman LE: A.T. Still University, Mesa, AZ; Sacred Heart University, Fairfield, CT; Old Dominion University, Norfolk, VA; Indiana State University, Terre Haute, IN

Context: As the Doctor of Athletic Training (DAT) degree continues to emerge as a route to develop advanced practice leaders in athletic training, it is necessary to understand stakeholders' perceptions of this degree. While survey research is useful to determine a baseline understanding of stakeholders' perceptions regarding the DAT degree, it is unclear whether employers in the academic setting perceive the DAT degree will have an impact on their organizations. Therefore, the purpose of our study was to explore the perceptions of employers regarding the perceived value and impact of the DAT degree.

Methods: We used a consensual qualitative research design and purposefully recruited individuals who posted an open faculty position for an athletic training program on the NATA Career Center website between 2017-2018. Nine employers, who were all athletic trainers (ATs), participated in this study (7 women, 2 men; age = 42±8.5 years; years as an educator = 10.3±5.9 years). The principal investigator conducted individual video conference interviews using a semi-structured interview guide to gain insight on employers' perceptions of the DAT degree as well as the role of ATs with the DAT degree in the academic setting. The interview guide was reviewed by a panel of experts for content validity and comprehensibility. Following transcription, a 3-person research team coded the data into themes and categories. Each researcher independently coded the data, and then

the team met to reach a final consensus ensuring accuracy and representativeness of the data. Trustworthiness of the data was ensured by member-checking, multi-analyst triangulation, and the use of auditors. **Results:** One predominant theme that emerged centered around impressions regarding the qualifications of an AT with a DAT degree. Participants' described their perceptions of a DAT-credentialed AT as someone capable of successfully conducting practice-based research and implements innovative practices both in and outside of the classroom. Participants also perceived a DAT-credentialed AT to embody characteristics of advanced practice, including leadership, soft skills, core competencies, and advanced application of knowledge and skills regarding a variety of topics (e.g., manual therapy, concussion) in clinical practice. Finally, while participants shared global impressions of the DAT degree, most discussed relative uncertainty regarding the available DAT degree programs and were unsure of the specific focus of the DAT degree. Many participants incorrectly identified the primary intent of the DAT degree to be the development of clinical experts.

Conclusions: While employers who are involved in the hiring decision of ATs in the academic setting have positive impressions regarding the qualifications of DAT-credentialed ATs, it is clear that the specific role of a DAT degree program is ambiguous to many. Further education is necessary to clarify the intention of the DAT degree and its place in the athletic training education continuum.

Academic Employers' Perceived Benefits and Deterrents of Hiring a Doctor of Athletic Training Credentialed Faculty Member

Eberman LE, Clines SH, Van Lunen BL, Welch Bacon CE: Indiana State University, Terre Haute, IN; Sacred Heart University, Fairfield, CT; Old Dominion University, Norfolk, VA; A.T. Still University, Mesa, AZ

Context: The Doctor of Athletic Training (DAT) degree is recognized as the advanced practice degree in the profession; however, employer perceptions have been mixed. Academic employers have indicated a willingness to hire DAT-credentialed faculty, but how these faculty may impact their organizations remains unclear. The purpose of this investigation was to explore academic employer perceptions of hiring DAT-credential faculty members. **Methods:** We recruited academic employers from athletic training programs who posted an open faculty position between 2017 and 2018. The senior author conducted individual video conference interviews with nine academic employers (7 women, 2 men; age = 42±8.5 years; years as an educator = 10.3±5.9 years). The interview was guided with a semi-structured script that was reviewed by a panel of experts for content validity. Each interview was professionally transcribed, de-identified, and checked for accuracy. Using the consensual qualitative research tradition, a 3-person research team independently coded the data into themes and categories and met to develop a consensus codebook. We established trustworthiness through member-checking, multi-analyst triangulation, and external review. **Results:** Employers indicated that there were potential benefits and deterrents to consider when hiring DAT faculty. Employers described that a mixed faculty make-up, where faculty with both research training (i.e., PhD, EdD) and advanced practice training (i.e., DAT) might benefit

students by providing multiple perspectives and areas of strength. Employers suggested that DAT-credentialed faculty might model behaviors, specifically the core competencies, and socialize students to the expectations of clinical practice. DAT-credentialed faculty might also help students bridge the gap between the classroom and clinical practice and may have more credibility among students and preceptors as an advanced practice leader than PhD- or EdD-credentialed faculty. Conversely, employers also indicated that there may be potential deterrents when hiring a DAT-credentialed faculty member. Specifically, participants indicated a concern whether DAT-credentialed athletic trainers would be eligible for faculty positions, particularly tenure-track faculty positions, at some institutions. This closely aligned with concerns whether DAT-credentialed faculty members could meet scholarship expectations that are often associated with some faculty appointments (i.e. tenure-track) and if they would be able to maintain clinical practice in their faculty positions. While academic employers believed the DAT degree might enhance the public perception of athletic trainers, they also questioned whether their other faculty colleagues would respect a DAT-credentialed faculty member. **Conclusions:** Employers noted the potential benefits of a mixed faculty make-up that included a blend of qualified faculty members. They described that DAT-credentialed faculty members may assist in developing well-rounded athletic trainers who would be better able to translate new knowledge into clinical practice. However, they also expressed uncertainty, which suggests further education is necessary to help higher education administrators understand the value of a DAT-credentialed faculty member.

The Role of Academic Debt and Benefits to the Profession on the Interest of Professional Post-Baccalaureate Athletic Training Students' in a Doctor of Athletic Training Degree

Cohen GW, Medina R, Hoffman E, Paladin S, Clines S, Welch Bacon CE, Eberman LE, Cavallario J, Van Lunen BL: Old Dominion University, Norfolk, VA; Sacred Heart University, Fairfield, CT; A.T. Still University, Mesa, AZ; Indiana State University, Terre Haute, IN

Context: The requirement of completing a post-baccalaureate degree for entry into clinical practice will necessitate those seeking advanced degrees in athletic training to consider the impact of academic debt (AD) and benefits to the profession. We examined interest in a Doctor of Athletic Training (DAT) degree, concerns regarding AD, and perceptions of benefits to the profession of currently enrolled post-baccalaureate athletic training students. **Methods:** Students from 15 of 51 programs that met the inclusion criteria (no additional IRB, good standing with the accreditation agency, had student enrollment) participated in this cross sectional study. 335 students were eligible, and 287 [91 Males (31.7%), 193 females (67.2%)] of them participated (85.7% completion rate). Participants completed a paper survey consisting of demographics and 6 themes which included accumulation of AD, professional goals, curricular content, interest, post-graduate employment opportunities, and benefits to the profession. Questions were asked in select one, open-ended, and 4-point Likert scale formats with responses associated with importance, interest, agreement, and likelihood. The main outcome measures for this part of the larger scale survey were interest in a DAT degree, amount of AD, and perceptions of the impact of a DAT degree on benefits to the profession. Statistics were calculated using IBM SPSS (Version 24; Armonk, NY). Descriptive statistics were used to calculate percentages and frequencies.

Mann-Whitney U tests were used to assess group differences between those interested or not interested in pursuing the degree ($P < 0.05$). **Results:** 170 (59.4%) participants were not interested or minimally interested in pursuing a DAT degree, while 115 (40.2%) were moderately or extremely interested. 43.7% ($n=125$) of participants reported debt accrual following completion of post-baccalaureate programming to range between \$40,000 and \$80,000, with 22% ($n=63$) of students accruing over \$80,000 in debt. There was no difference in AD between interest groups for pursuing a DAT degree ($P=.906$). Participants agreed to strongly agreed that a DAT degree would result in an increase in an athletic trainer's salary (70.7%, $n=202$), lead to athletic trainers being considered for hire (79%, $n=226$) or employed (74.1%, $n=212$) for more diverse settings, lead to an increase in professional recognition by other healthcare providers (83.9%, $n=240$) and within the general population (73.4%, $n=210$), and increase respect (80.1%, $n=229$) and collaboration (77.3%, $n=221$) with other healthcare providers, while also increasing awareness of athletic training amongst healthcare providers (79.8%, $n=228$). **Conclusions:** Accumulation of AD following completion of a post-baccalaureate athletic training program does not affect interest in pursuing a DAT degree within post-baccalaureate athletic training students. Post-baccalaureate athletic training students do agree that the DAT degree will be linked to increases in salary and recognition within healthcare. Future research should examine perceptions of DAT degree completers and employment, debt accumulation, and debt to earnings ratio.

Free Communications, Oral Presentations: Real Life Education Standardized Patients and IPE

Thursday, June 27, 2019, 1:15PM-2:15PM, Mandalay Bay B; Moderator: Stacy Walker, PhD, ATC, FNATA

Athletic Trainers' Preparation, Expectations, and Outcomes from a Standardized Patient Encounter

Boddicker BD, Neil ER, Winkelmann ZK, Walker SE, Eberman LE: Indiana State University, Terre Haute IN; Ball State University, Muncie, IN

Context: A standardized patient encounter (SPE), a common form of teaching and assessment in medical education, can improve confidence, communication, and clinical skills of the learner. The purpose of this study was to explore the perceptions and experiences of post-professional athletic training learners prior to and following an SPE. **Methods:** We used an action research design with pre and post SPE one-on-one interviews. Participants were athletic trainers enrolled as first year learners in a post-professional Doctor of Athletic Training (DAT) program (male=8, female=7, age=24±2, years of clinical experience=3±3). Before the SPE, the instructor provided a detailed assignment description, evaluative criteria, video examples of an SPE, and a question-and-answer session. Participants completed an electronic informed consent and demographic survey (Qualtrics® Inc., Provo, UT). The participants experienced the same case designed to for the learner to demonstrate a comprehensive initial injury evaluation using a whole-person approach: a 21-year-old patient that suffered an acute lateral ankle sprain during an intramural softball game. Semi-structured interviews were completed using teleconferencing software (Zoom, San Jose, CA) 1-2 weeks prior to and 1-2 weeks following the SPE. Interviews were transcribed, and data were analyzed using the consensual qualitative research tradition to identify common domains and categories. The analysis included a 3-person team using a multi-stage process ultimately

confirming a consensus codebook. Trustworthiness was established with multiple researcher triangulation, member checking, and external auditing. **Results:** Four domains emerged during data analysis: (1) emotional state, (2) design of the encounter, (3) realism, and (4) conscious consideration. Participants identified an emotional state that related to the fear of instructor and self judgement, and feeling overwhelmed from the time constraints of the SPE while simultaneously completing multiple tasks to care for the patient. The participants felt the design of the SPE created a safe learning environment for integration of newly learned skills such as whole-person evaluation. Participants expressed that they felt uncertainty as the SPE was perceived as an unknown situation. In the pre-SPE interviews, participants described a feeling of disbelief about whether the SPE would feel genuine and whether it would be different from their typical patients, but were often surprised with the authenticity of the SPE. Participants stated they used self-management strategies such as positive self-talk to control their feelings. Following the SPE, some participants expressed a growth mindset related to improving their clinical skills, while others lacked ownership by blaming their SPE performance on other factors. **Conclusions:** Despite their disbelief prior to the SPE, the design of the encounter provided an authentic learning environment for athletic trainers to integrate and practice their clinical skills, including whole-person evaluation, in a safe environment. However, the learners expressed anxiety and fear related to the SPE that altered their preparation and experience.

The Long-Term Impact of Standardized Patient Encounters During Professional Education on Athletic Training Professional Practice

Jarriel AJ, Armstrong KJ, Hardin BM: Georgia College & State University, Milledgeville, GA; James Madison University, Harrisonburg, VA

Context: As educators, we strive to provide learning opportunities that foster knowledge acquisition and skill development in a safe environment. Standardized patients have been found to enhance students interviewing skills, confidence, clinical skill development, and interpersonal communication. Inquiry of the utilization of SPs is growing in athletic training education, however the impact of these standardized patient encounters have not been examined beyond professional education. The purpose of this investigation was to understand how standardized patient encounters completed during professional education benefitted students in the transition to practice and during clinical practice as a clinician. **Methods:** We employed a consensual qualitative research design. 13 practicing athletic trainers (7 females, 6 males; 26.61 ± 2.14 years old; 3.69 ± 1.43 years experience), participated in this study. Practice settings included secondary school (7), collegiate (4), outpatient clinic (1), and military (1). Semi-structured telephone interviews were conducted to understand how standardized patient encounters completed during professional education impacted the athletic trainer's current clinical practice. All telephone interviews were audio recorded and transcribed verbatim. Data were collected until data saturation occurred. Data were initially read independently by three researchers for understanding and then was coded with meaning units. Data were compared until consensus was reached and a conceptual framework was developed. Trustworthiness was established through data analyst triangulation and

member checks. **Results:** Overall, participants indicated that the standardized patient encounters completed during professional education had a positive impact on their confidence and professional athletic training practice. Two themes emerged from the findings that described the participants' perceptions of how standardized patients facilitated their growth as a healthcare professional including 1) personal growth/development, and 2) professional growth/development. Personal growth/development included comments which emphasized communication and inter-personal skills, the importance of establishing a rapport with patients, and the importance self-reflection and demonstrating an awareness of personal limitations. Comments regarding professional growth/development emphasized how the standardized patient encounters mimicked realistic patient experiences, the importance of clinical decision making, providing holistic patient-centered care, and an increased ability to transition from the student role to autonomous practice as an athletic trainer. **Conclusions:** Athletic training practitioners who completed standardized patient encounters during professional education reported an increase in perceived confidence in clinical skill and inter-personal communication as they transitioned to practice and becoming an independent practitioner. Additionally, participants highlighted that standardized patient encounters should continue to be infused throughout the athletic training curriculum during professional education. Future considerations should involve infusing more holistic integrated cases surrounding psychosocial skills, conflict resolution among all stakeholders of the healthcare team, healthcare administration, and an increase in diverse patient population exposure.

Experiences of Professional Athletic Training and Clinical Psychology Students After Participating in an Interprofessional Standardized Patient Encounter

Gaven SL, Armstrong KA, Ocampo KW: University of Indianapolis, Indianapolis, IN; James Madison University, Harrisonburg, VA; Indiana State University, Terre Haute, IN

Context: Interprofessional education and practice (IPE) is a collaborative approach to learn about, from, and with healthcare providers to improve collaboration and patient care. With an increasing need to recognize, assess, and refer behavioral health conditions in patients, it is imperative to provide students with opportunities for engaging in interprofessional care in a non-threatening environment. The purpose of this study was to examine the experiences of professional athletic training and clinical doctorate in psychology students after participating in an interprofessional standardized patient encounter. **Methods:** We employed a phenomenological design utilizing post encounter debriefing with participants. 15 professional athletic training students (13 bachelor's and 2 master's students, 8 females, 7 males, 22.5 + 0.68 years old) engaged in a standardized patient encounter that warranted a referral to a behavioral health professional, where 6 clinical psychology students (5 females, 1 male, 29.6 + 5.28 years) assisted. Athletic training students obtained a detailed patient history and completed a physical examination, then immediately referred to a behavioral health practitioner. Together, students from both professions collaborated to complete further evaluation and develop a care plan. The following day, students from athletic training and clinical psychology participated in independent debrief sessions. These followed a structured debrief guide and were audio recorded and transcribed verbatim. Data were initially read independently

by three researchers for understanding and then was coded with meaning units. These meaning units allowed the data to be organized into emerging themes and subthemes. Trustworthiness was established through data analyst triangulation and peer review. **Results:** Overall, participants reported they developed an understanding of the professional expertise of the other health profession through this experience. Three themes emerged from participant comments including 1) authentic patient experience, 2) benefits of collaborative care, and 3) need for discussing roles and responsibilities prior to patient interaction. Most importantly, participants reported the realism in interacting with the standardized patient and in making the hand-off to another health professional. The authenticity allowed for both professions to learn about the knowledge and skill the other health professional possesses. Simultaneously, participants recognized that working collaboratively allowed for participants to learn from each other while providing care. Participants also reported the need to discuss the roles and responsibilities of each profession prior to interacting with the patient, to ensure that each understands how to best contribute during patient interactions. **Conclusions:** As emphases continue for interprofessional patient care experiences, standardized patient encounters provide real-time patient experiences in a non-threatening environment to practice interprofessional practice. Debrief facilitated the participant's ability to reflect on their own actions and clinical decisions while collaborating interprofessionally. These encounters allow for further understanding of different healthcare providers and the collaborative care that can be provided for optimal patient care.

Assessing Changes in Student Knowledge and Attitudes Following an IPE Experience

Heinerichs S, Curtis N: West Chester University, West Chester, PA

Context: Research indicates interprofessional education (IPE) improves professional identities and perceptions towards teamwork. Implementing IPE can be difficult because of structural needs such as lack of flexibility to add coursework because of specialized accreditation and difficulties with time-tabling due to the number of students involved. The purpose of this study was to identify changes in knowledge and attitudes of students in a voluntary IPE experience to inform needs for future planning. **Methods:** A descriptive research design conducted in a classroom setting was used. A convenience sample of forty-six out of a possible sixty undergraduate and graduate students from various disciplines (athletic training, exercise science, nursing, nutrition, public health, social work, and speech language pathology) at a public university participated in the study. Subjects completed two segments: first a web-based module and then an interactive in-person workshop. The Interprofessional Student Attitude Scale was used to assess knowledge and attitude changes. This 18-question survey includes eight questions from the Readiness for Interprofessional Learning Scale. The survey was administered online prior to completion of the module and at the conclusion of the workshop. The instrument had a Cronbach's alpha of .72. Wilcoxon Signed Rank Tests were used to compare the pre- and post-survey responses of the participants. **Results:** There were statistically significant changes in 10 of the 18 items. Median (Md) scores increased on the Likert-type scale (i.e., 5 - strongly agree, 4 - agree, 3 - neutral, 2 - disagree, 1 - strongly disagree) from pre to post in the following items: I have worked with students from other health professionals in an

inter-professional team ($p < 0.01$, Md pre = 2, Md post = 4), I understand the respective role of social workers within an interprofessional team ($p < 0.01$, Md pre = 4, Md post = 5), I understand the respective role of nurses within an interprofessional team ($p < 0.00$, Md pre = 4, Md post = 5), I understand the respective role of dietitians within an interprofessional team ($p < 0.01$, Md pre = 4, Md post = 4.5), I understand the respective role of athletic trainers within an interprofessional team ($p < 0.01$, Md pre = 4, Md post = 5), I understand the respective role of public health professionals within an interprofessional team ($p < 0.01$, Md pre = 3, Md post = 4). **Conclusions:** Students' knowledge of the disciplines significantly improved after the intervention and more intentional IPE opportunities should be implemented. Activities should include concepts and applications for helping students understand and value how working as an effective team can improve patient outcomes.

Free Communications, Oral Presentations: Injury and Wellness in Public Safety Individuals

Thursday, June 27, 2019, 2:30PM-3:30PM, Mandalay Bay B; Moderator: Nancy Burke, MS, LAT, ATC

The Influence of Firefighter Equipment and Gear on Dynamic Postural Stability

Kollock RO, Hale D, Sanders G, Rennie B, Thomas J, Long A: The University of Tulsa, Tulsa, OK; Northern Kentucky University, Highland Heights, KY

Context: Firefighters routinely face dangerous conditions. The nonfatal casualty rate for firefighters is 448.4 per 10,000 full-time workers. Injuries resulting from falling, jumping and slipping account for 20% of injuries at the fireground. The equipment and gear (EQG) worn by firefighters during fire-suppression activities is believed to be a contributing factor to injury. The EQG is designed to protect a firefighter from smoke inhalation and the extreme thermal conditions; however, EQG may impede normal movement and make it not only difficult to initiate a movement but also to control preceding movements and maintain stability. A loss of stability may result in an increased susceptibility to falls and/or injury. The purpose of this study was to determine the influence of EQG on dynamic postural stability during a single-leg landing (SLL). We hypothesized that dynamic postural stability would significantly differ with and without EQG. **Methods:** Twenty-eight fire cadets were recruited (27.67 ± 4.67 yrs., 169.23 ± 37.09 cm, 86.79 ± 13.84 kg). The participants performed three SLL trials with and without EQG. The SLL required the participant to drop onto their dominant leg from a 30 cm box placed approximately 10% of their height away from a 40 cm x 60 cm force plate. Upon landing, the participants had to stick the landing and remain motionless for a ten-second period. The dominant limb was defined as the limb the participants would use to kick a ball with maximal effort. The participant first performed three SLL trials wearing shorts, t-shirt, sneakers and no equipment or gear. Following

the without EQG condition, the participant then performed three more SLL trials wearing a self-contained breathing apparatus, turnout coat, pants, boots, hood, gloves and helmet. The main outcome measure was average dynamic postural stability index (DPSI) values. The first three seconds of the ground reaction forces immediately following initial ground contact was used to calculate the DPSI. Initial ground contact was defined as the instant the vertical ground reaction force exceeded 5% body weight. A higher DPSI value represents worse dynamic postural stability. A paired sample t-test was used to compare average DPSI between the two conditions. Alpha level was set at .05. **Results:** DPSI did significantly ($t(27) = -13.79$, $p < 0.001$) differ with EQG ($.52 \pm .07$) versus without EQG ($.35 \pm .05$). **Conclusions:** The results of the study indicate that EQG diminishes postural stability. The decrease in dynamic postural control, indicated by increases in DPSI values, may increase fall and/or injury susceptibility. Those involved with overseeing the health and safety of firefighters should consider inclusion of training programs that include balance activities with EQG to enhance dynamic postural control. Inclusion of balance exercises may help reduce the negative influence of EQG on stability during fire-suppression activities.

Barriers to Promoting Injury and Illness Prevention in the Fire Service: A Qualitative Report From Fire Chiefs

Games KE, Winkelmann ZK, Jackson BC, Clark CL, Watts SL, Eberman LE: Indiana State University, Terre Haute, IN

Context: The job tasks and duties of firefighters often place them at risk for injury and psychological stress. Previous work has developed evidence-based injury prevention and wellness protection interventions, yet adoption of these programs are low, despite significant investments from national firefighting organizations. **Methods:** We used an open-ended qualitative survey (Qualtrics®, Inc., Provo, UT) to assess the barriers fire chiefs experience in promoting injury and illness prevention strategies in the fire service. We recruited members of the International Association of Fire Chiefs (IAFC) and 54 fire chiefs (age = 51 ± 8 y; females = 4, males = 50, years of experience as fire chief = 7 ± 6 y) responded to the survey. We developed and content validated an open-ended survey with one item asking the participant to describe the barriers they experience in promoting injury and illness prevention. We analyzed qualitative data using the consensual qualitative research (CQR) tradition. The CQR process included a 3-person data analysis team and a multi-phase process to build a consensus codebook. Data credibility was established with multiple analyst triangulation and internal auditing. **Results:** Four domains emerged from the participant's responses: 1) resources, 2) culture, 3) reporting, and 4) no barriers. Fire chiefs stated that they lacked the resources to properly implement injury prevention and wellness as they required additional financial resources and education related to specific strategies to be successful. Fire chiefs also perceived that the firefighters they served did not have the time

to complete injury prevention, while the department itself lacked access to the appropriate personnel, such as healthcare providers, to implement the programming. Additionally, the culture of the fire department negatively influenced the fire chiefs as they maintained the status quo, whereby no current injury prevention strategies in place, and the “tough guy” mentality of the firefighters inhibited successful implementation efforts. Finally, fire chiefs discussed a lack of consistency, support, and communication in reporting injury and illnesses as a barrier when attempting to promote prevention programs. It is worth noting that a small sample of the fire chiefs (n=7, 13%) reported that they have not experienced barriers in promoting injury and illness prevention strategies. **Conclusions:** The present study highlights the barriers fire chiefs’ experience related to promoting injury and illness prevention strategies in the fire service. While many resources have been invested into the prevention strategies themselves, few resources have been devoted to overcoming the structural and culture barriers to promote adoption of these programs. Future work should develop specific adoption and compliance strategies for fire leadership. As the barriers described in this study were related to education, personnel, and support, the introduction of an athletic trainer to serve as the coordinator of care in the fire service may improve the successful adoption of injury and illness prevention strategies in the fire service.

Time-Loss From Work Due To Musculoskeletal Injuries in Public Safety Employees: A Systematic Review

Guerra EC, Games KE: Indiana State University, Terre Haute, IN

Context: Public safety employees (law enforcement, fire, and rescue) regularly place themselves at risk for injury as part of their daily job requirements. Data regarding work loss injuries in this sector is inconsistent and widely variable. The purpose of this systematic review (SR) was to examine the current literature regarding lost work days due to injuries sustained on the job in public safety employees. **Methods:** Utilizing meta-analysis of observational studies in epidemiology (MOOSE) guidelines, we completed an SR of current literature. The search included PubMed and CINAHL databases. Keywords searched included lost time, injury, firefighter, police, law enforcement, paramedic, EMS, and first responder. Inclusion criteria were full-text articles written in English, studying humans, and published between January 1980 and October 2018. Exclusion criteria included previously published systematic reviews and meta-analyses, fatalities, burns, smoke inhalation, heat exhaustion, head injuries, PTSD, and job titles that did not relate to firefighter, police, or first responder. The PubMed search utilized the “Advanced” Boolean builder with (firefight*) AND injury) AND lost time; (police) OR Law enforcement) AND injury) AND lost time; (paramedic) OR emergency medical services) OR EMS) OR first responder) AND injury) AND lost time. For CINAHL, we utilized the basic Boolean search term (first responders or firefighters or paramedics or police or emergency services) AND (injury or injuries or accident or trauma) AND (lost time). After reviewing the titles for relevance and removing duplicates, and initial screen of titles and abstracts were completed independently by two authors, followed by a full-text review.

Results: Our initial search yielded 151

articles, and 143 met initial inclusion criteria. After screening titles, abstracts, removing duplicates, and applying the exclusion criteria, ten studies remained for review. Of the ten studies included, nine provided specific information about time lost from work due to injuries. The studies reported on cases of between 277 – 21,690 time-loss injuries. The amount of time missed ranged from 6 work days per injury to 25 work days per injury. The literature suggests that injuries in EMS personnel typically resulted in higher rates of missed work compared to firefighters and law enforcement personnel. Injuries to the low back, including back strains, accounted for the largest number of injuries resulting in missed work. **Conclusions:** Our systematic review found that non-fatal workplace injuries result in significant lost work days in public safety populations. The burden of these lost work days is multiplied given that mandatory adequate staffing requires other members of the employee’s organization to work overtime in order to meet staffing minimums. Future work should focus on creating standardized injury surveillance and reporting system for public safety personnel to more effectively track the short-term and long-term outcomes and consequences of work-related injuries.

Fire Chiefs Perceived Barriers to Reporting Mental and Behavioral Illnesses in the Fire Service

Jackson BC, Thews KN, Winkelmann ZK, Eberman LE, Games KE: Indiana State University, Terre Haute, IN

Context: Firefighters are regularly exposed to psychological stress as part of their regular job duties. Often this psychological stress leads to mental and behavioral health concerns; however under-reporting of mental and behavioral health concerns often leads to delayed care. The purpose of this study was to identify perceived barriers to reporting mental and behavior illnesses (MBI) in the fire service. **Methods:** We utilized a cross-sectional, observational design. Data were collected through a web-based survey. The survey was content and face validated using previous literature and a panel of experts. Participants selected perceived barriers from a list of structural and cultural factors. Once identified, participants rated each barrier on a 4-point Likert scale (slightly challenging=1, moderately challenging=2, very challenging=3, extremely challenging=4). We also collected demographic data including age, sex, years of experience, firefighters under their command, and community data. Variables included perceived barriers that inhibit reporting MBI in the fire service. Data were analyzed using means, standard deviations, frequencies, and modes. **Results:** A random sample fire chiefs from the International Association of Fire Chiefs database accessed the survey (n=102/2085) with 52.9% of fire chiefs completing the tool in its entirety. Fire chiefs (n=54/102) are 50.0±7.9 years of age, predominantly male (male, 50, 92.5%; female, 4, 7.4%), with 7.4±5.9 years of experience as fire chiefs and commanding a medium department size of 65 firefighters. A change in duty status (n=17/54, 31.5%, mode=2) was the most frequently selected barrier to promoting MBI reporting. Although reported less frequently, fire chiefs also reported

poor communication (n=15/54, 27.8%, mode=3) and unhelpful medical services provided (n=11/54, 20.4%, mode=3) as very challenging barriers. Fire chiefs perceived embarrassment of MBI (n=45/54, 83.3%, mode=4), a belief that MBI jeopardizes their career (35/54, 64.8%, mode=3) and letting fellow firefighters down (31/54, 57.4%, mode=3) were the most frequent and challenging barriers preventing firefighters from reporting. **Conclusions:** Fire chiefs perceived that change in duty status, communication, and poor medical services are barriers to promoting MBI reporting in the fire service. However, fire chiefs do not see leadership as a barrier to reporting MBI. Fire chiefs believed that firefighters have barriers which deter reporting of MBI including embarrassment of the injury, disappointing coworkers, and putting their career in jeopardy. Together these results suggest there are structural and cultural barriers fire chiefs believe limit firefighters from reporting MBI. As healthcare services continue to expand in the fire service, athletic trainers must be aware of these barriers and create an environment to improve care of patients with MBI. Additionally, athletic trainers should consider educational interventions and healthcare collaboration with municipality stakeholders, fire chiefs, and other occupational health providers to reduce cultural and structural barriers to reporting MBI.

Free Communications, Oral Presentations: Masters Oral Awards

Tuesday, June 25, 2019, 8:00AM-9:00AM, Mandalay Bay C; Moderator: Dan Clifton, PhD, ATC

The Relationship Between Injury-Related Fear and Visuomotor Reaction Time in Individuals After Anterior Cruciate Ligament Reconstruction

Genoese FM, Baez SE, Heebner NR, Hoch MC, Hoch JM: University of Kentucky, Lexington, KY

Context: Individuals who sustain an ACL injury have exhibited deficits in reaction time prior to their injury. Increased levels of injury-related fear are cited as a primary reason for lack of return to sport after anterior cruciate ligament reconstruction (ACLR). Injury-related fear may also hinder the ability to process information and make decisions, which could further contribute to deficits in visuomotor reaction time (VMRT) and increase risk for additional injury in this population. The objective of this study was to examine the relationship between injury-related fear and VMRT in individuals with a history of ACLR.

Methods: Twenty participants (15 females; age = 24.47±4.75years, height = 168.94±9.12cm, mass = 67.91±14.63kg, 5 males; age = 24.6±2.41years, height = 183.39±9.4cm, mass = 82.83±7.46kg) with history of unilateral ACLR at least one year post-operatively (7.15±4.43 years) participated in this cross-sectional study. Participants completed the Fear-Avoidance Beliefs Questionnaire (FABQ) before completing a lower extremity VMRT task bilaterally. The FABQ is a dimension specific patient-reported outcome designed to measure fear-avoidance beliefs about sport (FABQ-S) and physical activity (FABQ-PA). Higher scores on each subscale represented elevated levels of fear-avoidance beliefs. Lower extremity VMRT was measured bilaterally using a novel clinical neurocognitive testing protocol. The VMRT test required participants to touch lighted targets systematically positioned on the ground with their foot as quickly as possible

while standing on a single limb. Higher VMRT (seconds) represents slower reaction time. Descriptive statistics were summarized for all variables (mean±standard deviation). Spearman's Rho correlations were employed to examine the relationship between injury-related fear and lower extremity VMRT (seconds). Correlations were interpreted as very weak (0.00-0.19), weak (0.20-0.39), moderate (0.40-0.59), strong (0.60-0.79) and very strong (0.80-1.0). Alpha was set a priori $p < 0.05$.

Results: The average FABQ-S score was 9.85±8.15 and the FABQ-PA was 6.70±5.13. The average VMRT for the injured limb was 0.55±0.05 seconds and the uninjured limb was 0.56±0.07 seconds. There was a moderate correlation between FABQ-S scores and injured limb VMRT ($r_s = 0.559$, $p = 0.01$). There was a strong correlation between the FABQ-PA scores and injured limb VMRT ($r_s = 0.635$, $p = 0.003$). The correlation between the FABQ-S and uninjured limb VMRT was weak ($r_s = 0.327$, $p = 0.159$), while the FABQ-PA score and uninjured limb VMRT was moderate ($r_s = 0.412$, $p = 0.071$). **Conclusions:** Our results indicate individuals with a history of ACLR who have greater levels of injury-related fear have slower lower extremity VMRT. This relationship appears to be stronger on the injured limb. Deficits in reaction time may increase susceptibility to errors in judgement or loss of coordination when trying to respond to environmental cues during sport. Injury-related fear may be considered a modifiable factor that could potentially reduce injury risk and improve VMRT. Future research should explore interventions, such as graded exposure therapy, to address injury-related fear and VMRT in individuals after ACLR.

Sport Sampling Affects LESS Scores and Physical Literacy Competency in Children

Malone ZC, Zuk EF, Root HJ, Beltz EM, DiStefano LJ: University of Connecticut, Storrs, CT; A.T. Still University, Mesa, AZ; Emory & Henry College, Emory, VA

Context: In order for youth athletes to maintain long-term physical activity participation they must avoid injury and develop physical literacy, which are the ability, confidence and desire to be active. Sport sampling is associated with improved landing technique, which may reduce the risk of injury. The association between sport sampling and physical literacy competency is currently unknown, but this knowledge would guide future recommendations for youth athletes. The purpose of this study was to compare physical literacy competency and landing technique between children with and without a history of sport sampling. It was hypothesized that children with experience participating in two or more sports would demonstrate greater competency and lower LESS scores than those who competed in one sport or less. **Methods:** This was a cross-sectional study including 179 children (92 males, 87 females) from six schools or local sport organizations that volunteered to participate. Physical literacy competency tasks, which examine fundamental movement skills, were assessed using the validated PLAYfun assessment tool and divided into five domains: locomotor, balance, upper extremity object control, lower extremity object control, and running. Each consisted of discrete tasks. Trained raters evaluated competency during these tasks using a continuous visual analog scale of 0-100 points. Participants also performed three trials of a standardized jump-landing task. A validated markerless motion capture system was used to calculate LESS scores. Participants also completed a questionnaire detailing

which sports they have played. Sport sampling groups were formed based on sport participation history (LOW SAMPLING: <2 sports; SAMPLING: ≥2 sports). Participants were divided into age groups based on their current grade (Elementary: grades K-4; Middle: grades 5-8). Separate analyses of variance for age groups were conducted to evaluate physical literacy competency in each domain and LESS scores between sport sampling groups. **Results:** In middle school children, the SAMPLING group (n = 57) demonstrated lower LESS scores (p = 0.003, SAMPLING: 6.42 ± 1.74 errors; LOW SAMPLING: 7.73 ± 1.97 errors) and greater locomotor scores (p=0.03; SAMPLING: 93.63 ± 13.00 points, LOW SAMPLING: 86.09 ± 19.40 points) than the LOW SAMPLING group (n=28). In elementary school children, the SAMPLING group (n=37) had higher LESS scores (p=0.03, SAMPLING: 8.39 ± 2.14 errors, LOW SAMPLING: 7.33 ± 1.70 errors) and improved upper extremity object control (p<0.001, SAMPLING: 71.26 ± 14.38, LOW SAMPLING: 53.47 ± 19.25), lower extremity object control (p < 0.001, SAMPLING: 63.42 ± 13.4, LOW SAMPLING: 45.78 ± 21.87), and total competency (p = 0.03, SAMPLING: 67.78 ± 10.73 points, LOW SAMPLING: 62.34 ± 11.01 points) compared to the LOW SAMPLING group (n = 45). **Conclusions:** Sport sampling is associated with improved physical literacy competency in children, especially upper and lower extremity object control in elementary school age groups. Sport sampling is associated with improved landing control in the older children of this study. Future research should evaluate the associations between other physical literacy factors, such as confidence and desire, and sport sampling.

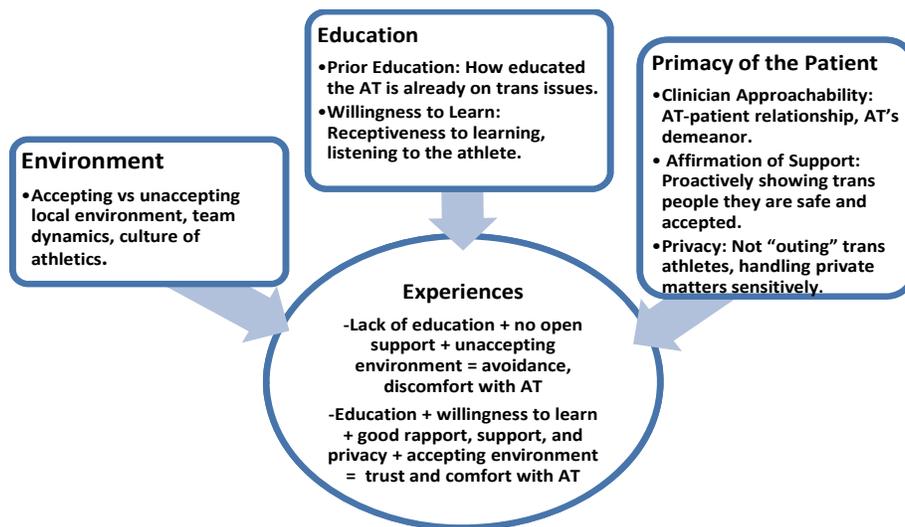
Experiences of Transgender Athletes in the Athletic Training Setting: A Qualitative Study

Munson E, Ensign KE: Ohio University, Athens, OH

Context: Transgender (“Trans”) is a term which means identifying as a different gender than you were assigned at birth. Transgender people often report negative healthcare experiences, including harassment and denial of care, leading many transgender people to avoid seeking healthcare. Little is known about transgender athletes’ experiences in the athletic healthcare setting and their experiences of with athletic trainers are currently unknown. The objectives of this study were to identify barriers transgender athletes may experience when seeking healthcare and to describe common experiences transgender athletes have with athletic trainers. **Methods:** A phenomenological qualitative design was chosen, consisting of semi-structured phone interviews. Interview questions addressed positive and negative experiences, avoidance, and perceived athletic trainer knowledge on transgender issues. Transgender participants were sampled from participants who

completed a lesbian, gay, bisexual, and transgender healthcare satisfaction survey and agreed to complete a follow up interview. Additional participants were added to the study from previous participants’ referrals. Participants needed to be 18 or older, transgender, an athlete within the past 5 years, and had access to an athletic trainer. Interviews were conducted until data saturation was reached. Nine participants (n=9) from high school (n=2), college (n=4), club (n=2), and semi-professional (n=1) athletics were interviewed. Mean age was 23.56±5.32. Participants included trans men (n=3), trans women (n=3), and non-binary/genderqueer people (those who do not identify as solely male or female) (n=4), with one participant identifying as both “trans man” and “non-binary”. Interviews were recorded, transcribed and analyzed for themes. Themes were checked with a peer reviewer and member checking was completed to validate findings. **Results:** Three themes emerged: Education, Primacy of the Patient, and Environment. Education includes the sub-themes Prior Education and Willingness to Learn, and describes athletic trainers’ knowledge on transgender issues and their receptiveness to learning about these issues. Primacy of the

Patient describes athletic trainers’ behaviors when interacting with transgender patients; including the sub-themes Clinician Approachability, Affirmation of Support, and Privacy. Environment describes how social environment impacts transgender athletes’ comfort with athletic trainers. Participants commonly perceived a lack of clinician education on transgender issues. When combined with unwillingness to learn, lack of support, or a hostile environment, this lead to discomfort and avoidance. Positive experiences were described when patient privacy was respected, support was demonstrated, and athletic trainers “learned with the athlete.” Figure 1 shows the relationship between the themes. **Conclusions:** Athletic trainers can improve their care of transgender patients in several areas. Information about transgender people should be included in professional athletic training curriculums, and athletic trainers should seek out continuing education on transgender topics. Athletic trainers can also use inclusive language, visually signal (posters, symbols) their facilities are safe for all people, and be aware of resources for transgender athletes.



The Effect of Exercise on a Novel Dual-Task Assessment for Sport Concussion

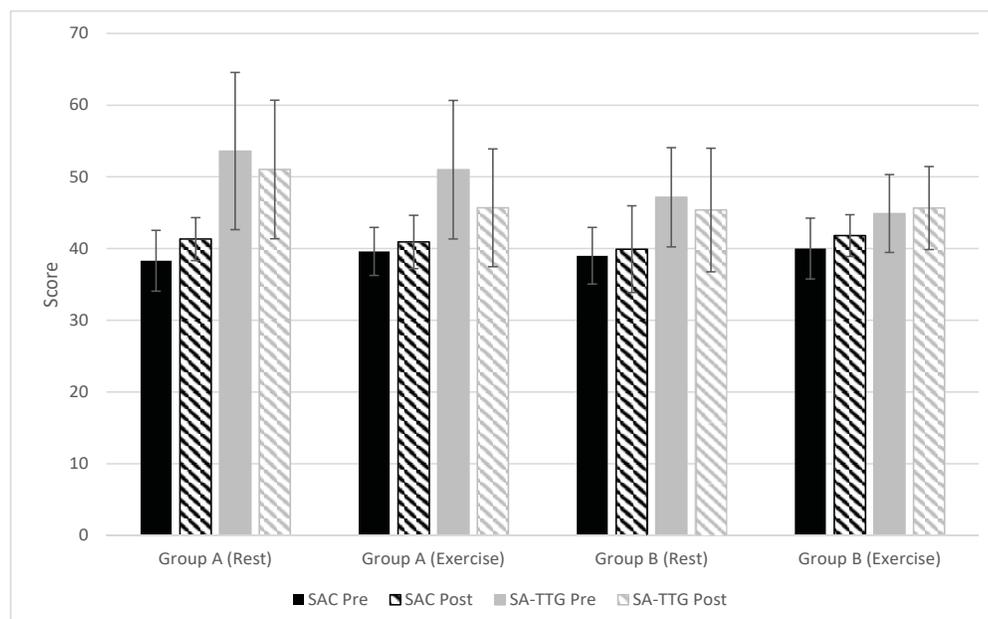
Jimenez J, Erdman NK, Hart JM, Resch JE: The University of Virginia, Charlottesville, VA

Context: The dual-task (DT) paradigm is theorized to increase cognitive load which may highlight subtle impairments following a sport concussion. Exercise has been shown to have variable effects on cognitive and motor performance; however, current research has not examined these effects on DT performance. The purpose of our study was to evaluate the effect of exercise and rest interventions on cognitive and motor performance, and subsequent test-retest reliability, using a novel DT assessment in a healthy collegiate population. **Methods:** Sixty healthy, recreationally active adults (32 females, 28 males; Age: 20.5±1.34 years, Height: 171.7±9.33 cm, Mass: 69.25±12.23 kg) participated in this study. Participants completed two, counter-balanced sessions consisting of exercise and rest interventions separated by a two-week test-retest interval. The exercise intervention consisted of five minutes of

incline treadmill walking alternated with one minute of jumping tasks (lateral hops, squat jumps) for a total of 30 minutes. The rest period required participants to sit at a desk with no added cognitive load (i.e. texting, reading, talking) for a period of 30 minutes. Prior to and following each intervention, participants completed the novel DT assessment which consisted of the standardized assessment of concussion (SAC) and timed tandem gait (TTG) test administered concurrently. For the SAC, individual domain scores for immediate recall (10-item list), concentration (digit span, months in reverse order), and delayed recall were summed to calculate the composite score. For the TTG, average values were calculated for each SAC domain and combined to generate the summed average TTG (SA-TTG) score. The concentration domain is comprised of two unique tasks (digit span, months in reverse order) for which average values were calculated separately. Independent sample t-tests identified differences between groups in pre-intervention scores for the SAC and SA-TTG. Thus, one-way analyses of covariance (ANCOVA) were used to compare SAC and SA-TTG

post-intervention scores while controlling for pre-intervention differences. Mixed-model intraclass correlation coefficients (ICC_{3,1}) with 95% confidence intervals were calculated to evaluate test-retest reliability between pre- and post-intervention scores. All analyses were performed with $\alpha=0.05$. **Results:** No statistically significant differences were observed following exercise or rest interventions for SAC or SA-TTG scores ($p>0.05$). Good to excellent reliability was observed following exercise for the SAC (ICC=0.80 [0.67, 0.88]) and SA-TTG (ICC=0.93 [0.88, 0.96]). Moderate to excellent reliability was observed following rest for the SAC (ICC=0.65 [0.42, 0.79]) and SA-TTG (ICC=0.97 [0.94, 0.98]). **Conclusions:** Composite scores for the SAC and TTG from our novel DT assessment were resistant to exercise in a healthy population as supported by an absence of statistical change following the intervention, as well as good to excellent test-retest reliability from pre- to post-intervention. Our results align with previously established test-retest values for individual administration of the SAC and TTG test.

Figure 1. Adjusted Group Means for Standardized Assessment of Concussion (SAC) and Summed-Average Timed Tandem Gait (SA-TTG) Composite Scores Prior to and Following Exercise and Rest.



Free Communications, Oral Presentations: Doctoral Oral Awards

Tuesday, June 25, 2019, 9:15AM-10:15AM, Mandalay Bay C; Moderator: Saskia Richter, PhD, ATC

Low Self-Efficacy and Mental Health Disorders Predict Persistent Postoperative Pain 3-Months Following Hip Arthroscopy

Jochimsen KN, Mattacola CG, Noehren B, Duncan ST, Jacobs CA: University of Kentucky, Department of Rehabilitation Sciences, College of Health Sciences, Department of Orthopedic Surgery and Sports Medicine, Lexington, KY

Context: Mental health scores have previously been reported to highly correlate with preoperative symptoms in patients with femoroacetabular impingement (FAI), and patients with psychological comorbidities such as depression or anxiety have demonstrated worse postoperative outcomes after hip arthroscopy. However, in order to design evidence-based interventions to improve outcomes for this high-risk subset, we must first identify the specific pain coping behaviors that underpin these poor outcomes. Therefore, the purposes of this study were to 1) determine the effect of preoperative pain catastrophizing, self-efficacy, and kinesiophobia on postoperative pain, and 2) determine if these variables were predictive of postoperative pain. We hypothesized that preoperative pain catastrophizing, low self-efficacy, and kinesiophobia would result in worse postoperative pain, and that these variables would be predictive of an increased risk of developing persistent postoperative pain. **Methods:** A total of 52 patients (41F/11M; age 36.7 ± 12.2 years; BMI 27.1 ± 4.6 kg/m²) with symptomatic FAI undergoing hip arthroscopy consented to participate in this IRB-approved prospective longitudinal study. Preoperatively patients completed the Pain Self-Efficacy Questionnaire (PSEQ), Tampa Scale for Kinesiophobia (TSK), Pain Catastrophizing Scale (PCS), and postoperatively patients completed a 10-point visual analog scale (VAS) for

hip pain at rest and during activity. Self-reported mental health disorders and duration of symptoms were recorded. Fisher's exact tests were used to compare the prevalence of increased postoperative pain defined as VAS > 3 based on preoperative thresholds on the PSEQ, TSK, and PCS, odds ratios were calculated, and separate multivariate logistic regressions were used to determine if models could be created to accurately predict the presence of increased postoperative pain three months post hip arthroscopy. **Results:** The odds of developing increased postoperative pain (VAS > 3) was 5.6 times higher for patients with high preoperative pain catastrophizing (95% CI 1.3-23.4), 42 times higher for those with low preoperative self-efficacy (95% CI 4.7-371.9), and 26.6 times higher for patients with both (95% CI 5.1-138.4). A model consisting of preoperative PSEQ and self-reported mental health disorders was predictive of postoperative pain at rest ($r^2 = .47$) and a model consisting of preoperative PSEQ was predictive of increased postoperative pain during activity ($r^2 = .15$). **Conclusions:** Low preoperative self-efficacy and/or high pain catastrophizing increase the odds of persistent postoperative pain after hip arthroscopy for symptomatic FAI. Pain related self-efficacy, a patient's belief in their ability to complete tasks despite their pain, and pain catastrophizing, an exaggerated negative response to pain, are important determinants of long-term recovery and are both viable treatment targets. As such, evidence-based interventions such as patient education and relaxation techniques should be applied in this high-risk population to mitigate the effects of poor preoperative cognitive coping.

Rationale for a Parsimonious Measure of Subjective Knee Function After ACL Reconstruction: A Rasch Analysis

Duckett TR, Hart JM, Fox C, Norte GE: The University of Toledo, Toledo, OH; University of Virginia, Charlottesville, VA

Context: The International Knee Documentation Committee (IKDC) Subjective Knee Evaluation is often used as an indicator of subjective knee function with return-to-sport decision-making after ACL reconstruction (ACLR). Yet, current research has not demonstrated whether the IKDC only measures knee function or additional dimensions that would distort the intended measure. Our purpose was to test the extent to which the 19 IKDC items formed a meaningful unidimensional measure of knee function that could differentiate ACLR patients from healthy individuals. **Methods:** A convenience sample of 80 patients with a history of primary, unilateral ACLR (38 females, age: 21.7 ± 7.8 years, time from surgery: 6.3 ± 1.0 months) and 80 healthy individuals (43 females, age: 22.1 ± 4.1 years) participated in this cross-sectional study. The IKDC was administered to all participants in a university laboratory. Participant responses from the total sample were analyzed using the Rasch measurement model. Model diagnostics (item reliability, variance explained, and mean square errors for item fit) were examined to determine the best set of items and rating scale structure that met the criteria for a unidimensional measure of knee function. This psychometric evaluation yielded a reduced 9-item version (IKDC-9). Next, receiver-operating-characteristic (ROC) curve analyses were used to identify cutoff values that maximized the ability of the IKDC and IKDC-9 to discriminate patient status (ACLR vs. healthy). The area under the curve (AUC), sensitivity, specificity,

positive likelihood (LR+), and negative likelihood (LR-) ratios were calculated for each ROC curve analysis. **Results:** The IKDC-9 exhibited higher item reliability (0.99 vs. 0.90), explained more variance (70.4% vs. 50.4%), and included fewer misfitting items (0 vs. 3), suggesting the improved rating scales and retained items of the IKDC-9 serve as better indicators of a unidimensional measure of knee function. An IKDC value of 91.5 (0-100) demonstrated excellent discrimination in patient status (AUC: 0.93 [95% CI: 0.89-0.97], $P < .001$), and yielded a moderate effect on the probability of being classified as having an ACLR (sensitivity: 0.86, specificity: 0.88, LR+: 7.47, LR-: 0.16). An IKDC-9 value of 23.5 (0-26) also demonstrated excellent discrimination in patient status (AUC: 0.91 [95% CI: 0.86-0.95], $P < .001$), and yielded a moderate effect on probability of being classified as having an ACLR (sensitivity: 0.74, specificity: 0.91, LR+: 8.27, LR-: 0.28). **Conclusions:** The new parsimonious IKDC-9 offers increased reliability, unidimensionality, and a more stable linear progression of patient perception from low to high knee functioning, all of which are necessary psychometric prerequisites of a commonly utilized outcome measure. Additionally, the IKDC-9 demonstrated an equivalent shift in probability of being classified as having an ACLR compared to the IKDC. A shorter instrument may enhance mental acuity during completion, while the increased validity of the IKDC-9 will provide a necessary foundation for its use in sports medicine outcomes research.

Challenges Associated With Clinical Immersion in Athletic Training Education: A Report From the Athletic Training Clinical Education Network

Myers SL, Campbell M, Mazerolle SM, Clements C, Eberman LE: University of Connecticut, Storrs, CT; Springfield College, Springfield, MA; Boston University, Boston, MA; Indiana State University, Terre Haute, IN; Athletic Training Clinical Education Network

Context: The Commission on Accreditation of Athletic Training Education (CAATE) will require professional masters programs to offer an immersive clinical experience starting in 2019. Clinical immersion is common in other healthcare fields; however little is understood about its implementation in athletic training. The purpose was to determine athletic training program administrators' perceived challenges of implementing immersive clinical experiences. **Methods:** In phase I participant and programmatic demographic data were collected and stored using Qualtrics online survey platform. Frequency and means were calculated for Phase I demographic data. To provide additional context to the survey responses, follow up phone interviews were conducted in phase II of the study and a general inductive lens was used to analyze these data. Pilot interviews, external review, and reaching data saturation were utilized to ensure content and to limit bias. 24 administrators from CAATE-accredited professional athletic training programs participated in phase I of the study, 15 from master's degree programs and 9 from programs offering both master's and bachelor's degrees. The respondents had 13 ± 6 years of experience in program administrative roles and 22 ± 7 years as credentialed athletic trainers. 17 administrators (12 PDs, 4 CECs, 1 Department Chair) completed one-on-one phone interviews in phase II. **Results:** 17 (71%) of the respondents currently include immersive clinical experiences in their

athletic training programs. 13 (76%) indicated their programs offered a minimum of one clinical immersive experience. Respondents identified three perceived challenges of immersive clinical experiences for the student: 1) isolation from peers and faculty, 2) financial burden due to off campus immersive placements, and 3) the amount of time a student may spend not engaged in quality learning experiences while still required to be physically present at their clinical site. Additionally, the respondents identified three challenges programmatically: 1) lack of a clear definition of the experience from the CAATE, as the 2020 CAATE standards at the time of data collection were not yet approved, 2) scheduling of immersive experiences, and 3) level of preceptor engagement with students. Program administrators believed that these factors greatly influenced 'buy in' from the students, faculty and preceptors. While programs acknowledge the benefits clinical immersion can provide in preparing students to transition to practice, challenges were still present in regards to the overall clinical immersion experience. **Conclusions:** Perceived challenges of immersive clinical experiences for both athletic training students and athletic training programs exist. PDs and CECs continue to seek clarity on beneficial practices for implementation of immersive experiences. If their perceived challenges are not addressed, buy in from faculty and preceptors could be influenced, thereby impacting the potential success of the student.

Virginia Concussion Initiative: Stakeholder Perspectives of Disparities in Concussion Policy Implementation

Nolton EC, Resch JE, Kerr ZY, Broshek DK, Brenner J, Reynolds JD, Como-Lesko N, Ambegaonkar JP, Cortes N, Caswell A, Caswell SV: George Mason University, Fairfax, VA; University of Virginia, Charlottesville, VA; University of North Carolina at Chapel Hill, Chapel Hill, NC; Children's Hospital of the King's Daughters, Norfolk, VA; Fairfax County Public Schools, Fairfax, VA

Context: Sport-related concussions (SRCs) are a public health burden and management of concussed school-aged children remains challenging. Since 2010, all states passed legislation regulating concussion management in public schools. The Virginia Department of Education (VDOE) provided guidelines to assist all 131 school divisions with integrating the unfunded mandate in policy and practice; however, implementation has not been evaluated. The purpose of the current study was to evaluate policy implementation in Virginia public high schools to understand real and perceived barriers to effective implementation. **Methods:** A sequential, mixed-methods approach was

employed to analyze policy content and understand stakeholder perspectives. A rubric (total 54 points) was developed to assess compliance of publicly-available school division policy documents to the VDOE guidelines. Three coders independently scored policy documents ($\alpha=.919$). A K-means cluster analysis was performed using a local ability-to-pay index and percentage of students eligible for free/reduced lunches. Using a cluster-stratified, random sample of divisions, stakeholder interviews ($n=60$) were conducted to gain multiple stakeholder perspectives from defined Concussion Management Team (CMT) roles (i.e. coordinators, facilitators, practitioners, and consumers). The interview protocol was properly vetted by subject-matter experts and approved by the local IRB. Open emic codes of the interviews were analyzed for emerging themes. **Results:** Overall compliance of policy documents was $59.2\pm 12.7\%$. Content analysis revealed high-resourced divisions tended to have policy documents and ones that were more recently revised (Table 1). Broad themes emerged as factors of implementation from the qualitative interviews: urbanicity (i.e. proximity to community services), school culture, communication, education quality, stewardship, and resources. Models for concussion literacy and injury management also became apparent, which were not previously

described in the VDOE guidelines. There was discrepant self-identification as coordinators of concussion management protocols between ATs and school nurses within their respective schools. There was also a disparity in perceived barriers or implementation quality across stakeholders within schools—administrators spoke highly of local practices despite practitioners reporting distinct challenges. Stakeholders from rural south and southwest border regions of Virginia also reported seeking medical services from providers located in neighboring states. **Conclusions:** Our data suggest that implementation of an unfunded health policy in an educational setting is complex. The coordination of various internal and external stakeholders requires a mechanism for communication between all parties. Management models differ within each school due to available resources and support. Additionally, the involvement of practitioners from neighboring states may necessitate interjurisdictional strategies to ensure care is compliant with Virginia guidelines. Diverse states like Virginia face unique challenges in supporting policy implementation within disparate school environments and are further complicated as policy aligns to evolving best practices. Virginia school divisions are in need of culturally-responsive resources that will build capacity for effective policy implementation.

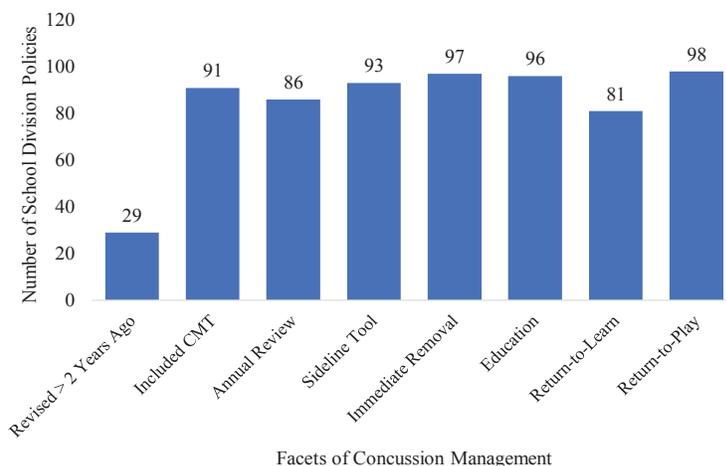


Figure 1. Counts of School Division policy documents (N=131) that included these major facets of concussion management that are outlined in the Virginia Department of Education guidelines.

Free Communications, Oral Presentations: Factors Related to Sport Specialization and Injury

Tuesday, June 25, 2019, 10:30AM-11:45AM, Mandalay Bay C;

Moderator: Tamara Valovich McLeod, PhD, ATC, FNATA

Injury History is Associated With Sport Specialization Level in High School Volleyball Athletes

Biese KM, McGuine TA, Hernandez MI, Schaefer DA, Kliethermes S, Brooks MA, Watson A, Lang P, Bell DR: University of Wisconsin, Madison, WI

Context: Sport specialization has been associated with increased risk of musculoskeletal lower extremity injuries in adolescent athletes. However, many studies neglected to control for the sport a participant specialized in when evaluating risk of injury. More research is needed to fully understand the risk of specialization as it pertains to a given sport. Volleyball, for example, is one of the most popular high school sports in the United States and has a history of club sport participation and specialization. Additionally, the sport of volleyball lends itself to repetitive actions, such as jumping and hitting, which may elevate injury risk. Therefore, the purpose of this study was to determine if sport specialization level is associated with musculoskeletal injury history in high school volleyball athletes.

Methods: This study was a cross-sectional survey. Participants (female, interscholastic athletes, grades 9-12) were recruited from a diverse sample of 79 Wisconsin high schools during the 2018 volleyball season. A total of 2,077 participants (Age=15.1±1.1 yrs.) enrolled in the study. Participants completed a questionnaire consisting of 1) demographic information, 2) sport specialization scale, 3) sport participation information, and 4) sport related injury in the previous 12 months. Sport specialization status was determined using a widely utilized 3 item specialization scale (total score: 0-1=Low, 2=Moderate, 3=High). Multivariable logistic regression analyses were used to investigate the association between sport specialization with history of lower extremity injury while adjusting for

grade level. Additionally, a one-way ANOVA with LSD post-hoc analysis was used to evaluate the difference between sport specialization categories and the age when volleyball became the participant's primary sport. **Results:** Twenty-two percent of the sample was classified as highly specialized (Low: 54.9%, Moderate: 22.7%, High: 22.5%), while 49.9% participated in club volleyball in the past year in addition to their high school team. Moderate and highly specialized athletes considered volleyball their primary sport at a younger age than their low specialized counterparts ($F = 21.4, p < 0.001$; Low-Moderate = 0.50 yrs, $p < 0.001$, 95% CI: 0.29-0.70; Low-High = 0.64 yrs, $p < 0.001$, 95% CI: 0.43-0.84). The odds of reporting any musculoskeletal injury (OR=1.68 (95%CI: 1.33-2.11)) and a lower extremity injury in the past 12 months (OR=1.73 (95%CI: 1.35-2.21)) were greater among Highly specialized athletes compared to Low specialization athletes. **Conclusions:** Volleyball players have high participation in club teams, lending themselves to year-round participation and high levels of specialization. Highly specialized volleyball players were approximately 68-75% more likely to have a previous musculoskeletal injury history in the past 12 months compared to low specialization athletes, after adjusting for grade level. Youth athletes, parents, coaches, and clinicians should be aware of the potential risks of intense, year-round participation in organized sports, especially volleyball. Efforts aimed at increasing safe sport awareness and education should be targeted within the volleyball community.

Sport Sampling Affects LESS Scores and Physical Literacy Competency in Children

Malone ZC, Zuk EF, Root HJ, Beltz EM, DiStefano LJ: University of Connecticut, Storrs, CT; AT Still University, Mesa, AZ; Emory & Henry College, Emory, VA

Context: In order for youth athletes to maintain long-term physical activity participation they must avoid injury and develop physical literacy, which are the ability, confidence and desire to be active. Sport sampling is associated with improved landing technique, which may reduce the risk of injury. The association between sport sampling and physical literacy competency is currently unknown, but this knowledge would guide future recommendations for youth athletes. The purpose of this study was to compare physical literacy competency and landing technique between children with and without a history of sport sampling. It was hypothesized that children with experience participating in two or more sports would demonstrate greater competency and lower LESS scores than those who competed in one sport or less. **Methods:** This was a cross-sectional study including 179 children (92 males, 87 females) from six schools or local sport organizations that volunteered to participate. Physical literacy competency tasks, which examine fundamental movement skills, were assessed using the validated PLAYfun assessment tool and divided into five domains: locomotor, balance, upper extremity object control, lower extremity object control, and running. Each consisted of discrete tasks. Trained raters evaluated competency during these tasks using a continuous visual analog scale of 0-100 points. Participants also performed three trials of a standardized jump-landing task. A validated markerless motion capture system was used to calculate LESS scores. Participants also completed a questionnaire detailing

which sports they have played. Sport sampling groups were formed based on sport participation history (LOW SAMPLING: <2 sports; SAMPLING: ≥ 2 sports). Participants were divided into age groups based on their current grade (Elementary: grades K-4; Middle: grades 5-8). Separate analyses of variance for age groups were conducted to evaluate physical literacy competency in each domain and LESS scores between sport sampling groups. **Results:** In middle school children, the SAMPLING group ($n = 57$) demonstrated lower LESS scores ($p = 0.003$, SAMPLING: 6.42 ± 1.74 errors; LOW SAMPLING: 7.73 ± 1.97 errors) and greater locomotor scores ($p = 0.03$; SAMPLING: 93.63 ± 13.00 points, LOW SAMPLING: 86.09 ± 19.40 points) than the LOW SAMPLING group ($n = 28$). In elementary school children, the SAMPLING group ($n = 37$) had higher LESS scores ($p = 0.03$, SAMPLING: 8.39 ± 2.14 errors, LOW SAMPLING: 7.33 ± 1.70 errors) and improved upper extremity object control ($p < 0.001$, SAMPLING: 71.26 ± 14.38 , LOW SAMPLING: 53.47 ± 19.25), lower extremity object control ($p < 0.001$, SAMPLING: 63.42 ± 13.4 , LOW SAMPLING: 45.78 ± 21.87), and total competency ($p = 0.03$, SAMPLING: 67.78 ± 10.73 points, LOW SAMPLING: 62.34 ± 11.01 points) compared to the LOW SAMPLING group ($n = 45$). **Conclusions:** Sport sampling is associated with improved physical literacy competency in children, especially upper and lower extremity object control in elementary school age groups. Sport sampling is associated with improved landing control in the older children of this study. Future research should evaluate the associations between other physical literacy factors, such as confidence and desire, and sport sampling.

Perceptions of Factors Related to Sports Specialization Between Parents and Children

Hernandez MI, Post EG, Biese KM, Schaefer DA, Bell DR, Brooks MA: University of Wisconsin-Madison, Madison, WI; San Diego State University, San Diego, CA

Context: Sport specialization among youth athletes has been associated with increased risk of overuse musculoskeletal injuries. Previous research demonstrates that children perceive specialization to be beneficial in making their high school team and receive athletic college scholarships. Previous research also shows parents play a significant role in their child's sport experience. However, it is unknown if parents and children answer questions related to specialization practices and beliefs in a similar manner. The primary aim of this study was to evaluate the beliefs of youth athletes and parents on factors related to sport specialization. The second aim of this study was to evaluate the level agreement between athletes and parent dyads on sports specialization. **Methods:** Online and paper/pencil surveys at youth sport tournaments in Wisconsin. Aim 1: 1998 participants (993 children (age = 14.1 ± 1.6 years, 1005 parents (age = 44.88 ± 6.2 years)). Aim 2: 77 paired parent-child dyads. Participants completed a self-administered survey validated by an expert panel that included questions regarding sport specialization patterns and beliefs. Responses were summarized via frequency and proportions(%). Chi-squares were calculated between parent and child responses. Kappa coefficients were calculated for each dyads to determine level of agreement. Sport specialization was classified using a common 3-point scale. Participants were classified as low, moderate, or high using the answers to these three questions: (1) if the athlete has quit other sports to focus on their main sport, (2) if they can identify a primary sport, and (3) if they train >8 months/year in their primary sport.

Results: Parents were more concerned

about risk of injury in sports compared to children ($P < 0.001$, $X^2 = 231.4$; Parent: A little: 19.4%, Somewhat: 40.3%, Very: 27.7%, Extremely: 7.1%; Child: A little: 33.7%, Somewhat: 31.1%, Very: 10.1%, Extremely: 3.7%). However, children were more likely to believe that specialization was associated with obtaining a college scholarship ($P < 0.001$, $X^2 = 201.6$; Parent: Extremely/very unlikely 45.4%, Somewhat: 40.9%, Very/extremely likely: 13.7%; Child: Extremely/Very unlikely 16.4%, Somewhat: 67.7%, Very/extremely likely: 15.8%). Children believed sport specialization is positively associated with receiving an athletic college scholarship ($P = 0.00$, $X^2 = 185.6$; Parent: A few 69.9%, Some 23.9%, Most 3.8%; Child: A few 39.9%, Some 45.7%, Most 10.1%). Dyad sub analysis indicated moderate level of agreement between parents and children for "quitting other sports to focus on one sport" ($K = 0.50$), and low level of agreement for "primary sports to be more important than other sports" ($K = 0.30$), and "training >8 months/year in primary sport" ($K = 0.32$). **Conclusions:** Parents and youth athletes had differing beliefs on factors related to sports specialization. Dyad analysis shows that parents and children answer sport specialization classification questions differently. Health care providers should be aware of these differences and messaging should be individualized to the audience.

A Comparison of Team Sport Volume Between High School and Club Sport Coaches

Post EG, Schaefer DA, Biese KM, Watson AM, McGuine TA, Brooks MA, Bell DR: San Diego State University, San Diego, CA; University of Wisconsin-Madison, Madison, WI

Context: Simultaneous participation on high school and club sport teams is becoming increasingly common. In order to minimize the risk of overuse injuries, better communication about total sport volume is needed between high school and club coaches. The purpose of this study was to compare the sport participation characteristics of interscholastic and adolescent-aged club teams. We hypothesized that club team coaches would report that their athletes would participate more months per year and hours per week, would take more overnight trips, and be less likely to track their athletes' sport volume than high school coaches. **Methods:** A total of 769 coaches (female N=266, 34.6%, response rate: 6.8%) from three sports (basketball, volleyball, soccer) completed a cross-sectional anonymous online questionnaire consisting of: 1) coach and team demographics, 2) team sport volume, and 3) awareness of their athletes' sport participation. Coaches were eligible to participate if they had served as the head or assistant coach of a high school or high school-aged club sport team in the past 12 months. Six content-area experts determined the content validity index (CVI) for each item on the questionnaire, with only items with a $CVI \geq 0.83$ included. Data were summarized by frequencies and proportions (%) and means and standard deviations. Independent t-tests were used to compare sport volume measures (months/year, hours/week, number of overnight trips) between high school and club coaches. Chi-square analyses were used to compare frequency of responses between high school and club coaches for awareness of their athlete's sport participation behaviors. **Results:**

Overall, 64.6% (N=497) of respondents were coaches of a high school team and 35.4% (N=272) were coaches of a club team with high school-aged athletes. Club coaches' teams played more months out of the year (6.9 ± 2.7 vs. 5.4 ± 2.0 , $p < .001$) and took more overnight trips for competitions (6.9 ± 9.1 vs. 2.7 ± 4.2 , $p < .001$) than high school coaches' teams, but participated in fewer hours/week of practice or competition during their season (8.3 ± 4.3 vs. 12.3 ± 3.8 , $p < .001$). High school coaches were much more likely than club coaches to report having limitations on the number of games per day (86% vs. 31%, $X^2=237$, $p < .001$), games per week (73% vs. 19%, $X^2=212$, $p < .001$), and games per season (93% vs. 19%, $X^2=437$, $p < .001$) that are mandated by their league or sport governing body. A majority of coaches in both settings reported that they do not track the amount of time their athletes participate in other sports (club: 89.2%, high school: 87.6%, $p=0.60$). **Conclusions:** Significant differences in sport participation volume exist between the teams of interscholastic and club coaches. With the increasing popularity of club sport participation among high school athletes, athletic trainers should aim to increase awareness of sport volume recommendations and encourage communication between club and high school coaches.

Association Between Level of Sport Specialization Upon Entry to Military Service and Lower Extremity Injury During 1 Year of Follow-Up at a US Service Academy

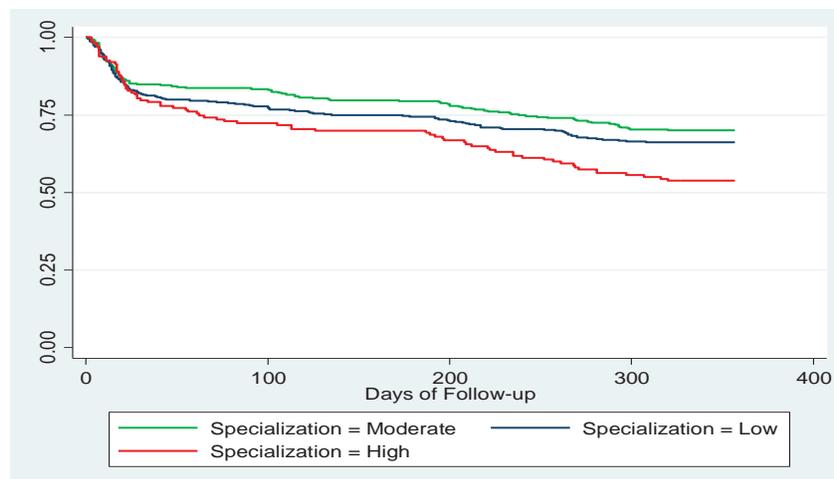
Miraldi SFP, Peck KY, Houston MN, Posner MA, DiStefano LJ, Padua DA, Marshall SW, Eckard TG, Cameron KL: Keller Army Community Hospital, United States Military Academy, West Point NY; University of Connecticut, Storrs CT; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Context: Sport specialization has recently been linked to both acute traumatic and chronic overuse injuries; however, no prospective studies to date have examined the association between sport specialization prior to accession and injury risk upon entry to military service. The purpose of this study was to prospectively examine the association between level of sport specialization upon entry to military service and lower extremity (LE) injury risk during the first year of training in a US Service Academy (SA) population. **Methods:** We conducted a prospective cohort study with the incoming class of 2021 at a SA. Within their first week of arrival, participants who consented

completed baseline assessments including the LESS, which is an assessment of LE movement quality, and a baseline questionnaire that included injury history and demographic information, as well as established questions to evaluate level of sport specialization. The 3-Point Scale was used to classify level of sport specialization upon entry to military service and included three levels (low, moderate, high) based on established definitions. The primary outcome of interest was time from baseline assessment to incident LE injury during the one-year follow-up period. Kaplan-Meier survival estimates were calculated by level of sport specialization at baseline. Univariate and multivariable Cox Proportional Hazards regression models were used to estimate hazard ratios (HR) and 95% confidence intervals (95%CI) between baseline level of sport specialization and time to LE injury during the follow-up period. **Results:** 892 cadets (212 females) provided consent and agreed to participate in the study (height=176.17±8.76, mass=75.34±13.37 kg). Of the cadets screened at baseline, 43.7% (n=390) reported low, 37.8% (n=337) reported moderate, and 18.5% (n=165) reported high levels of sport specialization upon entry to military service. Kaplan-Meier survival estimates for LE injury

by level of sport specialization upon entry to military service are presented in Figure 1. In univariate models, cadets with low specialization were 12% more likely (HR=1.12, 95%CI: 0.94-1.34, p=0.205) to sustain a LE injury during the follow-up period and those with high specialization were 51% more likely (HR=1.51, 95%CI: 1.23-1.85, p<0.001) when compared to those with moderate specialization; however only the later was statistically significant. Cadets with high specialization were also 35% more likely (HR=1.35, 95%CI: 1.11-1.63, p=0.002) to sustain a LE injury when compared to those with low specialization. Similar results were observed in multivariable models controlling for important confounding variables. **Conclusions:** Level of sport specialization upon entry to military service appears to be associated with LE injury risk during the first year of training. This held true in univariate models and multivariable models controlling for potentially important confounding variables. Those who reported high levels of specialization upon entry to military service were at increased risk for LE injury during the follow-up period.

Figure 1. Kaplan-meier survival estimates for time to lower extremity injury during the follow-up period by level of sport specialization upon entry to military service.



Free Communications, Oral Presentations: Hip and Pelvis Case Reports

Wednesday, June 26, 2019, 7:00AM-8:00AM, Mandalay Bay C; Moderator: S. John Miller, PhD, PT, ATC

Development, Recognition, and Treatment of Bilateral Acetabular Labral Tears and FAI in a High School Female

Kuntz CR: Cleveland Clinic, Medina, OH

Background: This report deals with the development, recognition, and treatment of an athlete with bilateral acetabular labral tears and associated FAI. The athlete was a 16 YO female high school soccer and basketball player. The athlete initially presented to the athletic training facility and physician office in August of 2016 with left sided, point tender iliac crest pain. She denied greater trochanter pain, sartorius, rectus femoris or adductor origin pain. She had full, pain free ROM and was subsequently diagnosed and treated for an oblique strain and iliac apophysitis. She was cleared for soccer and basketball participation and was treated conservatively in the athletic training facility with rehabilitation including hip and core strengthening. Over the course of 8 months, throughout her soccer and basketball season, the pain did not subside. By May of 2017, her pain was bilateral, the right more severe than the left. Upon presentation in the athletic training facility and physician's office, the athlete maintained full bilateral ROM, denied any groin pain but maintained point tender pain at each iliac crest. Using x-ray images, the diagnosis of bilateral iliac crest apophysitis was confirmed. She was again, treated conservatively and instructed to alter activity as needed. Over the course of the next three months the athlete was treated with strengthening for core and hip musculature, she focused on stretching and was treated with various modalities. In August of 2017 she was released for full activity at which point her pain remained bilateral at the iliac crest and was equal in intensity. Throughout soccer and basketball season her pain was monitored, activity was altered as needed, and rehabilitation

was maintained. Throughout her basketball season the pain intensified and began affecting her activities of daily living. In November 2017 she began experiencing bilateral anterior lateral groin and hip pain. Due to the change in her symptoms, she was referred to a different orthopedic surgeon. **Differential Diagnosis:** Possible differential diagnoses included iliac crest apophysitis, bursitis, femoral head avascular necrosis, fracture, referred pain from lumbosacral and sacroiliac joints, FAI and acetabular labral tear. **Treatment:** In December 2017, upon exam and MRI results, the athlete was diagnosed with bilateral acetabular labral tears and FAI. In February 2018, she underwent simultaneous bilateral arthroscopic acetabular labral repair, acetabuloplasty, and femoral plasty. She was one of the first five patients to receive this specific procedure from our orthopedic surgeon, and surgery was successful. She progressed through the rehabilitation program in the athletic training facility and physical therapy clinic and returned to full soccer participation in August 2018. **Uniqueness:** The presence of bilateral acetabular labral tears in a high school athlete is difficult to recognize and diagnose correctly. Also, having concurrent bilateral labral repair is a relatively new practice, and following the rehabilitation and outcome of surgery serves as a learning experience to all medical professionals involved. **Conclusions:** Continual research and education on the proper diagnosis of acetabular labral tears is warranted, as is the implementation and outcome of simultaneous acetabular labral repair.

Greater Trochanteric Chondroblastoma in a Female Collegiate Soccer Player

Trapp JL: Sacred Heart University, Fairfield, CT

Background: A chondroblastoma is a rare, benign cyst of cartilaginous origin predominantly found in the adolescent population at the ossification centers of the body's long bones. These cysts typically affect males more than females. Patients often present initially with localized pain and no distinct mechanism of injury. Diagnosis of a benign greater trochanteric chondroblastoma occurred as a result of a rupture of the right gluteus medius at its insertion at the greater trochanter. A concurrent muscular injury has not been previously documented in a benign chondroblastoma case, denoting this study a Level 3 clinical CASE study.

Patient: An 18 year old female collegiate soccer player presented to the athletic trainer with an acute right hip injury. The patient reported performing a cross body kick and hearing a "pop" accompanied by immediate pain in the right hip. Upon initial evaluation, the patient complained of a deep pain in the right hip and displayed decreased right hip flexion, extension, abduction, adduction, and internal and external rotation as compared to the unaffected limb. Due to the patient's discomfort, the athletic trainer was unable to perform manual muscle testing or special tests. The patient was immediately referred to see the team general medical physician, who diagnosed the patient with a grade 3 gluteus medius strain and subsequently ordered radiographs and magnetic resonance imaging (MRI) of the right hip and pelvic girdle. Imaging revealed a 2.0 x 1.8 x 1.0 cm "lucent lesion" located within the proximal epiphysis of the patient's right greater trochanter. The patient was referred for a clinical biopsy. Tissue analysis revealed the lesion to be benign, and the patient was subsequently diagnosed with a proximal femoral epiphyseal chondroblastoma with an associated grade 3

gluteus medius strain. **Intervention or Treatment:** A curettage technique followed by a bone graft consisting of cortico-cancellous bone chips was used to treat the chondroblastoma. This is a commonly-used technique for resolving this type of lesion. Surgery was completed in March of 2018. Post-surgically, the patient was non-weight bearing (NWB) for two weeks, partial weight bearing (PWB) for four weeks, and was cleared for full weight bearing (FWB) at six weeks post-operative. The patient underwent rehabilitation with the ATC to restore hip range of motion (ROM) and gluteus medius strength. The patient continued to increase lower body strength and conditioning through resistance training and sport-specific workouts up to fourth months post-op. **Outcomes or Other Comparisons:** The patient was cleared to return fully to sport at four months post-op with full ROM and strength as compared to the unaffected limb. Throughout the fall soccer season, the patient was able to participate in all practices and games. It is reported that chondroblastomas often recur at the greater trochanter, but at eight months post-op, the patient had not had a recurrence. **Conclusions:** Atypical for a chondroblastoma, no pain was reported by the patient prior to the injury incident, and diagnosis was made as a result of an acute injury that necessitated further imaging. Until gluteus medius strength and ROM were restored, exercise had to be carefully prescribed so as not to introduce altered lower body movement patterns. Clinicians encountering a similar case should consider diagnostic imaging and ensure the complete rehabilitation of any associated muscular injury prior to progressing the patient to sport-specific training. **Clinical Bottom Line:** In an athletic population, chondroblastomas may closely resemble a common athletic complaint or acute injury and may not be preceded by pain. Chondroblastomata should be included in the differential diagnosis for injuries involving the musculoskeletal structures surrounding the long bones of the body and imaging should be obtained to rule out such a differential.

Implementing Patient Outcomes and Functional Assessment to Direct Treatment Interventions for Hip Pain: A Level 2 Case Series

Patterson RD, Goodwin CD:
Temple University, Philadelphia, PA; Marshall University, Huntington, WV

Background: Greater trochanteric pain syndrome (GTPS) is a common occurrence affecting ~25% of the population. Concomitant hip pain and functional limitations (e.g., thoracic rotation, back pain) complicates the evaluation process, which can lead to misdiagnosis and delays in appropriate interventions. Additionally, athletic trainers should consider biomechanical components. Implementing a functional movement screen may serve to reduce treatment time and improve return to play outcomes. However, there is little research supporting the combination of patient reported outcome measures (PROMs) and functional movement screens to best direct care for GTPS. Therefore, the objective of this case series was to evaluate PROMs following evaluation using the Selective Functional Movement Assessment (SFMA) and manual therapeutic interventions in three athletes diagnosed with GTPS. **Patient:** Three female intercollegiate cross-country athletes (19.3±0.9 y/o; 68.0±0.82 in; 129.33±14.64 lbs), diagnosed by a physician with GTPS were included in this case series. All athletes described an insidious onset of hip symptoms and no previous hip conditions, but were running on ~55-75 miles per week. Athlete 1 reported a history of hip pain that lasted three months (resting pain 5/10). Athlete 2 reported persistent hip pain for 2 months, describing resting pain at a 7/10. Additionally, this athlete had decreased thoracic rotation attributing from her spinal fusion for scoliosis. Athlete 3 was suffering with hip pain for over a year, though her pain was less significant at rest (4/10). **Intervention or Treatment:** Each athlete was evaluated using the SFMA, which

identified dysfunctional patterns and categorized limitations into joint mobility dysfunction (JMD; n=3) and stability/motor control dysfunction (SMCD; n=3). JMD was treated with Mulligan Mobilization with Movement (MWM) followed by 4x4 Corrective Exercise Matrix to reinforce functional movement. SMCD was treated again with the 4x4 Corrective Exercise Matrix and pattern assistance to combine muscle activation and functional movement to improve outcomes. Specifically, athlete 1 was treated for JMDs for thoracic rotation, lumbar flexion, hip internal rotation, and SMCD for shoulder extension. Athlete 2 was treated for JMD of cervical flexion, hip internal rotation, lumbar flexion and tibial internal rotation, and SMCD for shoulder flexion. Athlete 3 was treated for JMD for thoracic rotation, lumbar extension and SMCD of hip flexion. All athletes were also treated for sacroiliac joint dysfunction and upper extremity extension rolling patterns. Athletes also completed three PROMs [i.e., Numeric Pain Rating Scale (NPRS), Disablement in the Physically Active Scale (DPA), International Hip Outcome Tool (iHOT-33)], to measure the athlete's perception about their recovery. **Outcomes or Other Comparisons:** Athletes self-reported hip pain for an average of 6.0±4.2 months with a reported NPRS of 3.0±1.9. The initial DPA was 24±8.5 and iHOT-33 was 116.7±17.5. The athletes reported a final NPRS score of 0.1±0.2, DPA score of 10.3±1.3, and an iHOT-33 score of 185.3±23.9, which was achieved in 5.7±0.9 treatments. This corresponded with a change of ~3, ~14, and ~68 points respectively. This met the Minimally Clinically Important Difference (MCID) for the NPRS (change of 2 points) DPA (change of 9 points), and iHOT-33 (change of 8 points). Additionally, all athletes remained pain free during the two-week follow-up. **Conclusions:** Conservative treatment of GTPS has a 90% success rate, but may take several months for full resolution of symptoms. Using a functional screen to address seemingly unrelated body regions combined with

manual therapy interventions and corrective exercises to resolve identified dysfunctions resulted in clinically significant improvements in PROMs for all athletes. The addition of PROMs also provided important insight in directing athlete care through the identification of beneficial interventions. **Clinical Bottom Line:** The combination of PROMs and a functional movement screen resulted in improved patient outcomes and full symptom resolution associated with GTPS.

Osteitis Pubis: A Tale of Misdiagnoses

Irby A, Gehr S, Wilkins S:
University of Nebraska, Omaha,
NE; Iowa Western Community
College, Council Bluffs, IA

Background: The patient is a twenty-year-old male (height 154.94cm; mass 82.8kg) college football player with a history of undiagnosed hip pain in high school. The original indication of hip pain was in early September 2017. The patient performed a tackle and immediately felt pain in his hip, but he finished the game, recalling his effort at about 75-80%. On October 21, 2017, the athlete performed another tackle which resulted in additional hip pain. During an injury evaluation on October 23, 2017, the patient reported pain in his groin, specifically with palpation of the rectus femoris. Range of motion for hip flexors, adductors, abductors were decreased when compared bilaterally. Hip flexion and adduction strength were 3+/5; internal and external rotation strength were 4/5. The grind test was negative, while Thomas test was positive. The original diagnosis was a mild Hip Flexor/Groin Strain. **Differential Diagnosis:** Adductor sleeve injury, labral tear, hip flexor/groin strain, and athletic pubalgia. **Treatment:** The patient did not improve with conservative treatment and was sent for further evaluation and imaging on November 11, 2017. Physical examination showed: acute distress, no sacroiliac joint pain, moderate pain with adduction, and slight pain with hip flexion and internal rotation. There was no pain with palpation of the pubic symphysis or adductor muscles at rest; however, there was pain with adduction and flexion against resistance. A magnetic resonance image (MRI) did not detect any malalignment of the lumbar spine, nor any type of direct or indirect hernia, nor was there change in quad size or any redness or edema. The physician diagnosed the injury as an adductor sleeve injury with a possible labral tear. Treatment consisted of non-steroidal anti-inflammatory drugs

(NSAIDs) for pain management and rehabilitation exercises with the athletic trainer to strengthen adductors and the pelvic floor. On January 23, 2018, the athlete continued to have hip and groin pain. He returned to the same physician with reported difficulty flexing his hip. He was sent for a second MRI, which showed swelling and edema around the pubic symphysis, as well as intramuscular swelling within the attachment sites at the pubic symphysis. The results of the MRI led the physician to re-diagnose the condition as osteitis pubis. Following unsuccessful treatment for the prior diagnoses, the patient successfully completed a treatment protocol that included isometric strengthening exercises for groin and abdominal muscles to alleviate pressure and irritation around the pubic symphysis. Exercises included: clam shells, ball squeezes, hip bridge lifts, and 4-way-hip exercises. Later phases of the rehabilitation protocol included step ups, squat walks, lunges on an unstable surface, physioball curls, plank push-ups, mini squats, and single leg squats with the suspension/resistance bands. This treatment protocol allowed the patient to return to play approximately eight weeks after the osteitis pubis diagnosis. **Uniqueness:** In this case, the athlete had a previous, undiagnosed hip injury, then, two years later had a hip injury that was presented as both an adductor sleeve injury and a hip flexor/groin strain. As the presentation of the injury changed, treatment changed, which prolonged his recovery time and prevented him from returning to the field. **Conclusions:** Osteitis pubis is a complex injury that requires careful evaluation and recognition of symptoms to accurately diagnose. The treatment and rehabilitation protocol for osteitis pubis followed guidelines that allowed him to return to pre-season football workouts without pain or further groin discomfort.

Free Communications, Oral Presentations: Electrical Stimulation Techniques for Pain and Muscle Strengthening

Wednesday, June 26, 2019, 8:15AM-9:45AM, Mandalay Bay C; Moderator: Blaine Long, PhD, AT, ATC

Changes in Pain Perception, Aerobic and Resistance Exercise Progressions, and the Amplitude of Electrotherapy During a Ten-Session Rehabilitation Programme for Patients With Anterior Knee Pain

Lee J, Roh Y, Oh M, Kim S, Song S, Doo H, Park J: Kyung Hee University, Yongin, Korea

Context: A rehabilitation programme for patients with anterior knee pain (AKP) typically consists of the use of disinhibitory modalities, and aerobic and resistance exercise. Reporting changes in these key components during multiple training sessions would help clinicians and patients for future establishment and implementation of rehabilitation. We observed changes in pain perception, progressions in aerobic and resistance exercise, and the amplitude of transcutaneous electrical neuromuscular stimulation (TENS) during a ten-session rehabilitation programme for patients with AKP. **Methods: Study Design:** Clinical observation study. **Setting:** Patient clinic. **Participant Population:** Fifteen (9 males and 6 females) patients with AKP (age: 21 years, height: 171 cm, weight: 75 kg; month post pain: 48 months). **Interventions:** Patients received a ten-session (with a day rest period between sessions) rehabilitation programme. Upon arrival to the clinic, patients received 30-min pre-exercise modalities (cryo-electrotherapy). Two channels of TENS and two ice bags were applied to the affected knee joint. Patients performed a 5-min treadmill jogging at a speed of 6.0 km/h for females and 7.0 km/h for males. The jogging speed was increased (by 0.5 km/h) when patient did not reach the cutoff heart rate ($220 - \text{age} \times 0.7$). Afterwards, patients performed a 25-min resistance exercise. Straight leg raises and lunges were performed on the odd number sessions. Knee extension exercises and squats were performed on

the even number sessions. The intensity of strengthening exercises was determined by the DAPRE method. **Main Outcome Measures:** Pain perception (using visual analogue scale) was assessed before and after each session. Jogging speed (km/h), external loads (kg) of knee extension exercises, current intensity of TENS (mA) were also recorded. Statistical analyses: Two-way (pain perception: session by time) and one-way (rest of outcome measures) ANOVA were performed ($p < 0.05$ for all tests) with calculations of Cohen's d effect size with 95% confidence intervals were performed. **Results:** Each treatment session did not immediately reduce pain (session effect: $F_{1,266} = 0.01$, $p = 0.92$) but overall pain perception was decreased after the 4th session of treatment (time effect: $F_{9,266} = 5.91$; $p < .0001$; 3.2 to 1.7 cm, 47%, $d = 0.78$). Jogging speed was increased ($F_{9,126} = 34.06$, $p < 0.001$) at the 3rd session (6.0 to 7.2 km/h, 20%, $d = 0.95$), and there were further increases at the 5th (7.7 km/h, 28%, $d = 1.49$) and the 9th session (8.3 km/h, 38%, $d = 1.82$). External loads of knee extension exercises at every session were improved (session effect: $F_{4,126} = 167.15$; $p < 0.001$). The amplitude of TENS was increased at the 4th session (25.5 to 30.7 mA, 20%, $d = 1.24$) but there was no further increase ($F_{9,126} = 4.75$; $p < 0.001$). **Conclusions:** Our data suggest that a minimum of four sessions appear to be necessary to expect reduction in pain perception, progression of strengthening exercises, and accommodation of electrical stimulation during a ten-session of rehabilitation programme for chronic AKP patients.

The Effects of Electrically Induced Vastus Lateralis Fatigue on Vastus Medialis Activity During Knee Extension

Kearney JW, Powers ME, Gildard M: George Mason University, Fairfax, VA; Marist College, Poughkeepsie, NY

Context: An imbalance between the vastus medialis (VM) and the vastus lateralis (VL) and improper timing of activation between them are perceived to result in abnormal patellar tracking and patellofemoral pain syndrome (PFPS). Thus, therapy often involves strengthening the VM to increase the VM/VL ratio and correct patellar tracking. Unfortunately, the current literature fails to identify rehabilitation methods that consistently result in preferential VM activation as both the VM and VL are active throughout the full range of motion during open chain knee extension (OCKE). We hypothesized that selectively fatiguing the VL prior to exercise would enhance the activation of the VM during OCKE. **Methods:** A randomized crossover design was used to compare VM and VL activity and the VM/VL ratio during OCKE with and without VL fatigue. Twelve healthy resistance trained males and females (mass = 72.35 ± 16.7 kg, height = 166.58 ± 8.9 cm, age = 21 ± 2.0 y) with no contraindications to electrical stimulation (Estim) volunteered. Participants reported to the research laboratory for two testing sessions separated by at least 48-h and were assessed immediately before and after a randomly assigned and counterbalanced treatment or control condition. During the treatment condition, a maximal tolerable Russian current was delivered for 20-min at 100 bursts/sec to the dominant VL with a 5-s on-time and a 15-s off-time while the participant was seated with the knee in full extension. During the control condition, the participant remained in

the same position for 20-min while receiving no treatment. Immediately prior to treatment or control, electromyography (EMG) signals were recorded while participants performed a maximal volitional isometric contraction (MVIC) with the knee in full extension. EMG was then recorded while the participants performed five repetitions of OCKE from 90° of flexion to full extension with 80% of a previously determined one repetition maximum. A metronome was used to control velocity of movement. Immediately following treatment, EMG was again recorded during five more repetitions of the OCKE. The average normalized EMG activity during the 5 repetitions was used in the analyses. A two way analysis of variance with repeated measures was used to compare the normalized EMG. The alpha level was set a priori at .05 for all comparisons. **Results:** No differences were observed when comparing EMG activity (%MVIC) of the VMO ($F_{2,10}=.993$, $p=.365$) before ($62.85 \pm 46.21\%$) and after ($69.17 \pm 46.30\%$) treatment or when comparing VL activity ($F_{2,10}=.026$, $p=.878$) before ($45.47 \pm 25.99\%$) and after ($48.15 \pm 27.33\%$) treatment. Additionally, no change in the VMO/VL activity ($F_{2,10}=.456$, $p=.529$) was observed. **Conclusions:** Application of an Estim protocol to elicit VL fatigue did not enhance VMO activity or the VMO/VL ratio during OCKE. It is possible that fatigue was not actually achieved through Estim, thus other electrical stimulation protocols should be considered.

Effect of Functional Electrical Stimulation Applied to the Gluteus Medius During Resistance Training

Robinson MR, Norte GE, Murray A, Glaviano NR: The University of Toledo, Toledo, OH

Context: Gluteus medius (GMed) weakness is a common impairment for a variety of pathologies. Clinical presentation of GMed weakness during tasks like the single leg squat (SLS) is increased hip adduction, internal rotation, and knee valgus. This poor movement is often termed dynamic knee valgus (DKV). Functional electrical stimulation (FES) is an emerging treatment to improve activation of impaired muscles. However, it has yet to be evaluated at improving GMed strength or squatting mechanics in females with DKV. The purpose of this study was to examine the effectiveness of a strengthening intervention with or without FES on GMed function, when assessed by strength, muscle activation, and frontal plane kinematics. **Methods:** 22 healthy adult females (Age: 21.8 ± 1.4 yrs, Mass: 76.9 ± 18.8 kg, Height: 1.7 ± 0.1 m) with DKV completed this randomized controlled single-blinded study. Participants were randomized to one of two resistance-training groups; FES, administered visible GMed contraction during therapeutic exercise, or sham treatment, no stimulation during exercise. The intervention was composed of four exercises: side-lying abduction, seated hip external rotation, lateral step down, pelvic drop task, three times a week for 2-weeks. All measures were tested pre and post-intervention. Outcome measures were hip abduction torque (Nm/kg), normalized SLS GMed activity assessed by electromyography (percentage of maximal voluntary contraction), and SLS frontal plane projection angle (FPPA), a 2-dimensional measure of DKV. Patient credibility and expectancy measures were collected with Credibility and Expectancy Questionnaire (CEQ) to assess the intervention. Repeated measures ANOVAs were conducted with significance of $p < .05$. Cohen's d effect sizes

and 95% confidence intervals were also calculated. **Results:** Groups were similar at baseline for both demographics and all outcome measures. All participants completed all interventions sessions. Both groups demonstrated improvements in their FPPA during a SLS at the conclusion of the intervention (FES: Pre: $16.13^\circ \pm 8.63$, Post: $9.13^\circ \pm 8.04$, $p=.006$; Sham: Pre: $16.28^\circ \pm 5.97$, Post: $11.31^\circ \pm 5.11$, $p=.012$). No differences in hip abduction torque (FES: Pre: 0.75 ± 0.18 , Post: 0.76 ± 0.18 Nm/kg; Sham: Pre: 0.68 ± 0.17 , Post: 0.75 ± 0.15 Nm/kg, $p=.146$) were seen between groups. Additionally, there was no difference in SLS GMed activity (FES: Pre: 57.23 ± 30.97 , Post: 43.58 ± 16.38 ; Sham: Pre: 59.75 ± 23.57 , Post: 38.94 ± 21.26 , $p=.176$). Large effect sizes were found in FES group for FPPA ($d=.84[-.03, 1.71]$). Moderate and large effect sizes for SLS electromyography post-intervention were identified (FES: $d=.55[-.3, 1.4]$; Sham: $d=.93 [.05, 1.81]$). Credibility values were similar between groups upon completion (FES: 23.7 ± 2.28 ; Sham: 21.72 ± 3.37 ; $p=.120$). However, expectancy was significantly greater in the FES group (FES: 19.99 ± 3.8 ; Sham: 15.86 ± 5.12 ; $p=.045$). **Conclusions:** Our findings imply that resistance training of 2-weeks with/without FES both elicited improvements in FPPA that exceeded the standard error of measure (3.2°) during a SLS. However, it did not meet the smallest detectable difference (8.93°) which may suggest implementing a longer FES strength training intervention for decreased FPPA measurements. Additionally, those in FES group had higher expectation of success at improving strength and squatting mechanics, which may lead to better patient reported outcomes.

The Negative Effect of an Automatic Intensity Step-Down Function During NMES Treatments

Bremner CB, Holcomb WR:
Southern Utah University,
Cedar City, UT; Mercer
University, Macon, GA

Context: Effectiveness of neuromuscular electrical stimulation (NMES) treatments is considered to be primarily dependent upon peak torque production during NMES-induced contractions throughout the treatment. A positive relationship exists between stimulus intensity and the subsequent NMES-induced torque production, thus researchers and clinicians often attempt to maximize stimulus intensities during NMES treatments. However, various electrical stimulators have a little known function that automatically reduces the stimulus intensity when a change in impedance is sensed during a treatment; which may result in a greater decline in torque production over the course of a treatment and subsequently reduce its efficacy. We believe a lack of familiarity with this “automatic step-down” function may exist, as there is a dearth of literature addressing its potential consequences; thus a comparison of the decline in NMES-induced torque over the course of NMES treatments with and without the occurrence of the automatic step-down is warranted. Therefore, our objective was to examine the effects of this little known function that may automatically reduce the stimulus intensity when a change in impedance is sensed. We hypothesized that the percent decline in peak torque production would be significantly greater during treatments in which the automatic step-down occurred. **Methods:** We performed our study in a research laboratory using an observational study design. A convenience sample of 20 healthy recreationally active males completed the study and were divided into two groups based on the occurrence ($n=9$, 23.6 ± 5.5 yr, 173.6 ± 8.0 cm, 77.4 ± 10.2 kg) or non-occurrence ($n=11$,

24.5 ± 5.2 yr, 174.9 ± 5.6 cm, 77.1 ± 12.4 kg) of an automatic step-down in stimulus intensity over the course of a standardized NMES treatment. Participants performed a treatment session of 18 NMES-induced isometric quadriceps contractions using a biphasic current delivered via two channels from an electrical stimulator with the automatic step-down function (Sonicator® Plus 940, Mettler Electronics® Corp., Anaheim, CA). Participants self-selected a maximum comfortable stimulus intensity prior to beginning the treatment. Peak torque during the final NMES-induced contraction was measured with an isokinetic dynamometer and normalized to body mass, which was then converted to a percent decline value relative to the normalized peak torque recorded during the initial contraction. An independent t-test was used to analyze the data. **Results:** A significantly greater percent decline ($t_{18}=2.362$, $P=0.015$, $d=1.051$) was observed for the group in which the automatic step-down occurred ($63.9\pm 15.1\%$) relative to the group in which it did not occur ($48.2\pm 14.6\%$). **Conclusions:** Based on our results, the automatic step-down function has the potential to negatively impact the effectiveness of NMES treatments, as it resulted in a significantly greater reduction in NMES-induced torque output over the course of a treatment. Consequently, we believe researchers and clinicians need to be aware of the existence of this function in various commercially available devices and its potential negative consequences.

Effectiveness of the Kneehab® XP Electrical Stimulator on Motor Point Targeting

Holcomb WR, Boudreaux R,
Bremner CB, Miller MG: Mercer
University, Macon, GA; Southern
Utah University, Cedar City, UT;
Western Michigan University,
Kalamazoo, MI

Context: The Kneehab® XP is a neuromuscular electrical stimulator that uses multidirectional currents running between four stimulating electrodes affixed to a thigh garment that is easily applied over the quadriceps. However, studies examining the effectiveness of the Kneehab® XP have been mixed. One potential limitation is less control over the specific location of each electrode, whereas with conventional NMES each electrode is placed on the patient manually. This is important because electrode placement over motor points is essential to optimize treatment effectiveness. Therefore, our objective was to determine how frequently the Kneehab® XP electrodes targeted four specific motor points in the superficial quadriceps muscles: rectus femoris (RF), vastus medialis oblique (VMO), distal vastus lateralis (DVL), and proximal vastus lateralis (PVL). **Methods:** We performed our study in an Athletic Training Clinic using an observational study design. A convenience sample of ten healthy female collegiate soccer players (20.1 ± 1.8 years, 167 ± 5 cm, 69.1 ± 7.3 kg, $BMI=24.9\pm 3.4$ kg/m²) completed the study. One examiner identified motor points using a pencil electrode (Mettler Electronics XK2, Active Forever, Scottsdale, AZ) via an electrical stimulator (Intelect Legend XT, Chattanooga Group, Inc., Hixson, TN). Stimulation amplitude was set to an amplitude that would only cause a muscle contraction when the pencil electrode was passed over a motor point. The pencil electrode was moved until a motor response was noted and this precise location was marked. This process was repeated for each motor point. So that motor points would be

visible to the first examiner, electrodes were removed and the fabric beneath the electrodes was cut away from the garment. The second examiner then centered the garment on the thigh according to manufacturer instructions. The first examiner observed and recorded whether marks were visible in the cut outs where the electrodes were located. To provide further details about motor point locations, the distance from each mark to the closest edge of the cut out was measured. These procedures were repeated on the opposite leg. Percent agreement values were calculated by comparing whether or not the manually identified motor point marks were visible in the cut out where each electrode was located. Mean distances from the motor point mark to the closest edge of each electrode cut out were calculated. **Results:** A 15% agreement was observed with respect to the PVL motor point while all other motor points had 100% agreement. The mean distances from each motor point to the closest edge of the cut out were: RF = 18.4 ± 12.3 mm; VMO = 22.1 ± 6.8 mm; DVL = 24.2 ± 8.0 mm; PVL = 1.67 ± 0.47 mm. **Conclusions:** The electrodes on the garment intended to target the motor points of the RF, VMO, and DVL are positioned appropriately. The electrode intended to target the motor point of the PVL should be repositioned on the garment.

Intrinsic Foot Muscle (IFM) Training and Neuromuscular Electrical Stimulation Lead to Increased Arch Height Index and Improved Y-Balance Composite Scores

Gutkunst DJ, Newsham KR:
Saint Louis University, St. Louis, MO

Context: Intrinsic foot muscles (IFM) contribute to static and dynamic stability¹, and impaired balance has been linked to lower-extremity injuries². This randomized controlled trial was designed to assess effects of a 4-week IFM exercise training program, alone or combined with neuromuscular electrical stimulation (NMES), on foot posture and functional balance. We hypothesized that IFM exercises would lead to increased arch height index (AHI) and improved Y-Balance Test (YBT) performance compared to a control group. **Methods:** Inclusion criteria included: age 18-30 years; recreationally active; and with IFM dysfunction, defined as an inability to selectively extend the great toe or lesser toes. Exclusion criteria included lower-extremity injury within 6 months or any previous neuromuscular injury. Twenty-four individuals (18

females, 6 males) met the inclusion/exclusion criteria, agreed to participate, and were randomly assigned to one of three groups: progressive IFM training (IFMT), N=10; combined IFM training and NMES (IFMT+NMES), N=8; or control group receiving no training (Control), N=6. Training was supervised 3 days/week for four weeks and unsupervised other days. IFMT+NMES followed training described by McKeon & Fourchet¹ during the first two weeks, while IFMT performed a conventional exercise progression. Training groups performed the same progression during the third and fourth weeks of training and all unsupervised sessions. Testing was completed at baseline and 4 weeks. Foot posture was assessed by AHI in a seated position (AHI_{seated}) and single-leg stance (AHISLS). The Y-Balance Test composite reach score was used to assess functional balance in the anterior, posteromedial, and posterolateral directions. For outcome dependent variables, a two-way, 3x2, Group*Time repeated-measures analysis of variance was performed in SPSS (IBM, Chicago, IL), with $\alpha=0.05$ and Bonferroni adjustments for post-hoc comparisons. **Results:** AHI_{seated} and AHISLS both increased from baseline to 4-week post-testing in the IFMT and

IFMT+NMES groups, but remained stable in the Control group (Table 1). For AHI_{seated}, there were statistically significant increases in the IFMT and IFMT+NMES groups, but no change in the Control group. For weight-bearing AHISLS, the Control group had no significant change; the IFMT group had a non-significant increase ($p=0.062$), and the IFMT+NMES group had a highly significant 8.6% increase. Both training groups increased Y-Balance composite reach scores, though only the IFMT group reached statistical significance. There was no change in the Control group (84.7% to 85.2%, $p=0.785$), a significant improvement in the IFMT group (87.1% to 90.9%, $p=0.012$), and a non-significant improvement in the IFMT+NMES group (86.3% to 89.2%, $p=0.075$). **Conclusions:** Four weeks of progressive IFM exercises, alone or with NMES, showed significant improvements in AHI and YBT. Improved foot posture and functional balance may result in improved biomechanics and reduced injury risk. Future work will assess the durability of these short-term improvements, fatigue effects, and translation to clinical populations.

Table 1: Arch Height Index (AHI). Data are Mean \pm SD. *P*-values and effect sizes are for post-hoc t-tests of Baseline vs 4-Weeks for each group.

	<u>Baseline</u>	<u>4-weeks</u>	<u>% change</u>	<u>P-value</u>	<u>Effect size</u>
<i>Seated arch height index (AHI_{seated})</i>					
Control	0.414 \pm 0.067	0.415 \pm 0.075	+0.3%	0.870	0.001
IFMT group	0.384 \pm 0.059	0.401 \pm 0.056	+4.4%	0.006	0.312
IFMT+NMES group	0.349 \pm 0.030	0.372 \pm 0.034	+6.6%	0.001	0.404
<i>Standing arch height index (AHI_{SLs})</i>					
Control	0.386 \pm 0.067	0.395 \pm 0.066	+2.4%	0.144	0.099
IFMT group	0.365 \pm 0.061	0.375 \pm 0.060	+2.6%	0.062	0.156
IFMT+NMES group	0.328 \pm 0.027	0.356 \pm 0.034	+8.6%	<0.001	0.560

Free Communications, Oral Presentations: Injury Screening and Outcomes in the Military

Wednesday, June 26, 2019, 10:00AM-11:15AM, Mandalay Bay C; Moderator: JoEllen Sefton, PhD, ATC

Patient and Injury Demographics of Athletic Training Medical Care for Reserve Officer Training Corps (ROTC): A Report from the Athletic Training Practice-Based Research Network

Radzak KN, Sefton JM, Timmons MK, Lopp R, Stickley CD, Lam KC: University of Nevada, Las Vegas, Las Vegas, NV; Auburn University, Auburn, AL; Marshall University, Huntington, WV; University of Central Missouri; Warrensburg, MO; University of Hawaii, Manoa, Honolulu, HI; A.T. Still University, Mesa, AZ

Context: The use of athletic trainers (ATs) to treat the numerous musculoskeletal injuries in military members has increased. However, clinical practice characteristics of ATs working with the military is largely undefined. Although Reserve Officer Training Corps (ROTC) cadets are not active duty military, they must meet the same physical standards and undergo organized physical training (PT). The current study aimed to identify patient and injury demographics of medical care provided by ATs for five universities' ROTC programs. **Methods:** A retrospective chart review of electronic medical records was performed using the Athletic

Training Practice-Based Research Network (AT-PBRN). ATs at five clinical practice site within the AT-PBRN documented injury assessments via a web-based electronic medical record system. Medical records of cadets (ROTC students) or cadre (Military Science instructors) who participated in ROTC during the 2017-2018 academic year were utilized for analysis. Summary statistics were calculated for patient and injury demographic variables of interest. Patient demographic variables included: military branch (Army, Navy, Air Force, Marines), military science year (MS1 through MS4, representing the years of ROTC experience), and training group membership (in order of most advanced fitness to least: Alpha, Bravo, Charlie, Delta). Injury demographic variables included: mechanism of injury, activity associated with injury, anatomical location of injury, and injury diagnosis.

Results: A total of 253 unique injuries were documented. Injury incidence per ROTC program ranged from 45-56. Frequencies and percentages of selected variables of interest are presented in Table 1. The majority of injuries occurred in Army ROTC participants (n=186/253), however only two clinical sites provide medical care for branches other than the Army. MS4 cadets presented with injuries least frequently (n=27/253).

Cadets in the most advanced fitness group, Alpha, presented with the most injuries (n=87/253). Injuries most commonly occurred during PT (n=114/253), followed by non-ROTC/non-sport related injuries (n=67/253). Insidious onset (n=98/253) and non-contact (n=97/253) mechanisms of injury were prevalent. The most frequent anatomical location of injury was the knee (n=42/253), followed by the ankle (n=41/253), shoulder (n=34/253), and calf (n=31/253). General sprain/strain, and sprain/strain at the thigh/hip/groin were the most frequent diagnoses (both n=25/253), followed by knee pain (n=17/253) and quadriceps strain (n=14/253). **Conclusions:** In ROTC participants, the most frequent location of injury was the knee and most injuries were insidious onset. These findings are similar to active duty Army musculoskeletal injury demographics. Cadets who have been in ROTC the longest (MS4) reported the least amount of injury. Alpha group cadets appear at higher injury rates. Although PT accounts for the highest activity associated with injury, over a quarter of injuries occurred outside of ROTC training. Further investigation is needed to evaluate the effects of injury outside of ROTC training on successful ROTC participant and commissioning into active duty.

Table 1: Summary Statistics of Selected Variables of Interest, frequency (percentage)

	Army	Navy	Air Force	Marine	Non-specified		
Military Branch	186 (73.5%)	2 (0.8%)	6 (2.4%)	14 (5.5%)	45 (17.8%)		
	<i>Non-specified or Other</i>						
Military Science Year	MS1 57 (22.5%)	MS2 45 (17.8%)	MS3 67 (26.5%)	MS4 27 (10.7%)	57 (22.5%)		
	<i>Non-specified or Other</i>						
Training Group	Alpha 87 (34.4%)	Bravo 34 (13.4%)	Charlie 14 (5.5%)	Delta 17 (6.7%)	Cadre 5 (2.0%)	70 (27.7%)	
Mechanism of Injury	Contact 11 (4.3%)	Non-contact 97 (38.3%)	Fall 23 (9.1%)	Twisting 16 (6.3%)	Insidious 98 (38.7%)	Ruck March 6 (2.4%)	Fall from Height 2 (0.8%)
Activity During Injury	Physical Training (PT) 114 (45.1%)	Field Training Exercise 5 (2.0%)	Ruck March 11 (4.3%)	Land Navigation 2 (0.8%)	Obstacle or Confidence Course 4 (1.6%)	Non-traditional PT 6 (2.4%)	Non-ROTC or Non-sport 67 (26.5%)

Association Between Performance on the Landing Error Scoring System and Bone Stress Injury Risk in US Military Academy Cadets

Eckard TG, Padua DA, Miraldi SFP, Peck KY, Posner MA, DiStefano LJ, Marshall SW, Cameron KL: University of North Carolina at Chapel Hill, Chapel Hill, NC; United States Military Academy at West Point, West Point, NY; University of Connecticut, Storrs, CT

Context: Lower-extremity (LE) bone stress injuries (BSI) cause significant reductions in training time and personnel readiness in the military. The ability to efficiently screen incoming military personnel for BSI risk is critical to the development of effective injury prevention programs. Objective: To prospectively examine the association between Landing Error Scoring System (LESS) scores assessed using a novel depth camera and markerless motion capture software system and BSI incidence in a military training population. **Methods:** Study Design: Prospective cohort study. Setting: The US Military Academy

(USMA) at West Point. Patients: 1,987 first-year USMA cadets from the classes of 2019 and 2020 during their first year at the Academy. Interventions: In their first week at USMA, cadets were screened with the LESS using a depth camera (Microsoft KinectTM, Microsoft Corp, Redmond, WA) and markerless motion capture software (PhysiMax Technologies Ltd, Tel Aviv, Israel). Potential risk factor covariates including sex, body mass index (BMI), and history of LE injury were obtained via baseline questionnaire. Exposure was measured as days of follow-up prior to injury during the 1 USMA academic year follow-up period (368 days). Main outcome measures: Incidence rate of LE BSI during the one-year follow-up period obtained from the Cadet Injury and Illness Tracking System at USMA. Multivariable Poisson regression models were used to produce adjusted incidence rate ratios (IRR) to quantify the association between pre-injury LESS scores and BSI incidence rate during follow-up, adjusted for pertinent risk factors. Risk factors were included in the final model as covariates if the 95% confidence interval for the crude IRR

did not contain 1.00. **Results:** A total of 54 LE BSI occurred in 42 cadets during the study period, resulting in an overall incidence rate of 0.07 BSI per 1,000 person-days (95% CI 0.05, 0.09). The mean number of exposure days was 345.4 (SD 61.12, range 3-368). The mean LESS score was 5.22 (SD 1.99, range 0-14). The crude IRR for LESS score was 1.08 (95% CI: 1.02, 1.15; p=0.01) (Table 1). The final model was adjusted for sex and BMI and yielded an adjusted IRR for LESS score of 1.06 (95% CI: 1.002, 1.13; p=0.04), meaning that each additional LESS error documented at baseline was associated with a 6% increase in the incidence rate of BSI during the follow-up period. **Conclusions:** These data provide evidence that LESS scores, measured using a depth camera and markerless motion capture software system, are associated with the incidence rate of LE BSI in a military training population. This is consistent with previous evidence examining the relationship between the LESS scored by raters from video replay and prospective BSI risk.

Table 1. Crude and Adjusted Estimates for LESS Score and Covariates

		Unadjusted Estimates			Adjusted Estimates		
		Unadjusted rate ratio	95% confidence interval	p-value	Adjusted rate ratio	95% confidence interval	p-value
LESS Score	---	1.08	1.02, 1.15	p=0.01	1.06	1.002, 1.13	p=0.04
Sex	Female	2.67	2.10, 3.39	p<0.01	2.07	1.57, 2.70	
	Male	---	---	---	---	---	---
Injury History ^a	Yes	1.05	0.82, 1.35	p=0.68	---	---	---
	No	---	---	---	---	---	---
Body Mass Index (BMI)	---	0.86	0.82, 0.90	p<0.01	0.91	0.86, 0.95	p<0.01

^aNot included in final multivariate model

Evaluation of Landing Error Scoring System and High School Sport Participation in Army Reserve Officer Training Corps

Ericksen HM, Reckelberg RM, Earl-Boehm J: University of Wisconsin, Milwaukee, WI

Context: Musculoskeletal injuries are common in the military population. Army Reserve Officer Training Corps (ROTC) cadets participate in physically demanding training. Limited previous sport participation experience and poor landing mechanics could lead to injury and affect a cadet’s future career in the Army. The Landing Error Scoring System (LESS) has been widely used to evaluate landing biomechanics in various physically active populations; however, the ROTC population is under-represented in these studies. The purpose of this study was to evaluate LESS scores and high school (HS) sport participation in a university ROTC population.

Methods: We used a cohort design to evaluate 52 ROTC cadets (34 males, 18 females; 19.9±2.3years; 171.8±10.4cm; 71.6±13.2kg). Participants were included if cleared to participate in physical training sessions. As part of a combine

testing session, LESS data was collected by having participants jump from a 30 cm high box to a landing area half of their height away from the box, upon landing they immediately jumped up as high as possible. Two-dimensional video recordings were performed for 3 successful trials from frontal and sagittal views. An athletic trainer with 10 years of experience scored each participant’s jump-landings. Participants LESS scores were classified into quartiles: excellent, good, moderate, poor; and into acceptable/poor. We also examined previous HS sport participation and previous participation in sports requiring more jump-landing (soccer, basketball and volleyball). Pearson’s Chi Square was used to examine LESS classification and acceptable/poor ratings. P-value was set at $p \leq 0.05$. Frequencies of HS sport participation and participation in jumping sports were reported.

Results: A greater than expected number of cadets were categorized as poor ($\chi^2(3, N = 52) = 42.462, p < 0.001$) and a greater than expected number of cadets recorded a LESS score >5 ($\chi^2(1, N = 52) = 19.692, p < 0.001$). 32.7% of cadets reported no previous HS sport participation, and of those participating in HS

sports 54.3% reported no participation in sports requiring more jump-landing. LESS and sports participation results are presented in Table 1. **Conclusions:** Our results demonstrated that 63.5% of cadets had a poor LESS score and 80.8% were classified as moderate or poor. Poor LESS scores in the military population have demonstrated association with lower extremity injuries. However, LESS scores in the ROTC population have not been adequately evaluated. ROTC cadets coming in with limited previous sport participation and limited jump-landing experience may be placing themselves at increased risk of injury. ROTC is a program that prepares cadets for a military career. However, if this population is at higher risk for injury that may affect their ability to sustain the high demands of a military career. Future research should investigate the LESS and the implementation of intervention programs to improve LESS scores in the hopes of decreasing overall injury risk in this population.

Table 1: LESS and Sport Participation Results	N	Percentage
LESS Classification	52	
Excellent (≤ 4)	3	5.70%
Good ($>4 \leq 5$)	7	13.50%
Moderate ($>5 \leq 6$)	9	17.30%
Poor (>6)	33	63.50%
LESS Score	52	
Poor (≥ 5)	42	80.80%
Acceptable (< 5)	10	19.20%
High School Sport Participation	52	
At least 1 year	35	67.30%
No participation	17	32.70%
High School Soccer, Basketball or Volleyball Participation	35	
At least 1 year	16	45.70%
No participation	19	54.30%

Association Between Movement Quality Upon Entry to a US Service Academy and Lower Extremity Injury During One Year of Follow-Up

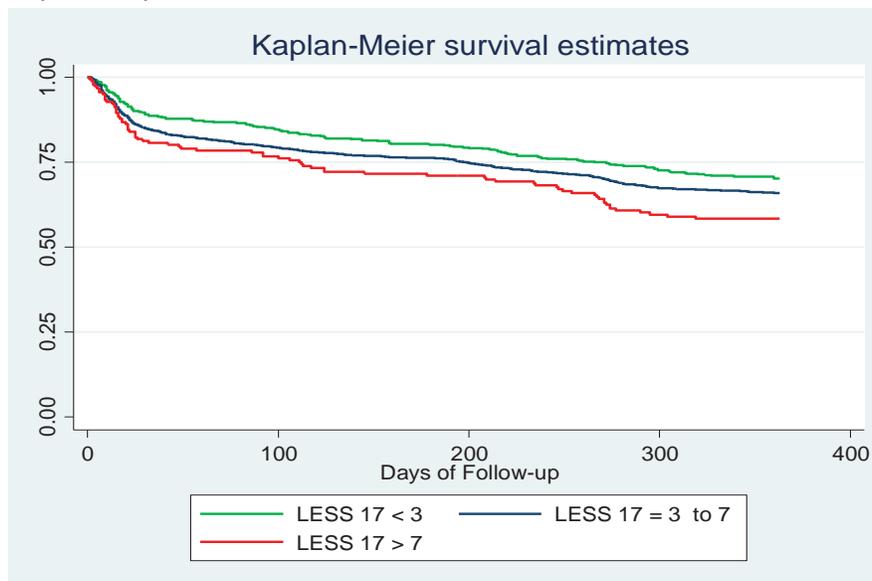
Cameron KL, Miraldi SFP, Peck KY, Houston MN, Posner MA, DiStefano LJ, Padua DA, Eckard TG, Marshall SW: Keller Army Community Hospital, United States Military Academy, West Point, NY; University of Connecticut, Storrs, CT; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Lower extremity (LE) injuries are common in young athletes and military service members. These injuries place a significant burden on military populations and healthcare resources, and they negatively impact combat readiness. Identifying recruits with high-risk movement patterns in an efficient manner may assist military leaders in administering injury prevention strategies to decrease injury rates. The purpose of this study was to utilize a novel technology to examine the association between LE movement quality upon entry to military service and time to LE injury during the first year of service. **Methods:** We conducted a prospective cohort study at a US Service

Academy to address this objective. Incoming freshman from the graduating classes of 2019-2021 were recruited to participate in this study and provided informed consent. During their first week at the Academy participants completed a baseline questionnaire (e.g., demographics, injury history, etc.) and the Landing Error Scoring System (LESS) using a depth camera (Microsoft Kinect™, Microsoft Corp, Redmond, WA) and markerless motion capture software (PhysiMax Technologies Ltd, Tel Aviv, Israel). Active surveillance in the cohort was conducted from baseline through the end of their first year to identify all incident LE injuries during the follow-up period. Movement quality evaluated with the LESS was operationally defined as high quality <3, moderate quality 3-7, and poor quality >7. The primary outcome of interest was time from baseline assessment to incident LE injury during the follow-up period. Kaplan-Meier survival estimates during the follow-up period were calculated by movement quality at baseline. Univariate and multivariable Cox Proportional Hazards regression models were used to estimate hazard ratios (HR) and 95% confidence intervals (95%CI) between baseline movement quality and time to LE injury

during the follow-up period. **Results:** 3,027 individuals (687 females) agreed to participate in the study (height=175.56±8.69cm, mass=74.67±12.33kg). Of the participants screened at baseline, 493 (16%) were identified as having high, 2,353 (78%) moderate, and 181 (6%) poor quality movement patterns. Kaplan-Meier survival estimates by LE movement quality at baseline are presented in Figure 1. In univariate models participants with moderate movement quality at baseline were 20% more likely (HR=1.20, 95%CI: 1.01-1.44, p=0.041) to sustain a LE injury during the follow-up period and those with low quality movement were 54% more likely (HR=1.54, 95%CI: 1.16-2.04, p=0.003) when compared to those with high quality movement. Similar results were observed in multivariable models controlling for sex and LE injury history. **Conclusions:** LE movement quality assessed with the LESS appears to be associated with time to LE injury during follow-up after controlling for potentially important confounding variables. These results also demonstrate that this novel technology can be used to successfully screen large groups of athletes/soldiers and identify those at higher risk for LE injury.

Figure 1: Kaplan-meier survival estimates for time to lower extremity injury during the follow-up period by lower extremity movement quality assessed with the LESS upon entry to military service.



Anterior Cruciate Ligament Reconstruction Survivability in the US Military: A 5-Year Case-Control Study

Mauntel TC, Pav V, Dickens JF: Walter Reed National Military Medical Center, Bethesda, MD; Uniformed Service University, Bethesda, MD; Kennell & Associates, Inc, Falls Church, VA; Johns Hopkins Bloomberg School of Public Health, Baltimore, MD; John A. Feagin Jr Sports Medicine Fellowship, Keller Army Hospital, United States Military Academy, West Point, NY

Context: Anterior Cruciate Ligament injury is a common and potentially career-limiting injury for US military Service Members. Career longevity, and medical separation have not been evaluated following primary anterior cruciate ligament reconstructions (ACLR). The purpose of this study was to determine differences in military separation rates following ACLR without and with concomitant procedures as compared to Service Members with no history of knee injury. **Methods:** We conducted a case-control study of ACLR without and with concomitant procedures (meniscus [M] and/or cartilage [C])

between 2009-2011 to determine the impact of ACLR on military duty status. The Military Health System Data Repository (MDR) was queried to identify Active Duty US Service Members with a history of ACLR and a minimum of two years of pre-ACLR MDR data. Individuals with a recorded knee injury within two years prior to the index injury were excluded from the study. A Control cohort of Active Duty Service Members without a recorded knee injury were identified for each fiscal year cohort. Demographic, military service (occupation, duty status), surgical information, and separation data were abstracted for up to five years after the index event for each cohort. ACLR, ACLR + M, ACLR + C, and ACLR + M + C, were compared to each other and the Control cohort to determine differences in medical separation and duty status during the five-year study period. Chi-square analyses examined differences in attrition percentages between the ACLR and Control cohorts and between the ACLR sub-groups ($\alpha \leq 0.05$). **Results:** Separation rates and separation rates by category and by year for the ACLR cohort (n=2848; male=87%; mode age group=25-34 years; enlisted=86%) and the Control cohort (n=17,810; male=84%; mode age group=25-34 years; enlisted=76%) are presented in Table 1. The reasons for

separation from service were similar between cohorts with the exception of medically related Disability (ACLR=11.17%, Control=4.94%; $X^2=174.45$, $p \leq 0.001$). No differences were observed for separation reasons within the ACLR sub-cohorts. The proportion of individuals separating from service was higher in the ACLR cohort than the Control cohort for all years, with the exception of Year 3-4. ACLR sub-group analyses revealed significant differences in annual attrition rates between the ACLR and ACLR+M cohorts for Year 2-3 (ACLR = 11.14%, ACLR + M = 8.39%; $\eta^2=5.46$, $p=0.020$) and between the ACLR+M and ACLR+M+C cohorts for Year 2-3 (ACLR + M = 8.39%, ACLR + M + C = 15.08%; $\eta^2=6.21$, $p=0.013$). No other differences were observed. **Conclusions:** US Service Members with ACLR are more likely to separate from the military within 5 years following the index injury than individuals without ACLR. The reason for increased separation rates is medically related disability. Thus, targeted injury risk mitigation and improved post-injury surgical and rehabilitation techniques must be optimized to minimize disability and improve outcomes and medical readiness in Service Members following ACLR.

Table 1: Service Member Separation Rates by Separation Category and Year

	ACLR (n = 2,848)	Control (n = 17,810)	% Difference	p
Separation Category (%)*	49.51%	42.59%	6.92%	<0.001
Administrative	3.69%	3.41%	0.28%	0.447
Behavior	3.55%	2.95%	0.60%	0.083
Complete Obligation	27.63%	28.17%	-0.54%	0.551
Disability*	11.17%	4.94%	6.23%	<0.001
Death	0.46%	0.63%	-0.19%	0.083
Failure to Meet Military Standards	1.90%	1.45%	0.45%	0.068
Early Release	1.12%	1.40%	-<0.01%	0.231
Annual Participant Attrition (%)				
Index – Year 1	8.11%	7.98%	0.13	0.812
Year 1 – Year 2*	12.15%	9.24%	2.91	<0.001
Year 2 – Year 3*	10.25%	8.38%	1.87	0.001
Year 3 – Year 4	9.52%	8.96%	0.56	0.33
Year 4 – Year 5*	9.48%	8.04%	1.44	0.010

* Indicates significant difference

Free Communications, Oral Presentations: Visual Concussion Assessment

Wednesday, June 26, 2019, 5:15PM-6:15PM, Mandalay Bay C; Moderator: Jacob Resch, PhD, ATC

The Effect of Exercise on a Novel Dual-Task Assessment for Sport Concussion

Jimenez J, Erdman NK, Hart JM, Resch JE: The University of Virginia, Charlottesville, VA

Context: The dual-task (DT) paradigm is theorized to increase cognitive load which may highlight subtle impairments following a sport concussion. Exercise has been shown to have variable effects on cognitive and motor performance; however, current research has not examined these effects on DT performance. The purpose of our study was to evaluate the effect of exercise and rest interventions on cognitive and motor performance, and subsequent test-retest reliability, using a novel DT assessment in a healthy collegiate population. **Methods:** Sixty healthy, recreationally active adults (32 females, 28 males; Age: 20.5 ± 1.34 years, Height: 171.7 ± 9.33 cm, Mass: 69.25 ± 12.23 kg) participated in this study. Participants completed two, counter-balanced sessions consisting of exercise and rest interventions separated by a two-week test-retest interval. The exercise intervention consisted of five minutes of

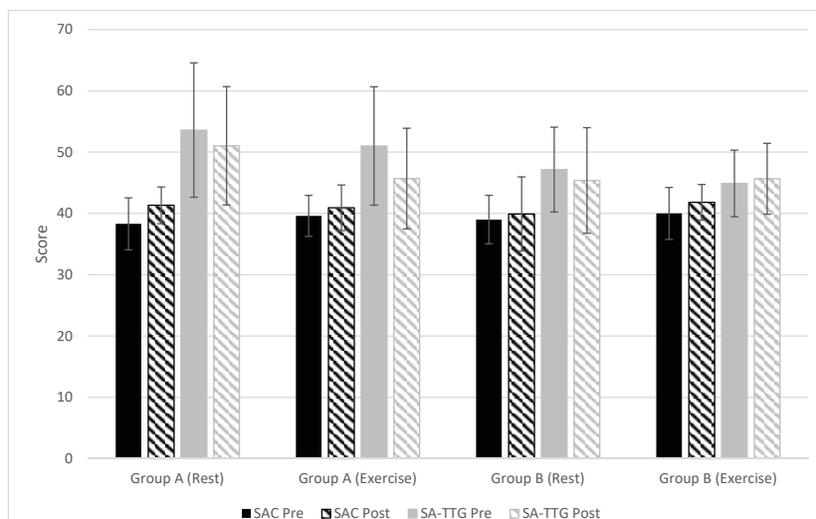
incline treadmill walking alternated with one minute of jumping tasks (lateral hops, squat jumps) for a total of 30 minutes. The rest period required participants to sit at a desk with no added cognitive load (i.e. texting, reading, talking) for a period of 30 minutes. Prior to and following each intervention, participants completed the novel DT assessment which consisted of the standardized assessment of concussion (SAC) and timed tandem gait (TTG) test administered concurrently. For the SAC, individual domain scores for immediate recall (10-item list), concentration (digit span, months in reverse order), and delayed recall were summed to calculate the composite score. For the TTG, average values were calculated for each SAC domain and combined to generate the summed average TTG (SA-TTG) score. The concentration domain is comprised of two unique tasks (digit span, months in reverse order) for which average values were calculated separately. Independent sample t-tests identified differences between groups in pre-intervention scores for the SAC and SA-TTG. Thus, one-way analyses of covariance (ANCOVA) were used to compare SAC and SA-TTG

post-intervention scores while controlling for pre-intervention differences. Mixed-model intraclass correlation coefficients (ICC_{3,1}) with 95% confidence intervals were calculated to evaluate test-retest reliability between pre- and post-intervention scores. All analyses were performed with $\alpha=0.05$.

Results: No statistically significant differences were observed following exercise or rest interventions for SAC or SA-TTG scores ($p>0.05$). Good to excellent reliability was observed following exercise for the SAC (ICC=0.80 [0.67, 0.88]) and SA-TTG (ICC=0.93 [0.88, 0.96]). Moderate to excellent reliability was observed following rest for the SAC (ICC=0.65 [0.42, 0.79]) and SA-TTG (ICC=0.97 [0.94, 0.98]).

Conclusions: Composite scores for the SAC and TTG from our novel DT assessment were resistant to exercise in a healthy population as supported by an absence of statistical change following the intervention, as well as good to excellent test-retest reliability from pre- to post-intervention. Our results align with previously established test-retest values for individual administration of the SAC and TTG test.

Figure 1. Adjusted Group Means for Standardized Assessment of Concussion (SAC) and Summed-Average Timed Tandem Gait (SA-TTG) Composite Scores Prior to and Following Exercise and Rest.



Native Language May Affect Performance on the King-Devick Test, But Not the ImPACT

Cosby A, Medina McKeon JM:
Ithaca College, Ithaca, NY

Context: Following concussion, neurocognitive testing is recommended. Two of the most common tests are the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) and the King-Devick tests. Both tests, in part, rely on the athlete's ability to quickly read and comprehend the English language, which may disadvantage an athlete whose native language is not English. Therefore, we assessed the effect of native language on performance on the English version of the ImPACT and King-Devick test in athletes. **Methods:** Electronic databases (PubMed, SPORTDISCUS and MEDLINE) were searched through October 2018. Search terms included iterations of "concussion", "testing", "baseline", "language", "Spanish", and "ImPACT", and "King-Devick". Studies were limited to peer-reviewed, original studies, published within the last 5 years. Selection criteria required that studies 1) utilized native English speakers; 2) utilized non-native English speakers; and 3) baseline tested athletes on concussion tests in English. Selected outcomes of interest were the 1) ImPACT scores for Verbal Memory, Reaction Time, and Impulse Control subsections; and 2) King-Devick total completion time. The subsections on the ImPACT test were selected based on the responses that incorporate 'word recall' and 'color naming', specific language-based tasks, into the composite score. Means, standard deviations, and sample sizes for the ImPACT composite score for (Verbal memory, Reaction time & Impulse Control), and the KD total time score, were extracted for both groups. Hedges' g effect sizes (ES) [95% CIs] were calculated to determine the magnitude of the difference in scores between the native English and non-native English groups and these effects were pooled into a summary model. A 7-question critical appraisal tool for matched-control

studies was used to assess evidence quality. **Results:** Five cohort studies were eligible. One study was removed due to not reporting standard deviations. The pooled effect of native language on performance on English testing was weak (ES=0.08[0.15, 0.01], $p=0.03$). However, the summary model for the King-Devick test indicated that the effect of language was strong (ES=0.59[1.10, 0.08], $p=0.02$) favoring better performance for native English speakers. In contrast, there were no group differences for the ImPACT composites (ES=0.04[0.09, 0.01], $p=0.16$). All 4 studies scored 7/7, indicating little risk of methodological bias. **Conclusions:** While performance on selected subsections of the ImPACT (Verbal Memory, Reaction Time, and Impulse Control) depends on verbal performance with a speed component, the pooled results indicated there was little impact of native language on performance of an English version of the ImPACT. In contrast, there was a strong effect of native language on performance for the King-Devick, with a trend towards better performance for native English speakers. This is an important consideration, particularly following injury, when no baseline test is available. It is possible that non-native English speakers may perform lower, making comparison to normative values potentially invalid.

Executive Function is Related to Visuomotor Reaction Time in Collegiate Athletes

Hoch MC, Heebner NR, Quintana C, Han DY, Abt JP: University of Kentucky, Lexington, KY

Context: Visuomotor reaction time (VMRT) is an emerging component of sports-related concussion management, musculoskeletal injury prevention, and performance optimization because it is important for injury avoidance and the execution of sport-specific skills. VMRT requires the rapid integration of visual processing and motor coordination suggesting cognitive function may be an underlying factor associated with performance. Therefore, the purpose of this study was to examine the relationship between VMRT and cognition in collegiate athletes. We hypothesized athletes with greater executive function and processing speed among the cognitive domains would exhibit faster VMRT. **Methods:** A total of 112 Division-I collegiate athletes (63 male, 49 female; age: 19.88 ± 1.37 yrs, height: 172.46 ± 56.31 cm, mass: 68.59 ± 5.85 kg) volunteered to participate. During a single testing session, each participant completed an upper extremity VMRT task and three measures of executive functioning and processing speed. The upper extremity VMRT task was a custom protocol consisting of eight wireless LED discs which required participants to touch illuminated targets as quickly as possible. During a 60 second trial, targets randomly illuminated, one at a time, and participants had a maximum of 0.8 seconds to extinguish the target. Reaction time (RT) was measured for each successfully extinguished target and averaged across the trial. The number of targets extinguished (RT-Hits) in each trial was also recorded. For RT and RT-Hits, the average of three trials was used for analysis. Shorter RT (sec) and greater RT-Hits (#/min) were indicative of greater VMRT. Executive function and processing speed were assessed using validated tablet-based cognitive tests. Executive function was evaluated with the Dimensional Card Sort Test

(DCST), which assessed cognitive flexibility, and with the Flanker Task (FT), which assessed inhibitory control in the context of selective visual attention. Processing speed was evaluated through the Pattern Comparison Processing Speed Test (PCPS). Fully-corrected standard scores (T-score) were used for all cognitive tests to account for age, sex, education level, race, and ethnicity. Higher T-scores represented greater cognitive function. The relationship between VMRT and cognitive measures was examined through Spearman correlations. The significance level was set at $p \leq 0.01$. **Results:** RT (0.48 ± 0.04 sec) was moderately correlated to the DCST (55.21 ± 10.31 T-score; $r = -0.33$, $p < 0.001$) and the FT (48.35 ± 10.69 T-score; $r = -0.40$, $p < 0.001$). However, RT was not significantly related to the PCPS (62.93 ± 9.32 T-score; $r = -0.20$, $p = 0.03$). RT-Hits (83.77 ± 19.86 #/min) was moderately correlated to the FT ($r = 0.34$, $p < 0.001$) but was not significantly correlated to the DCST ($r = 0.21$, $p = 0.09$) or the PCPS ($r = 0.13$, $p = 0.18$). **Conclusions:** Athletes with greater executive function exhibited faster RT and more RT-Hits indicating this aspect of cognitive function was associated with greater VMRT. Enhancing executive function skills; particularly inhibitory control in the context of selective visual attention, during rehabilitation, training, and injury prevention interventions may improve VMRT in collegiate athletes.

Clinical Versus Functional Reaction Time: Implications for Post-Concussion Management

Lynall RC, Lempke LB, Johnson RS, Schmidt JD: University of Georgia, Athens, GA

Context: Post-concussion reaction time deficits are well-described in the literature. Clinically, these deficits are commonly measured via computerized neurocognitive tests utilizing the Stroop paradigm or with the drop-stick method in quiet rooms using only hand and finger movement. Upon return-to-sport following concussion, athletes must react to multiple stimuli in highly dynamic sport environments (functional reaction time). Our objective was to determine if functional reaction time was associated with clinical reaction time. **Methods:** Eleven healthy individuals (7 females; age = 22.3 ± 2.8 yrs, height = 165.7 ± 13.2 cm, mass = 66.5 ± 16.1 kg) completed two valid and reliable clinical reaction time paradigms in a cross-sectional laboratory study; 1) computerized Stroop task (CNS Vital Signs; 12 trials), 2) drop-stick (8 trials), and two functional reaction time tasks; 1) jump landing (4 trials), 2) anticipated cut (4 trials in each direction). Stroop reaction time was the average time it took the participant to strike the spacebar after presentation of a colored word written in the same color font (e.g. the word "Red" written in red color). Drop-stick reaction time was the average time it took the participant to catch a wooden dowel attached to a hockey puck after it was dropped by the tester. Jump landing was a maximum vertical jump after landing from a 30cm box. Anticipated cut was a right or left cut at 45° after landing on a single leg from a jump off a 30cm box. Both functional reaction time outcomes, recorded using motion capture (Qualisys), were the average time it took for the participants' sacrum to move more than 3cm in either the sagittal or transverse plane, whichever occurred first, after presentation of a visual stimulus. Pearson correlation coefficients were calculated

between all reaction time measures. **Results:** Significant positive correlations were observed between jump landing (0.45 ± 0.05 s) and anticipated cut reaction time (0.42 ± 0.05 s; $p = 0.023$; $r = 0.674$), jump landing and drop-stick reaction time (0.19 ± 0.02 s; $p = 0.034$; $r = 0.641$), and anticipated cut and drop-stick reaction time ($p = 0.045$; $r = 0.614$). Stroop reaction time (0.62 ± 0.08 s) was not significantly correlated with drop-stick ($p = 0.092$; $r = 0.532$), jump landing ($p = 0.225$; $r = 0.398$), or anticipated cut ($p = 0.529$; $r = 0.213$) reaction time. **Conclusions:** Reaction time deficits are commonly measured after concussion using variations of the Stroop task administered through computerized neurocognitive tests or the drop-stick method. We observed no significant correlations between functional reaction time and Stroop reaction time, suggesting traditional static reaction time measures may not reflect the same neuromotor processes utilized during functional reaction time assessments. This is concerning given the highly dynamic nature of sport. Concussed athletes often complete the Stroop reaction time in a quiet, secluded room using only their fingers, but they must react on the field to a multitude of internal and external stimuli presented simultaneously. More research is needed to determine how functional reaction time is affected after concussion.

Free Communications, Rapid Fire Poster Presentations: Pediatric Athletics: Research in the Area of Pediatric Injuries and Pediatric Sports

Thursday, June 27, 2019, 7:00AM-7:45AM, Mandalay Bay C; Moderator: Hayley Root, PhD, MPH, ATC

Early Sport Specialization is Associated With Increased Chance of Injury

McCall K, Brown V, Medina
McKeon JM: Ithaca College,
Ithaca, NY

Context: Sport specialization for youth athletes is occurring earlier compared with previous generations, increasing the risk of associated physical, mental, and social ramifications. We assessed the impact of level of sports specialization on risk of injury. Secondly, we evaluated the effect of sex on level of sport specialization. **Methods:** We searched PubMed and SPORTDiscus through September 2018. Search terms included iterations of “sport specialization”, “female”, “training”, “competition”, and “injury”. Studies were limited to peer-reviewed original articles, published in English within the past 5 years. Selection criteria required studies 1) evaluated sport specialization in youth athletes; and 2) included frequencies of injured and non-injured athletes. Selected outcomes were 1) sport participation numbers; 2) sport specialization classification (low, moderate, high); 3) injury frequencies; and 4) sex of injured athletes. Sport specialization classification was performed utilizing validated or unvalidated scales, with questions regarding 1) the athlete’s ability to identify a “primary sport”; 2) participation in a “single sport only”; 3) the athlete’s need to “quit one sport to focus on primary sport”; and/or 4) “participation >8 months of the year” in a single sport. Odds ratios (OR) [95% CIs] were calculated to determine the association of 1) sport specialization (low v. moderate, low v. high) on injury (injury v. no injury) and 2) sex (female v. male) on sport specialization (low v. moderate, low v. high). Four summary models were calculated to determine pooled effects across studies. An 8-question critical appraisal tool for cohort & case-control studies was used to assess evidence

quality. **Results:** Seven studies were eligible (6 case-control, 1 cohort). Two studies were subsequently removed as they utilized the same datasets as 2 of the already included studies. When compared to low specialized athletes, moderately specialized athletes were 50% more likely to be injured (OR=1.5[1.3, 1.8], $p<.001$) and highly specialized athletes were 80% more likely to be injured (OR=1.8[1.5, 2.1], $p<.001$). When compared to males, females were more strongly associated with moderate specialization (OR=1.2[1.1, 1.4], $p=0.01$) and high specialization (OR=1.5[1.1, 2.0], $p=0.01$). Included studies each scored 7/8. All studies failed to blind participants or assessors. **Conclusions:** Early sport specialization has a biopsychosocial impact on young athletes. Based on the included studies, there was a strong association between sport specialization and injury, specifically for LE and overuse injuries. Further, female athletes were more likely to be more highly specialized in a sport compared to males. Physically, early sport specialization appears to be an injury risk factor for both sexes. Psychosocially, the rationale for increased sport specialization in female athletes needs further exploration, including a determination of its full impact on injury rates. The clinical magnitude of sport specialization on young athletes has an impact on how ATs can better educate young athletes, parents, and coaches.

The Relationship Between Training Load and Neuromuscular Control in Adolescent Female Basketball Athletes

Beltz EM, Denegar CR, Burland JP, Huggins RA, Lepley LK, DiStefano LJ: Emory & Henry College, Emory, VA; University of Connecticut, Storrs, CT

Context: Training load (TL) is proposed to influence injury risk by altering modifiable risk factors. Neuromuscular control (NMC) is a known risk factor for injury that is modulated by other intrinsic factors, such as fatigue. While both NMC and TL are independently related to musculoskeletal injury risk, the relationship between NMC and TL remains unclear. Therefore, the purpose of this study was to evaluate the relationship between NMC and TL in adolescent female basketball players. **Methods:** Observational, cohort study. Twenty female basketball athletes (15.6 ± 1.4 years, 168.0 ± 7.4 cm, 59.5 ± 8.5 kg) at two high schools volunteered for this study. NMC was assessed at three time points (PRE, MID, POST) over a single athletic season using a standardized jump-landing task and the Star Excursion Balance Test (SEBT). For the jump-landing task, participants jumped forward off a

30 cm-high box to a distance approximately half their height and immediately performed a maximal vertical jump upon landing. The jump-landing task was videotaped from sagittal and frontal views and graded at a later date by a blinded single-rater using the Landing Error Scoring System (LESS). TL was estimated using Session RPE (sRPE), which is the product of the CR-10 Rating of Perceived Exertion and minutes of physical activity, which were self-reported daily. The average LESS score for three jump-landings was used for analyses. A composite SEBT score, normalized to limb length, was calculated. Reach distances for individual SEBT directions (anterior [ANT], posteromedial [PM], posterolateral [PL]) were calculated using the maximum distance. The absolute bilateral difference in anterior reach distance (R-L ANT), which has been shown to be predictive of lower extremity injury in high school basketball athletes, was also calculated. Total sRPE over the previous 7 (sRPE7) and 28 days (sRPE28), and acute:chronic sRPE, were calculated. Bivariate, bootstrapped correlations (1000 samples) were used to evaluate associations between TL (sRPE the day prior, sRPE7, sRPE28, acute:chronic sRPE) and NMC (LESS, SEBT, individual reach distances, R-L ANT) variables. $\alpha \leq 0.05$. **Results:** R-L ANT reach

distance was negatively correlated with sRPE7 ($p=0.03$, $r=-0.40$, 95%CI [-0.67, 0.01]) and acute:chronic sRPE ($p=0.03$, $r=-0.38$, 95%CI [-0.63, -0.07]) (Table 1). There were no other significant correlations between TL and NMC variables ($p>0.05$). **Conclusions:** R-L ANT was negatively associated with measures of training load, suggesting that as loads increased there was a decrease in theoretical injury risk. These data do not support epidemiological evidence that indicates an increase in injury incidence with increasing workloads. There may be a threshold above which TL impairs NMC, and this threshold may not have been reached in many or all of the participants in this study. Additional research regarding the relationship between NMC and TL is warranted, specifically to understand thresholds at which increases in TL impair NMC across subpopulations of athletes.

Table 1. Correlations between training load and neuromuscular control variables. * $p \leq 0.05$

	sRPE Day Prior			sRPE7			sRPE28			Acute:Chronic sRPE		
	r	r ²	p-val	r	r ²	p-val	r	r ²	p-val	r	r ²	p-val
LESS	0.09	0.01	0.61	-0.06	0.004	0.74	-0.19	0.04	0.30	0.12	0.01	0.51
SEBT	-0.05	0.002	0.79	-0.18	0.006	0.92	0.08	0.006	0.67	-0.16	0.03	0.38
ANT	-0.11	0.01	0.55	-0.04	0.002	0.83	<0.001	<0.001	0.99	-0.05	0.002	0.80
PM	-0.01	<0.001	0.95	-0.08	0.006	0.65	0.05	0.002	0.80	-0.24	0.06	0.19
PL	-0.03	0.001	0.89	-0.06	0.004	0.76	0.14	0.02	0.44	-0.13	0.02	0.46
R-L ANT	0.05	0.003	0.78	-0.40*	0.16*	0.025*	-0.31	0.10	0.08	-0.38*	0.14*	0.030*

Self-Reported Physical Activity Volumes in Pediatric Patients With Overuse Knee Injuries

Young JA, Napolitano J, Duerson D, Boucher L, Onate J: The Ohio State University, Columbus, OH

Context: Tendonitis and apophysitis are common overuse injuries seen in the pediatric knee, which are generally considered to be caused by repetitive stress leading to microtrauma. While causes of overuse injuries are multifactorial, training volume is an easily modifiable risk factor. Conversely, the majority of children have been reported as not meeting the current recommendations for weekly moderate to vigorous physical activity (MVPA) of 420 minutes/week. The purpose of this study was to examine self-reported exercise volume of subjects reporting to a sports medicine clinic with knee apophysitis or tendonitis. **Methods:** Subjects between the ages of 5 and 18 and diagnosed by a sports medicine physician with patellar tendonitis, Osgood-Schlatter's disease or Sinding Larsen Johansson disease between March 2015 and March 2018 were included. Age, sex, and minutes per day, days per week, and minutes per week of self-reported exercise were recorded. Subjects were coded as active if they reported that they participated in recommended 420 minutes of moderate to vigorous physical activity (MVPA) per week and insufficiently active if they reported less than 420 minutes of MVPA per week. **Results:** 930 subjects had complete data for assessment (57% male, 43% female) and mean age was 12.2±2.4. 57% of children were sufficiently active at the weekly cut-point, but only 5.4% reported daily activity of 60 minutes or more. In addition, 10.2% reported more hours per week than their age in years. Males reported more physical activity than females (439±351 and 368±263, respectively) and more likely to meet weekly MVPA guidelines ($p < .001$). **Conclusions:** Training volume is often discussed as a modifiable risk factor in overuse injuries. Our data suggest that many pediatric

patients with knee overuse injuries are self-reporting below current MVPA guidelines. Only between 20-40% of children in the US are considered sufficiently active, which is in line with our findings. Previous research demonstrated that modifying training regimens to increase by the recommended 10% rule did not reduce overuse injury rates in novice runners. Highly sports specialized children reported overuse injuries, even after adjusting for weekly training volume. Physical activity levels start decreasing by age 5 which may lead to decreased motor skill development typically occurring at a young age. Decreases in motor control may leave children's bodies unprepared for the demands of physical activity, even those that are not considered highly specialized or participating in higher weekly training volumes. Half of our patients with overuse injuries of the knee were not sufficiently active. Before recommending decreasing activity after diagnosis of a pediatric knee overuse injury, healthcare providers need to ascertain if over-training is a truly a contributing factor. In those reporting less than recommended MVPA, other physical activity options should be discussed.

Does a Parent's Background Influence Their Child's Participation in Contact Sports?

Memmini AK, Van Pelt KL, Wicklund AH, Broglio SP: University of Michigan, Ann Arbor, MI; Orthopaedic & Spine Center of the Rockies, Fort Collins, CO

Context: Concussions occur most often in high-contact sports such as football, soccer, cheerleading, and rugby. Football in particular has seen a decrease in participation over the previous decade, which has been hypothesized to be associated with increased attention on concussive injuries. The purpose of this study was to determine the effects of a parent's background on their child's sport participation in youth athletics. We proposed that parent gender, professional background and personal concussion history would influence the level of contact-sport participation they would allow for their child. **Methods:** An anonymous electronic survey (Qualtrics, Provo, UT) was administered to faculty and staff from a Midwestern university and affiliated medical center between 2017 and 2018 ($n=5848$, $age=39.52\pm 13.80$ years). Only responses of individuals who were parents were included in the survey analysis ($n=3200$). Participants indicated their gender (Male: $n=737$, 23.1%; Female: $n=2449$, 76.9%), professional background (Medical: $n=506$, 16.2%; Non-Medical: $n=2613$, 98.3%), and concussion history (Yes: $n=968$, 30.3%, No: $n=2183$, 69.7%). All respondents indicated their child's (son and/or daughter) current sport participation, which were subdivided into high-contact, partial-contact, and non-contact sport categories. Responses indicating child participation in multiple sports were categorized by the highest level of contact category (i.e. partial and high-contact sport participation was labeled as high-contact). Data were analyzed by chi-square tests to determine relationships between parent's gender, professional background, and concussion history on the level of contact sport

participation they would allow for their child. **Results:** Chi-square analysis revealed no significant relationship between contact category and parent concussion history ($\chi^2=1.21$, $p=0.75$, $df=3$) or parent gender ($\chi^2=2.53$, $p=0.47$, $df=3$). In addition, parents with a professional medical background were no more or less likely to allow high-contact sport participation for their child, than parents without a medical background ($\chi^2=2.56$, $p=0.46$, $df=3$). Overall, 98.3% ($n=3132$) of parents surveyed would allow their child(ren) to play in one or more high-contact category sport, regardless of their personal background. **Conclusions:** These initial analyses revealed non-significant relationships between parent concussion history, gender, and professional background on the sports participation of varying contact-levels for their children. Additional analyses must be considered to determine other potential factors that may be influencing responses, such as stratifying same-sport analysis between parent and child participation. Future studies could consider similar covariates, but with hypothetical children, such as a potential son or daughter.

ACL Injury Prevention Knowledge of Youth Sport Coaches

Martinez JC, Pagnotta KD, Trojian T, DiStefano LJ: Old Dominion University, Norfolk, VA; Jefferson University, Philadelphia, PA; Drexel University, Philadelphia, PA; University of Connecticut, Storrs, CT

Context: Adolescent and youth sport coaches are key stakeholders in the areas of adoption, implementation, and adherence to preventative training programs (PTP). Previous literature has been divided on establishing the level of knowledge youth sport coaches have regarding their athletes' risk of injury. A clearer understanding of the knowledge gap that exists in youth sport coaches regarding injury risk, mechanisms of injury and knowledge of preventative training programs will help to guide coach education of such programs.

Methods: An electronic survey entitled "ACL Injury Prevention" was distributed to a youth (middle and high school) sport coaching listserv via a web-based platform (Survey Monkey). 197 coaches began the survey and 182 coaches [basketball ($N=91$, $Age=42\pm 12y$) and soccer ($N=91$, $Age=41\pm 11y$)] completed at least 80% of the questions of interest. Ten questions focused on mechanism of ACL injury, risky movement patterns, long-term effects of ACL injury and the goals of a preventative training program (PTP). Independent t-tests were utilized to identify differences between soccer and basketball coaches on each subscale (Knowledge of Injury, Knowledge of Risk and Knowledge of PTP) and the survey as a whole. A key was created by a content-area expert and each question was scored as correct or incorrect for a total score out of 10. Alpha level was set a priori at $p<.05$. Coaches were also asked to identify the top three reasons ACL injuries are considered to be devastating. These data were analyzed using a basic inductive qualitative approach, borrowing from the grounded theory. Two separate researchers discussed

the findings to ensure agreement on all themes and terminology. **Results:** Overall, coaches scored $74\pm 14\%$ (Range= 30-100%) on the ACL Injury Prevention Survey. Youth soccer coaches scored higher overall on the survey ($t(180)=3.08$, $P=.002$, Soccer $77\pm 14\%$ correct; Basketball $70\pm 13\%$ correct) than basketball coaches. There were no significant differences between groups on Knowledge of Risk (70% correct (0-100%)) or Knowledge of PTP (83% correct (0-100%)). Regarding the top reasons youth sport coaches considered ACL injuries to be devastating, basketball coaches were concerned with the length of the rehabilitation following ACL injury, the athlete's time away from sport, and that the athletes had to undergo surgery to repair the ACL. Soccer coaches were also concerned with the length of the rehabilitation and time away from sport, but more also discussed the long-term complications following ACL injury. **Conclusions:** Youth sport coaches demonstrate minimally above average knowledge regarding ACL injury prevention. The largest gaps in knowledge appear to be regarding knowledge of ACL injuries and knowledge of ACL injury risk. The topics of length of rehabilitation and time away from sport should be integrated into coaching education materials regarding preventative training programs as these have the potential to increase coach buy-in.

Free Communications, Oral Presentations: Athletic Trainer Documentation and Patient-Reported Outcomes

Thursday, June 27, 2019, 8:00AM-9:00AM, Mandalay Bay C;

Moderator: Matthew Rivera, DAT, LAT, ATC

Unique Challenges and Needs for Patient Care Documentation in the Secondary School Setting

Kasamatsu TM, Nottingham SL, Eberman LE, Neil ER, Welch Bacon CE: California State University, Fullerton, CA; University of New Mexico, Albuquerque, NM; Indiana State University, Terre Haute, IN; A.T. Still University, Mesa, AZ

Context: Athletic trainers (ATs) have acknowledged patient care documentation as an important part of clinical practice; however, ATs who used one electronic medical record (EMR) platform have reported low accountability, lack of time, and culture of the secondary school setting as barriers to documentation. It is unclear whether ATs using paper, other EMRs, or a combined paper-electronic system exhibit similar behaviors or experience similar challenges. Therefore, we explored ATs' documentation behaviors and perceived challenges while using varying systems to document patient care in the secondary school setting. **Methods:** The study was grounded within a consensual qualitative research approach. A purposeful, snowball sampling technique was used to recruit ATs who practiced in various types of secondary schools for ≥ 1 academic year and self-identified as using paper, electronic, or a combined approach to documenting patient care. Two investigators individually interviewed 20 ATs (12 females, 8 males; age = 38 ± 3 years; clinical experience = 15 ± 13 years; location = 11 states and District of Columbia) via telephone. The semi-structured interview guide was modified from previous studies to capture differing documentation systems and was peer-reviewed and piloted for the current study. Interviews were transcribed verbatim. Following the consensual qualitative research tradition, three researchers independently coded transcripts over four rounds

using a consensual codebook to confirm codes, themes, and data saturation. Member checking, peer reviewing, and including multiple researchers were used to triangulate data and enhance trustworthiness. **Results:** The secondary school setting was central to three emergent themes: 1) challenges to documentation, 2) documentation behaviors, and 3) professional development. Overall, ATs spent 5 ± 4 hours per week documenting patient care using paper ($n = 6$), electronic ($n = 8$), or a combined approach ($n = 6$). ATs identified challenges to documentation, including lack of time, high patient volume, and multiple providers or locations where care was provided. Oftentimes these challenges affected their documentation behaviors, which included their process and criteria whether to document or not, the content documented (eg, interventions, communication with stakeholders, required paperwork for the employer), and the logistics of where and when they documented care. To enhance patient care documentation in the secondary school setting, ATs described the need for more professional development, including profession-wide resources/guidelines, opportunities to seek feedback regarding their documentation, and a desire to view exemplary cases and how documentation has been used to improve clinical practice. **Conclusions:** Challenges particular to the secondary school setting affect ATs' documentation behaviors regardless of the system used to document care. Many ATs desire more resources to guide their documentation and to demonstrate how it can be used to improve clinical practice. Targeted professional development is needed to promote best practices in patient care documentation and to characterize services ATs provide in secondary schools.

Athletic Trainers' Perceptions of Patient Reported Outcomes Integration

Gardner LM, Kasamatsu TM, Montgomery MM: Michigan State University, East Lansing, MI; California State University, Fullerton, CA

Context: Patient reported outcomes (PROs) are written instruments that capture the patient's perspective on their pain, quality of life, mental health, and functioning in society among a variety of other factors. Although validated PROs are used in clinical practice across allied health care professions, they have not been widely implemented in the athletic training profession. It is unclear why athletic trainers (ATs) have not routinely implemented PROs and the challenges they have experienced while attempting to integrate PROs into clinical practice. Therefore, the purpose of this study was to investigate ATs' perceptions of the integration of region-specific PROs into a Division I collegiate athletic training clinic and challenges experienced during this process. **Methods:** Using a qualitative case study design, we recruited participants from one institution with ATs who had varying levels of clinical experience and familiarity with PROs. Eight practicing ATs (4 full-time, 4 graduate assistants; 6 males, 2 females; 29 ± 5.5 years of age, 6.6 ± 5.2 years of clinical experience) integrated PROs into their clinical practice (pre-season, post-injury, post-season) and were interviewed regarding this experience. The interview guide was developed based on previous studies on PROs, peer-reviewed, and then piloted with a practicing AT in the collegiate setting. One researcher conducted individual, in-person, semi-structured interviews, which were recorded and transcribed verbatim. Transcripts were independently coded by two investigators using an inductive approach over four

rounds. Multiple researcher analysis, use of a consensus codebook, peer debriefing, and member checking of transcripts were implemented to enhance trustworthiness. **Results:** Four themes emerged, including: 1) perceptions of PROs, 2) mechanics of implementing PROs, 3) barriers to implementing PROs, and 4) strategies for improving implementation. ATs' perceived PROs to be useful to identify region-specific functional deficits and track patients' treatment progression; however, they identified limited use of PROs within the athletic training profession and lack of previous exposure to PROs during their professional education. The majority of ATs discussed a culture change and the increasing importance placed on PROs within professional development programs. Regarding the mechanics of implementation, many ATs admitted PRO usage is feasible, but a learning curve is associated with their application and collection. Multiple barriers affected their implementation of PROs, including forgetting, usefulness or clinical application, and athlete compliance. Clinicians described strategies for improving PRO implementation such as integration during students' clinical education and application of its usefulness during professional development programs. **Conclusions:** ATs acknowledged the usage of PROs in the collegiate setting is feasible, although the mechanics of implementation and barriers associated with their application reduced the consistency of their use. AT's usage of PROs may increase with additional strategies focused on practical clinical application of PROs and utilization reminders.

Athletic Trainers' Knowledge and Application of Medical Documentation Following An Evidence-Based Educational Intervention

Neil ER, Welch Bacon CE, Nottingham SL, Kasamatsu TM, Eberman LE: Indiana State University, Terre Haute, IN; A.T. Still University, Mesa, AZ; University of New Mexico, Albuquerque, NM; California State University, Fullerton, CA

Context: Athletic trainers (ATs) have stated that medical documentation is a weakness in clinical practice citing lack of time to document, lack of knowledge regarding what to include in documentation, and lack of oversight and review as reasons for the poor quality of their medical documentation. ATs serving as preceptors have additional responsibilities to engage athletic training students in best practices for medical documentation. Therefore, we explored the role of an educational intervention and chart review to improve the knowledge and application of medical documentation by ATs that serve as preceptors

Methods: We used a single-cohort design of 11 AT preceptors for professional masters athletic training programs (age = 34 ± 15 y; males = 5, females = 6; years of clinical experience = 13 ± 12 y; years as a preceptor=5±8y;

secondary school=2, 18.2%, college/university=9, 81.8%) that were recruited through e-mail communication from program administrators. The data collection and educational intervention were conducted via a web-based platform. Initially, each participant provided consent, a deidentified medical chart for one patient from their clinical practice, and completed perceived knowledge (PK) and actual knowledge (AK) assessments. Next, each participant engaged in a BOC-approved, evidence-based educational intervention delivered asynchronously with interactive modules. The modules focused on mechanics and best practices of medical documentation, quality improvement strategies, and avenues to engage students in medical documentation. Participants completed a follow-up PK and AK assessment immediately following and 4 weeks post-intervention, in addition to providing another deidentified medical chart. The principal investigator evaluated both charts using a validated tool. All data were analyzed using SPSS® for measures of central tendency and a 2x3 repeated-measures analysis of variance for knowledge (PK and AK) and time (pre-intervention, post-intervention, follow-up). Mauchly's test indicated violations of sphericity, indicating Greenhouse-Geisser corrections for within-subjects effects were necessary. Post-hoc

comparisons were conducted as needed and paired-samples t-tests were used to compare pre and follow-up chart review scores. Significance was set at P<0.05 a priori. **Results:** We found a significant knowledge by time interaction ($F_{2,20} = 6.610, P=0.016$) and significant effects for knowledge ($F_{1,10} = 619.56, P<0.001$) and time ($F_{2,20} = 5.771, P=0.029$). There was a significant increase in the PK scores from pre-intervention to post-intervention ($t_{10} = -2.425, P=0.036$), and from pre-intervention to follow-up assessment ($t_{10} = -4.812, P<0.001$), yet no significant differences in AK were identified at any point. A significant difference was also identified between PK and AK at pre-intervention ($P<0.001$), post-intervention ($P<0.001$), and follow-up ($P<0.001$). A significant improvement in chart review scores was identified from pre-intervention to follow-up ($t_{10} = -4.437, P<0.001$ (Table)). **Conclusions:** ATs' perceptions about and their ability to perform medical documentation significantly improved as a result of the educational intervention, yet no change occurred in their AK. While improvements occurred, participants still scored poorly on the follow-up chart review indicating that continuous quality improvement is vital for professional development regarding medical documentation.

Table. Perceived Knowledge, Actual Knowledge, and Performance Scores

	Pre-Intervention	Post-Intervention	Follow-Up
Perceived Knowledge	3.9±0.5	4.3±0.6	4.3±0.5
Actual Knowledge	10.6±1.7	10.8±1.2	10.1±1.0
Chart Review	20.8±6.4%	N/A	52.0±24.0%

Perceived Knowledge Scale: 1=strongly disagree to 6=strongly agree

Actual Knowledge Total Score: 13 points

Chart Review Score: 0-100%

Aspects of Technology That Influence Athletic Trainers' Current Patient Care Documentation Strategies in the Secondary School

Nottingham SL, Kasamatsu TM, Eberman LE, Neil ER, Welch Bacon CE: University of New Mexico, Albuquerque, NM; California State University, Fullerton, CA; Indiana State University, Terre Haute, IN; A.T. Still University, Mesa, AZ

Context: Previous research on Athletic Trainers' (ATs) documentation practices has focused on users of one electronic medical record (EMR) platform. These studies have identified several strategies and challenges ATs in secondary schools experience when documenting patient care. However, it is important to understand if clinicians who use other documentation platforms have similar experiences documenting patient care. Therefore, the purpose of our study was to examine the documentation practices of ATs who use various forms of patient care documentation, including paper, EMRs, or both. **Methods:** Using a consensual qualitative research design, we purposefully recruited ATs who were practicing in their current secondary school for ≥ 1 year. We sought participants who worked in a variety of geographic locations, in different types of secondary schools, and who used paper documentation, EMRs, or both. 20 ATs participated in this study, including 12 women and 8 men who averaged 38 ± 14 years of age, 15 ± 13 years of clinical experience, and 11 ± 11 years employed at their current secondary school. Two investigators conducted individual semi-structured telephone interviews with participants to gain insight on their documentation practices. Interview guides were adapted from previous studies to fit both paper and EMR users, then peer-reviewed and piloted. Completed interviews were transcribed verbatim and three researchers inductively coded the transcripts using a consensual qualitative research

process that included four rounds of consensus coding. Upon finalizing the coding we confirmed data saturation. Trustworthiness was addressed with member-checking, multiple analyst triangulation, and peer review. **Results:** The overarching finding of this study was that ATs' documentation practices are largely influenced by technology, including positive and negative aspects of technology. Three themes emerged, including: 1) current documentation strategies, 2) challenges to documentation, and 3) future documentation strategies. Participants' current documentation strategies included the use of both paper and EMRs, as they found different benefits to using each platform. Oftentimes documentation practices were shaped by challenges to documenting, including barriers to technology use such as unreliable networks, software design issues, and lack of a streamlined approach. Lastly, participants identified future strategies for improving documentation, including needing better EMR options and streamlining their individual approach to documentation. Although ATs acknowledged using both paper and EMR documentation platforms is inefficient, many believed this was necessary to complete patient care documentation with the resources available. **Conclusions:** Many ATs in secondary schools desire to incorporate the use of EMRs in their clinical practice, but face several challenges when attempting to do so. In turn, clinicians are often duplicating documentation on paper or using two separate platforms to document. ATs should communicate with administrators to select an EMR that fits their documentation needs and seek out better resources such as network access and educational opportunities to learn how to use EMRs.

Free Communications, Oral Presentations: Foot and Ankle Case Reports

Thursday, June 27, 2019, 10:45AM-12:15PM, Mandalay Bay C;

Moderator: Carrie Docherty, PhD, LAT, ATC

Functional Outcome Measures In Collegiate Athletes After Turf Toe Injuries: A Level 2 Case Series

Shubow KM, Corbett RO, Hart JM, Park JS, Hertel J: University of Virginia, Charlottesville, VA

Background: No methods of identifying deficits between limbs in athletes following turf toe injury are discussed in the sports medicine literature. The purpose of this Level 2 case series is to describe the results of a comprehensive battery of outcome measures related to functional performance and perceived confidence in four intercollegiate athletes with history of turf toe injury. **Patient:** Four male NCAA Division I athletes who incurred acute unilateral turf toe injuries that required conservative or surgical management and had returned to full sport participation provided informed consent to participate in this study. Subject 1 was a 20-year-old football player (height = 193 cm, mass = 152 kg) who was assessed 15 months after injury. Subject 2 was a 20-year-old baseball player (height = 185 cm, mass = 88 kg) who was assessed 27 months after injury. Subject 3 was a 22-year-old lacrosse player (height = 188 cm, mass = 92 kg) who was assessed 8 months after injury. Subject 4 was a 21-year-old football player (height = 187 cm, mass = 103 kg) who was assessed 31 months after injury. **Intervention or Treatment:** Following injury, all subjects were initially evaluated by their team athletic trainer and subsequently referred to an orthopedic foot and ankle specialist for further evaluation. Subjects 1 and 2 had operative repair of the 1stMTP plantar plate and received post-operative care from their athletic trainer. Subjects 3 and 4 underwent conservative treatment with their athletic trainer. All four cases proceeded unremarkably and the athletes were cleared for return-to-sport based on subjective clinician judgment. In an effort to develop objective criteria for making return-to-sport decisions in athletes with turf toe injuries, these 4 athletes were subsequently evaluated on a battery of objective and subjective functional tests at the time points previously described.

Tests included the Foot and Ankle Ability Measure Sport scale (FAAM Sport), range of motion (ROM) and strength of 1stMTP flexion and extension, peak plantar pressure under the hallux during walking, a timed lateral hop test, and a single leg maximal vertical jump test. Comparisons between the injured and uninjured limbs were made as appropriate. **Outcomes or Other Comparisons:** Subject 1 reported a score of 81.25% on the FAAM Sport and, compared to the uninjured limb, he demonstrated 15° less 1st MTP dorsiflexion ROM, 5° less 1st MTP plantar flexion ROM, 30% less 1st MTP extension strength, and 42% less 1st MTP flexion strength. Subject 2 scored 100% on the FAAM Sport but demonstrated deficits of 13° less 1st MTP dorsiflexion ROM, 5° less 1st MTP plantar flexion ROM, and 30% less 1st MTP flexion strength compared to the uninjured limb. Subject 3 scored 100% on the FAAM Sport but demonstrated deficits of 8° less 1st MTP dorsiflexion ROM, 5° less 1st MTP plantar flexion ROM, and 9% less 1st MTP plantar flexion strength compared to the uninjured limb. Subject 4 scored 100% on the FAAM Sport but demonstrated deficits of 5° less 1st MTP dorsiflexion ROM compared to the uninjured limb. None of the subjects demonstrated any substantial side-to-side differences in plantar pressure during walking or on the lateral hop or vertical jump tests. **Conclusions:** Functional deficits remain in athletes who have a history of turf toe injury after return-to-sport. The results of this case series may provide preliminary evidence of the need for a greater emphasis on ROM and strength exercises during the rehabilitation of operatively and non-operatively treated turf toe injuries in athletes. **Clinical Bottom Line:** Structured evaluations of 1st MTP function prior to and after return-to-sport may be warranted for athletes following turf toe injuries as functional deficits were found in 4 athletes who were medically cleared to return-to-sport.

Navicular Fracture in a Collegiate Soccer Player: A Level 3 Clinical Case Study

Kruithof EE, Gribble PA: University of Kentucky, Lexington, KY

Background: Navicular stress fractures were first reported in the literature in 1970. Original studies documented navicular fractures as a rare injury with incidence rates of 0.7 to 2.4%; yet more recently, incidence rates are reported as high as 25%. Current evidence suggests no statistical difference between conservative and surgical management, however some literature favors non-weight bearing, conservative management over surgical fixation. While conservative management follows a clear protocol, insufficient data exists regarding surgical methods. In this case, open reduction and internal fixation of the navicular was chosen. **Patient:** The patient is an 18-year-old female; at the time of injury she participated in high school soccer and track (height: 165cm, mass: 59kg). She complained of right foot pain following a tackle during soccer practice. The patient sought out evaluation and radiographs from an orthopedic surgeon, and was diagnosed with posterior tibialis tendinopathy. Two months after onset, pain increased and the patient was unable to bear weight. She returned to her orthopedic surgeon for reevaluation and an MRI. Physical evaluation was unremarkable, revealing midfoot swelling and tenderness over the navicular; with all other tests negative. The MRI revealed a complete, nondisplaced nonunion navicular fracture at the lateral one-third and medial two-thirds junction. **Intervention or Treatment:** Two weeks after diagnosis, the patient underwent open reduction and internal fixation using two screws, a calcaneal bone graft, and bone marrow from the iliac crest. She was non-weight bearing for six weeks, and partial weight-bearing in a walking boot for an additional six weeks. At nine weeks post-surgery,

the patient's care was transferred to the sports medicine staff at a division one university where she began daily rehabilitation. The patient completed a gradual return to running progression using underwater and anti-gravity treadmills between weeks 11 and 18. At 19 weeks, the patient began progressing into collegiate soccer practices, and at 21 weeks the patient was cleared for full participation. **Outcomes or other Comparisons:** Return to play decisions were based using several outcome measures, including the Foot and Ankle Ability Measure, single-leg calf raises to failure, and heart rate and activity-load volume. Previous literature suggests a mean time to return to sport of 16.4 weeks for surgical patients and 21.7 weeks for conservative patients, with suggestions that severe fractures, such as in this case, require longer time to return to sport. The reported success rates for both conservative and surgical management were reported lower than 50%. Surgical fixation is often completed with one or two screws and bone grafting, but a unique aspect of this case is the use of bone marrow concentrate, which is not mentioned in the literature. **Conclusions:** While average time to return to sport following surgical fixation is 16.4 weeks, due to the fracture severity and length of immobilization, this case took 21 weeks. This case is classified as a success, as the patient has returned to preinjury level with no pain or deficiencies. In a case this severe, a conservative return to running progression is vital due to the high tensile forces that are placed through the central third of the navicular during running. Finally, while the use of bone marrow concentrate is not mentioned in the literature, this additive to the surgical technique is believed to have helped this patient achieve positive results. **Clinical Bottom Line:** Although surgical fixation for navicular fractures is not largely mentioned in the literature, it is required for severe fractures and elite athletes. Surgical fixation along with a conservative return to running progression yielded positive results for this patient without complications.

The Use of Blood Flow Restriction as Part of a Non-Operative Rehabilitation Program for a Talus Fracture in a Professional Hockey Player: A Case Report

Dover GC, Di Lemme S, Sander-son J, Celebrini RG: Concordia University, Montreal, Quebec, Canada; Vancouver Canucks, Vancouver, BC, Canada; University of British Columbia, Vancouver, BC, Canada

Background: Foot or leg injuries account for 14% to 30% of all injuries suffered by NHL players. Talus fractures are uncommon, accounting for less than 1% of fractures in the general population and usually require surgery and non-weight bearing for 6 weeks. Blood flow restriction is becoming more common in strength and conditioning and could be useful for injury rehabilitation when the athlete presents limitations due to pain and weakness. Our level 3 exploration case report presents a comprehensive rehabilitation program including blood flow restriction in a professional hockey player who suffered a non-displaced talus fracture. **Patient:** The athlete was a 22 year-old, male professional hockey player in his 4th season. During a game his skate blade got stuck in a rut, forcing his foot into dorsiflexion and eversion against the boards. The athlete could not weight bear and had pain on the top and

lateral aspects of his right foot. Palpation of the lateral malleolus was painful and the Kleiger test was negative. Radiographs were inconclusive but the next day a computed tomography (CT) scan indicated a comminuted intra-articular fracture involving the medial anterior process of the base of the talus. **Intervention or Treatment:** During weeks 1-4 the rehabilitation goals were: address the lesion site, decrease pain, maintain upper body, lower body, and core strength as well as cardiovascular fitness (table 1). A specific goal during week 2 was to increase the strength of the injured limb using blood flow restriction. Blood flow restriction exercises were completed NWB in a seated or standing position. The exercises were completed 3 times a week including four sets of 30, 15, 15, and 15 repetitions, using gravity as resistance. By week 3 the athlete was partial weight bearing. By week 4 the main goal was to progress the athlete to full weight bearing and begin skating. During weeks 5-6 the rehabilitation goals were to increase the load on the injured limb during lower body exercises, increase strength of the injured foot and ankle, increase lower body proprioception and functional exercises, and progress to on-ice hockey specific demands. During week 6 the athlete was skating and performing hockey drills with minor restrictions, and since he was returning from a fracture with limited activity we wanted to measure training volume and intensity. During on-ice

sessions, the athlete wore a heart rate monitor to calculate a training effect until his return to competition at week 7. **Outcomes or Other Comparisons:** Blood flow restriction was a novel part of the non-operative treatment and we wanted to monitor the athlete's pain severity, pain interference, and self-reported function during the rehabilitation. Pain and function scores improved throughout the rehabilitation. Moreover we recorded bilateral lower body girth measurements, which remained relatively constant during rehabilitation indicating no significant atrophy occurred early on. During the return to play phase, measuring workload was important since abrupt variations in workload have been correlated to an increased risk of injury. **Conclusions:** Our athlete was able to return to play in 7 weeks while other talus fracture programs require 6 weeks of non-weight bearing. While detailed rehabilitation protocols are available for many lower extremity injuries, very few non-operative rehabilitation protocols for talus fractures are available. Moreover, little evidence supporting the use of blood flow restriction for injury rehabilitation has been reported. **Clinical Bottom Line:** This is the first case we are aware of that uses blood flow restriction for injury rehabilitation in a professional athlete. Because significant hypertrophy can be achieved at 15-30% of 1-repetition maximum, using blood flow restriction may be helpful specifically in early injury rehabilitation when pain can limit ROM and strengthening.

	Week 1	Reps	Week 2	Reps	Week 3	Reps	Week 4	Reps
Weightbearing status	NWB (crutches) + boot		NWB (crutches) + boot		Feather WB (crutches) + boot		Feather WB (crutches) + rigid foot and ankle orthotic	
Modality	low-intens. pulsed ultrasound		low-intens. pulsed ultrasound		low-intens. pulsed ultrasound		low-intens. pulsed ultrasound	
Blood Flow Restriction			BFR at rest	4x 5 mins:5 mins	BFR ANK pf/df	1x30, 3x15	BFR HIP abd skating	1x30, 3x15
			BFR std HIP abd	1x30, 3x15	BFR HIP abd skating	1x30, 3x15	BFR std H/S curl	1x30, 3x15
			BFR std H/S curl	1x30, 3x15			BFR KN ext with 5 lb	1x30, 3x15
			BFR KN ext	1x30, 3x15			BFR ANK pf/df	1x30, 3x15
			BFR ANK pf/df	1x30, 3x15			BFR on bike	11 mins
Upper body	DB bench press	4x8	DB press kneeling	4x8	DB press kneeling	4x10	1/2 kneel FP	3x12
	DB press kneeling	4x8	DB bench press	4x8	seated cable row	4x8	seated cable row	4x10
	1/2 kneel FP	4x12	1/2 kneel FP	4x12	banded pull apart	4x12	high-incl DB press	3x10
	birddog row	4x10	seated cable row	4x10	low incline DB press	4x10	banded push-up	4x8
	seated cable FP	4x10	banded pull apart	4x12	1/2 kneel FP	4x12	std FP	4x12
	DB row bench	4x10					DB bench press	4x10
Core	hollow body hold	4x30s	hollow body hold	4x30s	hollow body hold	4x30s	stir the pot	3x20
	stir the pot	4x30s	stir the pot	4x30s	stir the pot	4x30s	reverse crunch	4x12
	reverse crunch	4x12	reverse crunch	4x12	reverse crunch	4x12	groin side plank	3x20s
	SWB dead bug	4x10	SWB deadbug	4x10	birddog row	3x10	hollow body hold	3x20s
	groin side plank	4x20s	groin side plank	4x20s			ab wheel	3x10
	kneeling side plank	4x30s	birddog row	4x10				
Lower body	landmine RDL	4x8	landmine RDL	4x8	landmine RDL	4x8	SL squat	4x8
	reverse hyperext H/S	4x12	SL glute bridge	4x12	SL glute bridge	4x12	landmine RDL	4x8
							SL hip thrust bench	4x12
							reverse hyperext H/S	4x7

Table 1. Non-surgical rehabilitation program for a talus fracture in a professional hockey player indicating the progression of weightbearing status, modality use and exercises during weeks 1 to 4. abd: abduction ANK: ankle df: dorsiflexion DB: dumbbell ext: extension FP: face pull H/S: hamstring kg: kilograms N: number of times exercise was performed during week NWB: non-weightbearing pf: plantarflexion Reps: repetitions RDL: romanian deadlift std: standing SWB: swiss ball s: seconds UB: upper body

Achilles Tendon Re-Rupture Proximal to the Primary Repair in a Collegiate Football Punter

Poole CM, O'Connor Sutherland AC, Martin BM, Clanton TO: The Steadman Clinic, Vail, CO; Steadman Philippon Research Institute, Vail, CO

Background: Achilles tendon ruptures typically present in males between the ages of 30-50 years-old, who participate irregularly in physical activity. This Level 3 CASE study falls outside of the normal age and level of physical activity demographic. In general, re-rupture rates of 1.7-5.6% are experienced following surgical management, while higher re-rupture rates of 11.7-20.8% are associated with conservative management. **Patient:** The patient is a 22 year-old male, Division I collegiate football punter, five months following a right Achilles tendon repair using the Percutaneous Achilles Repair System (PARS) technique. He was progressing well with rehabilitation per protocol, when the patient experienced a "pop" followed by pain in his right Achilles tendon while performing agility drills. After initial clinical evaluation by the athletic trainer and head team physician, an MRI was obtained showing a complete rupture of the Achilles tendon approximately two centimeters proximal to the previous repair site. Due to the unique re-rupture location, the head team physician referred the patient for further evaluation. Four additional orthopaedic surgeons were consulted before the patient selected a treatment approach. **Intervention or Treatment:** Having been evaluated by five different orthopaedic surgeons, variations of surgical techniques and non-operative management were discussed. The patient eventually underwent an open PARS revision with an Achilles Midsubstance SpeedBridge™ technique two weeks following re-rupture. A sural nerve decompression and posterior compartment decompression fasciotomy were also performed. The patient was placed in a posterior stirrup splint in plantarflexion for 10 days following surgery. He was then transitioned into a plantarflexion short leg walking cast for an additional six weeks. Seven weeks following revision, the patient

was then converted into a walking boot with three, half inch heel lifts. The patient began rehabilitation under the guidance of his athletic trainer. Controlled AROM exercises were initiated following cast removal, including AROM up to neutral dorsiflexion. Passive dorsiflexion ROM was initiated 10 weeks following surgery. In addition to the strengthening and ROM rehabilitation program, the patient concurrently began a four week weight-bearing progression, followed by a two week boot-wean after cast removal. He was also permitted to begin generalized strengthening and conditioning activities. **Outcomes or Other Comparisons:** The presentation of an Achilles tendon re-rupture five months following surgery is highly unusual, with a paucity of literature and anecdotal evidence from physicians highly experienced in treating Achilles tendon ruptures. Furthermore, the rupture site proximal to the previous injury is particularly unusual. The highest rates of Achilles tendon re-ruptures typically occur between 6-8 weeks post-operatively and routinely transpire at the site of the previous rupture. Only one other report in the English literature has described an Achilles tendon re-rupture proximal to the initial repair site; however, the previously reported case did not include an elite athlete, as in this case. **Conclusions:** It is unclear exactly why a young, high level athlete experienced an Achilles tendon re-rupture proximal to the initial repair. No identifiable cause or pathology was found to be associated with this re-injury. Two months following surgery, the patient is progressing well with rehabilitation under the supervision of his athletic trainer, with the goal of participating in football next season. It is essential for athletic trainers to be knowledgeable of Achilles tendon re-rupture management strategies. Failure to recognize and appropriately treat Achilles tendon re-ruptures can impede the rehabilitation progress, lead to a decreased level of sports participation and may lead to permanent disability. **Clinical Bottom Line:** The objective of this case study is to educate athletic trainers regarding the presentation, surgical management and rehabilitation of a rare case of a late Achilles tendon re-rupture proximal to the primary repair in a collegiate football punter.

Reconstruction of a Pathological Pes Planovalgus Deformity in a Female High School Athlete

Dorrian S, Henry K, Gildard M, Powers ME: Marist College, Poughkeepsie, NY

Background: Flexible pes planovalgus, or flexible flatfoot deformity, is a multiplanar, physiological foot deformity that most-commonly manifests in the early pediatric years but then usually resolves without incident or invasive intervention. To date there is a lack of high-level evidence regarding surgical indications for this condition, nor is there a universally-accepted classification system for flatfoot deformities. **Patient:** A 15-year-old female multi-sport high school athlete was diagnosed with a flexible flat-foot deformity of the right foot and an accessory navicular bone. Her chief complaint that prompted evaluation involved a recurring series of painful blisters on the medial midfoot that decreased her ability to play soccer or perform any activities of daily living without significant discomfort. **Intervention or Treatment:** The patient reported a lack of success with months of conservative treatments, not limited to periods of immobilization, oral non-steroidal anti-inflammatory agents, activity modifications, and frequent sessions of physical therapy. Her physician concluded that surgical intervention would likely yield the best possible outcome after multiple failed attempts at conservative management and a resultant increase in symptomology. The selected surgical intervention was multi-faceted, including excision of the accessory navicular and resultant advancement of the tibialis posterior tendon, endoscopic recession of the gastrocnemius, and open-reduction internal fixation of the calcaneus to address the patient's hindfoot valgus deformity. The open reduction procedure was necessary to facilitate the medializing calcaneal osteotomy and the lateral column lengthening technique to the anterolateral calcaneus. The patient tolerated the procedure well and was subsequently immobilized post-operatively for four weeks before advancing to a Controlled Ankle Movement walker for another two weeks. **Outcomes or Other Comparisons:** At six weeks

post-surgery, the patient scored a 41/80 on the Lower Extremity Functional Scale (LEFS) and reported a 6/10 pain level by the evening hours on most days. Additionally, she presented with notable deficits in ankle dorsiflexion, inversion, and eversion, and strength deficits in her lower leg musculature as well as her ipsilateral quadriceps and hamstring muscle groups. Her course of treatment utilized a combination of clinic and home-based exercises focusing on neuromuscular re-education, arthrokinematic mobilizations, gait training, and therapeutic exercises to increase her limb strength and range of motion. By the twelfth week, the patient reported decreased stiffness in her foot to coincide with her gains in range of motion and her LEFS score improved to a 57/80, which exceeds the value for minimal clinically-important difference. The patient has resumed precursory skills for both soccer and softball without any recurring symptoms. Therapeutic intervention is expected to continue in the coming months to focus on strength and activity-specific skills, and the physician is optimistic at this point that the patient should make a full recovery.

Conclusions: A systematic review of the literature revealed that while pediatric flatfoot deformities generally appear in the early years of life, the deformities only persist in about 3% of the adult population, deeming this case seemingly rare. Unfortunately, epidemiological data is inconclusive due to the lack of consistent criteria for defining a flatfoot deformity. Regardless, this patient was recommended for an invasive reconstruction due to her functional limitations and lack of success with conservative interventions. Calcaneal osteotomies are the typical procedure to address these deformities, however our patient presented with a comorbid accessory navicular bone that was also attended to during her surgery which made her procedure and recovery increasingly unique.

Clinical Bottom Line: A majority of patients will respond positively to pes planovalgus with conservative management, including foot orthoses and accompanying therapeutic exercises. Athletic trainers should also be proactive in exploring alternative options for patients that fail to respond to non-operative therapy for flexible flatfoot deformities.

Diagnosis and Treatment of a Left Talus Lateral Process Fracture and Subtalar Loose Bodies

Sweigard JA, O'Connor Sutherland AM, Martin BM, Clanton TO: The Steadman Clinic, Vail, CO; The Steadman Philippon Research Institute, Vail, CO

Background: Ankle sprains are one of the most common athletic injuries sustained, especially in basketball¹. Though this injury initially presented and was managed as an ankle sprain, the lingering pain and decreased function suggested more significant injury. The talar fracture sustentacular injury, and loose bodies failed to appear in plain radiographs. MRI demonstrated diffuse edema within the talus, however, CT imaging was necessary to identify the specific injury and formulate a definitive treatment plan. Level 3 CASE study. **Patient:** 23 year-old NCAA Division I basketball player presents for evaluation of persistent pain and inability to return to sport following an injury to his left ankle. He had no history of left foot injuries, right side history included fibular stress fracture. Athlete developed a stress injury in the talus in December 2017 concurrent to an ipsilateral ankle sprain but was able to play through the pain. He then developed severe pain about one minute into a game in early December with no clear injury. He did not play the rest of the season. **Intervention or Treatment:** Crutch use immediately began for 3 weeks then transitioned to a walking boot for about 3 months. Gentle rehab began in February and progressed to full activity by June. Vitamin D levels were tested in March with a result of 17, and he began Vitamin D supplementation. Although pain-free in June and July his activity was very limited, doing 2 hours of practice/conditioning and 5 hours of lifting per week. In the beginning of August, he began to develop the same pain again, which was sharp and related to cutting, jumping, and running. He was typically pain-free at rest, but had achy pain at rest following activity. He had a subtalar injection in early September which provided

2-3 days of pain relief with full return of symptoms within 5 days. At that point, his team physicians and AT staff decided to pursue a second opinion. Physical exam by second opinion physician revealed left ankle ROM of 5° dorsiflexion, 45° plantarflexion, 10° eversion, 15° inversion, TTP over lateral process of talus and lateral gutter. Physician ordered a CT scan which demonstrated a clear fracture line at the lateral talar process, loose bodies within the subtalar joint also correlated with the patient's symptoms. An MRI showed diffuse edema. Since the athlete had pathology unlikely to resolve with further conservative treatment, he chose to undergo a surgical procedure. An open reduction and internal fixation (ORIF) of the left talus lateral process fracture and left subtalar arthroscopic debridement of loose bodies was performed. **Outcomes or Other Comparisons:** The patient is early in his postoperative rehabilitation and is beginning active range of motion exercises under the guidance of the athletic training staff. **Conclusions:** According to the current literature, talar stress fractures are relatively rare injuries, requiring advanced imaging techniques than plain radiographs to confirm the extent of injury. This case presented initially as less severe of an injury and was uncontrolled with conservative measures. This case shows that through proper imaging techniques and a thorough examination an uncommon injury can be diagnosed. The initial evaluation and diagnostic testing indicated a stress injury to the talus which was managed according to current practice standards. Previous radiographs and imaging techniques failed to show the full extent of injury, leading to missing a full season of competition. **Clinical Bottom Line:** Athletic trainers should have a high level of suspicion of a talar injury if an athlete has prolonged symptoms after an ankle sprain that is not responding to conservative treatment. An early diagnosis will decrease the recovery time after initial injury if timely addressed.

Free Communications, Oral Presentations: Head Impact Outcomes

Thursday, June 27, 2019, 12:30PM-1:45PM, Mandalay Bay C;

Moderator: Jason Mihalik, PhD, CAT(C), ATC

Comparison of Head Impact Mechanisms and Type of Play for Women's Lacrosse Over 4 Years

Riquelme JE, Bradney DA, Breedlove KM, Bowman TG: University of Lynchburg, Lynchburg VA; University of Michigan, Ann Arbor, MI

Context: Due to the potentially negative health consequences of impacts to the head, studying head impacts in sport is an important step to develop effective prevention strategies. Although lacrosse is one of the fastest growing contact sports in North America, minimal studies have examined head impacts in women's lacrosse. Our objective was to compare head impact mechanisms and type of play in women's lacrosse over a 4 year period in this descriptive epidemiology study. **Methods:** Twenty-nine women's lacrosse players (age = 20.39 ± 0.39 years, height = 162.13±6.50 cm, mass = 60.99 ± 4.82 kg) volunteered to participate over a 4 year period. Participants wore xPatch sensors during all games and practices. We used date and time stamped video recordings to verify all head impacts. xPatch sensors collected peak linear (g) and rotational (deg/sec²) accelerations of all head impacts over a 10 g threshold. The sensors have been shown to be valid and reliable compared to alternatives. Mechanism and type of play (offense, defense, transition, extra player, down a player) served as the independent variables. From this data, we calculated incidence rates (IR), incidence rate ratios (IRR), and 95% confidence intervals (CI₉₅) to determine frequency differences. In addition, we used a MANOVA to determine differences in the magnitude of head impacts. **Results:** Stick to head impacts occurred most often (IR = 483.87, CI₉₅ = 397.30-570.45) whereas, head to head impacts were the least common (IR = 20.16, CI₉₅ = 2.49-37.83; IRR = 24.00, CI₉₅ = 9.81-58.71).

A player was 53.50 (CI₉₅ 13.21-216.70) times more likely to sustain a head impact while playing defense (IR=431.45, CI₉₅ 349.70-513.20) compared to when her team had an additional player due to a penalty on the opposing team (IR=8.06, CI₉₅=3.11-19.24). The interaction between mechanism and type of play was not significant for the combined dependent variables (multivariate F_{16,458}=1.26, P=.22, η²=.04). However, the main effect for mechanism was significant (multivariate F_{10,458} = 2.91, P < .01, η² = .06). Follow-up ANOVAs showed mechanism significantly altered PLA (F_{230,230}=3.13, P<.01, η²=.06) and PRA (F_{230,230}=2.71, P=.02, η²=.06). Type of play also altered the combined dependent variables (F_{8,458}=2.37, P=.02, η²=.04); however, type of play did not alter PLA (F_{230,230}=2.40, P=.05, η²=.04) nor PRA (F_{230,230}=2.04, P=.09, η²=.03). **Conclusions:** Women's lacrosse players are most likely to sustain a head impact from stick to head contact while playing defense. Stick to head contacts are illegal in women's lacrosse but occurred often during the 4 years of our data collection. Prevention efforts should be focused on strict enforcement of women's lacrosse rules during participation.

Efficacy of 3D Multiple Object Tracking and Head Impacts and Cognitive Performance in Div. III Lacrosse

Marchesseault ER, Goss JR, Beaulieu C, Larson J, Rosene JM: University of New England, Biddeford, ME

Context: Accumulations of subconcussive head impacts in sports may result in negative effects on cognitive function. Three dimensional multiple object tracking (3D MOT) has been proposed as an intervention to train perceptual cognitive skill which leads to a decreased anticipatory response and increased rate of decision-making. The study examined the efficacy of 3D MOT intervention on the frequency and magnitude of head impacts and cognitive performance. It is hypothesized that 3D MOT will decrease frequency and magnitude of head impacts and increase cognitive performance.

Methods: The randomized control trial consists of a convenience sample of NCAA Division III men's (n = 32; age=20.25 + 1.24 years; height=178.92

+ 4.95cm; weight=79.17 + 8.34kg) and women's (n = 13; age=19.40 + 1.21 years; height=164.19 + 11.37cm; weight=64.82 + 5.13kg) lacrosse athletes, randomly assigned to a control group, no intervention (C) (n =24), or intervention group, 3D MOT (NT) (n =21). The 3D MOT group trained 2-4 times weekly over 12 weeks for 25 training sessions (sessions 1-15 seated, 16-20 standing, and 21-24 standing while cradling). Frequency, magnitude, and location of head impact and cognitive assessments were measured. Magnitude measures included peak linear acceleration (PLA), peak rotational acceleration (PRA), and peak rotational velocity (PRV). Live monitoring during practices and games, and video analysis confirmed head impacts. Cognitive assessments were performed one week prior to the season and one week following the end of the regular season. Independent samples t-tests compared head kinematics between practices and games, and cognitive assessments pre and post-season. Independent groups ANOVAs compared head kinematics between sex and groups. Significance was set at p=.05. **Results:** 280 male

head impacts and 43 female head impacts were recorded. Males had more impacts in games versus females regardless of group (MG = 5.03 + 5.23 hits/athlete; FG = 1.77 + 3.24 hits/athlete; p = .043). The NT group had greater PRA and PRV in games versus C. (NT PRA Games = 5.01 + 2.56 krad sec-2; C PRA Games = 3.83 + 2.36 krad sec-2; p=.004) (NT PRV Games = 20.27 + 9.083 rad . sec-1; C PRV Games = 16.52 + 8.38 rad . sec-1 ;p=.007) (figure 1). Post-season cognitive assessment scores were significantly higher than pre-season scores for both 3D MOT and C. (NT CTMT preseason = 65.94 + 24.78; NT CTMT postseason = 73.19 + 20.20 p = .036) (C CTMT preseason = 46.86 + 34.34; C CTMT postseason = 66.93 + 28.43 p = .014). **Conclusions:** Increased PRV and PRA may suggest that 3D MOT intervention will not elicit avoidance of head impacts or decrease magnitude. Further research is warranted to examine the appropriateness of 3D MOT training implementation and the effect on subconcussive head impacts in sport.

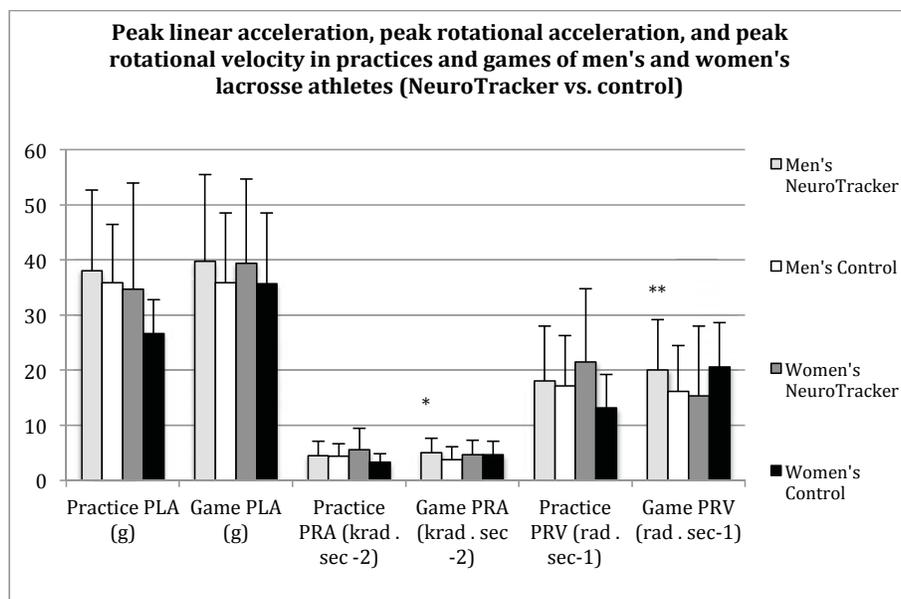


Figure 1

Comparing Men's Soccer Head Impact Characteristics Over a Three Year Time Period

Ennis KM, Bradney DA, Breedlove KM, Bowman TG: University of Lynchburg, Lynchburg, VA; University of Michigan, Ann Arbor, MI

Context: Head impacts are a concern in sports due to potential short term and long term negative health effects. By studying head impacts over multiple seasons, injury patterns may be recognized which can lead to rule changes within the sport and other injury reduction measures. To date, most literature has focused on women's soccer and other sports compared to men's soccer. The objective was to compare head impact characteristics (impact location and mechanism) in men's soccer over 3 years. **Methods:** We completed a descriptive epidemiology study on male collegiate soccer teams over three fall seasons (53 games, 94 practices). Participants included 26 NCAA Division III intercollegiate male soccer players (age = 19.64 ± 1.25 years, height = 181.70 ± 5.80 cm, mass = 76.98 ± 10.19 kg). Participants wore X2 Biosystem xPatch sensors that recorded frequency, location, and magnitude of head impacts over a 10 g threshold. All head impacts were confirmed through time-stamped video analysis. We determined frequency differences by calculating the incidence rates (IRs) per 1000 athlete-exposures (participation in a practice or game for any amount of time) and the incidence rate ratios (IRRs) with corresponding 95% confidence intervals (CI_{95}). A MANOVA was used to identify magnitude differences for linear acceleration (g) and rotational acceleration (deg/sec^2). **Results:** The overall male soccer player IR was 7.50/1000 athlete-exposures (CI_{95} = 2.85-12.15). The most common mechanism for a head impact was ball to head (IR = 441.86, CI_{95} = 406.18-477.55), and the most common location on the head for an impact was to the side of the head (IR = 478.62, CI_{95}

= 441.48-515.76). The interaction between mechanism and impact location ($F_{18,2254} = 1.97$, $P = .008$, $\eta^2 = 1.6$) and the main effect for location ($F_{6,2254} = 3.29$, $P < .01$, $\eta^2 = .9$) were statistically significant. The main effect for mechanism was not significant ($F_{10,2254} = 1.03$, $P = .419$, $\eta^2 = .5$, $1-\beta = .553$). Follow-up ANOVAs showed significant interactions between mechanism and location for linear ($F_{9,1128} = 1.97$, $P = .040$, $\eta^2 = 1.5$) and rotational ($F_{9,1128} = 2.95$, $P < .01$, $\eta^2 = 2.3$) accelerations. Main effects were significant for location when analyzing linear ($F_{3,1128} = 3.01$, $P = .029$, $\eta^2 = .8$) and rotational ($F_{3,1128} = 6.3$, $P < .001$, $\eta^2 = 1.6$) accelerations as well. The main effect for mechanism when analyzing linear ($F_{5,1128} = .248$, $P = .941$, $\eta^2 = .1$, $1-\beta = .111$) and rotational ($F_{5,1128} = .392$, $P = .855$, $\eta^2 = .2$, $1-\beta = .154$) accelerations were not significant. Post hoc results revealed no significant pairwise differences ($P > .05$). **Conclusions:** The IR for head impacts in our study of men's soccer players is lower than head impact IRs reported previously in women's soccer players and other sports. We speculate that these differences may be due to different levels of body control between sexes and differences between soccer and other contact sports. Head impact prevention efforts should be focused on impacts to the side of the head, the most common location in our data, and ball to head impacts, the most common mechanism, potentially through manipulation of player behavior.

Effect of Head Impacts on Vestibular Function

Miyashita TL, Ullucci P: Concordia University, Chicago, IL; Sacred Heart University, Fairfield, CT

Context: Research investigating the effect of cumulative subconcussive impacts on neurological function is still in its infancy, but repetitive head impacts may result in vestibular system dysfunction. This dysfunction could create visual deficits, pre-disposing the individual to further head trauma. The purpose of this study was to investigate the effect of subconcussive impacts on minimum perception time, static visual acuity, gaze stability (GST), and dynamic visual acuity (DVA) scores over the course of one competitive lacrosse season. **Methods:** This was a prospective cohort study-design, investigating the following dependent variables: minimum perception time, static visual acuity, gaze stability (GST), and dynamic

visual acuity (DVA) scores. Our independent variables were derived from data collected via GForce tracker sensors, and included: average linear acceleration (g), Head Impact Criteria (HIC), GADD Severity Index (GSI), rotational resultants, and total number of head impacts. Thirty-three Division I Men’s Lacrosse players (age = 19.51 ±1.20, height = 1.76 meters ±0.15, weight = 81.98 kg ±11.23) from one university participated in this study. At the beginning and end of the season, the players completed a vestibular-ocular reflex assessment, using the inVision system by NeuroCom® to assess: perception, static acuity, gaze stability, and dynamic visual acuity. Score differentials were correlated to the head impact exposure data collected via instrumented helmets. All analyses were performed using SPSS (version 23; IBM Corp. Armonk, NY) with a Bonferroni correction significance level of $p \leq .01$. VOR pre and post season measures were analyzed using a paired-samples t-test.

VOR score differentials were then computed and correlated to the head impact exposure data using a Pearson correlation coefficient. **Results:** No statistical differences were found between pre and post season VOR variables. A strong, positive correlation was found between perception score differentials and total number of head impacts, $r(31) = 0.54$. No other significant correlations were found (Table 1). **Conclusions:** Cumulative subconcussive impacts may negatively affect vestibular ocular reflex scores, resulting in decreased visual performance. This decrease in vestibular ocular function may place the athlete at risk of sustaining additional head impacts or other injuries. While these results are interesting, we feel it is important to note we collected several different variables for comparison, and only found significance on one measurement of vestibular ocular reflex.

TABLE 1. Correlation (*r*) of Vestibular Ocular Reflex Scores to Head Impact Exposure Data

	gForce	HIC†	GSI‡	Rotational Resultant	Total Number of Impacts
Perception	.13	.02	.04	.09	.54
Static Acuity	-.11	-.15	-.16	-.12	.00
GST§, Right	.21	.13	.15	.18	-.12
GST§, Left	-.11	.00	-.02	.03	-.18
Velocity Symmetry	-.02	.05	.05	.06	.00
DVA¶, Right	.08	.20	.20	.36	-.03
DVA¶, Left	-.23	-.04	-.06	-.03	.03
DVA¶ Symmetry	-.12	-.22	-.22	-.02	-.07

†HIC (Head Impact Criteria)
 ‡GSI (GADD Severity Index)
 §GST (Gaze Stability Test)
 ¶DVA (Dynamic Visual Acuity)

Free Communications, Oral Presentations: Emergency Care Considerations in the Secondary School Setting

Thursday, June 27, 2019, 2:00PM-3:15PM, Mandalay Bay C; Moderator: Robert Huggins, PhD, ATC

Athletic Directors' Perceptions Regarding the Value of Athletic Trainers Employed in the Secondary School Setting

Clines SH, Welch Bacon CE, Eason CM, Pagnotta KD, Huggins RA, Van Lunen BL: Sacred Heart University, Fairfield, CT; A.T. Still University, Mesa, AZ; Lasell College, Newton, MA; Thomas Jefferson University, Philadelphia, PA; University of Connecticut, Storrs, CT; Old Dominion University, Norfolk, VA

Context: Defining the value of athletic trainers (ATs) within the secondary school setting has become an important focus of the National Athletic Trainer's Association and spurred the creation of the Secondary School Value Model. While this resource is available to ATs, little is known regarding its use and effectiveness in achieving its intended goals. Our objective was to explore high school athletic directors' perceptions of the roles and services fulfilled by ATs employed in the secondary school setting and the means in which those perceptions are established, specifically as they relate to the value of athletic training services. **Methods:** Individual telephone interviews were conducted with ten athletic directors employed in schools utilizing the services of a full-time AT. Interviews followed a semi-structured guide, were digitally recorded, and transcribed verbatim. Data analysis followed the consensual qualitative research tradition where a 3-researcher team independently coded the data to capture themes and categories, then met to discuss the codes and establish a finalized consensus codebook. Data saturation guided recruitment and was confirmed using frequency counts. Trustworthiness strategies included peer review, field notes, member checking, and multiple analyst triangulation. **Results:** Athletic directors demonstrated a general understanding

of the roles and responsibilities of ATs, with the majority of participants identifying at least one role or responsibility completed by the AT at their school that aligned with each of the five domains of athletic training. Athletic directors also discussed the value of ATs, noting both direct and indirect value to their employment. Examples of value included the perception of enhanced athlete safety by having on-site medical care, increased productivity of coaches, and time saving benefits to parents and athletes. Financial value, or worth, of the AT was associated with factors such as AT salary to service provision comparisons and reduced out-of-pocket costs for parents. Lastly, athletic directors identified that despite available data (injury trends, patient encounters, etc.), formal assessment of the AT's performance is rarely conducted through the athletic department and are regularly deferred to the hiring organization (clinic-outreach, hospital network). Assessments by the athletic director are informal and are based on general interaction with and observation of the AT's position.

Conclusions: Athletic directors display a favorable view of ATs and find value in their services. However, athletic director support for ATs predominantly relies on anecdotal evidence rather than data to validate the use of athletic training services. The formal evaluation of the AT is thus deferred to the hiring organization where disconnect between the goals of the outside entity and athletic department or school board may exist. The use of an assessment tool or data specific to the athletic department may be a key factor in demonstrating the value of ATs within this setting.

The Odds of Having Venue-Specific Emergency Action Plans When Standing Orders Are In Place In Schools With an Athletic Trainer

Endres BD, Huggins RA, Coleman KA, Scarneo SE, Keith GG, Casa DJ: University of Connecticut, Storrs, CT

Context: Venue-specific emergency action plans (EAPs) are integral components of preventing catastrophic injury and sudden death in sports, yet vary widely between secondary school (SS) athletics programs. Along with SS athletic trainers (ATs), physician standing orders oversee the health and safety of SS student-athletes, including the creation of EAPs. To date, there is limited information documenting the relationship between having physician-signed standing orders and the adoption of EAPs at the SS setting in the United States. The purpose of this study was to examine the relationship between adopting venue-specific EAPs when physician-signed standing orders are either present or absent in schools with ATs. **Methods:** Cross-sectional online questionnaire. SS ATs in public (PUB) and private (PVT) SSs in the US completed an online questionnaire (Athletic Training Locations And Services (ATLAS) Survey) between June 2015 and October 2018. Duplicate data were removed and only the most updated survey response for each school was included. The response rate in our survey was 47% (n = 6471/13803). Separate 2x2 chi-square analyses and odds ratios (ORs) with 95% confidence intervals (CI) were calculated. Prevalence ratios (PRs) with 95% CI were calculated for PUB + PVT combined. A PR with 95% CI excluding 1.00 were considered statistically significant. A significant alpha level of $p < 0.05$ was set a priori. **Results:** A majority of AT respondents were from PUB schools (84%, n = 5449/6471). 92% (n = 5934/6471)

of total ATs (PUB+PVT) reported adoption of an EAP. Broken down into PUB and PVT schools, 91% (n = 4976/5449) of PUB ATs and 94% (n = 957/1022) of PVT ATs reported adoption of an EAP. 84% (n = 5422/6471) of ATs (PUB+PVT) reported operating under physician-signed standing orders. Broken down into PUB and PVT schools, 83% (n = 4549/5449) of PUB ATs and 85% (n = 873/1022) of PVT ATs reported operating under standing orders. PUB and PVT schools combined (n = 6471, OR = 2.10 [1.71, 2.57], p<.001), PUB schools (n = 5449, OR = 2.05 [1.65, 2.54], p<.001), and PVT schools (n=1022, OR=2.42 [1.36, 4.29], p=.005) were at increased odds of adopting a venue-specific EAP when operating under standing orders. The proportion of ATs stating they had adopted an EAP was highest amongst those who also reported operating under physician-signed standing orders. (PR=1.08 [1.05-1.11]). **Conclusions:** In the SSs surveyed, schools were at increased odds of adopting a venue-specific EAP when standing orders were present. Board of Certification guidelines state that SS ATs should work with standing orders signed by a physician. This study demonstrates there is an association between standing orders and the increased adoption of EAPs. Future studies should investigate the relationship between physician-signed standing orders and other components of emergency care, such as appropriate access to an AED. Findings from these studies could help inform stakeholders in order to make evidence-based changes to improve the health and safety of SS student-athletes.

Prevalence of A Best Practice Emergency Action in Montana Class AA Secondary Schools
 Davis AL, Moody VJ: University of Montana, Missoula, MT

Context: Research suggests the high rates of sport related deaths in secondary school athletics may be preventable with adequate planning, preparedness, and resources. An Emergency Action Plan (EAP) is designed to describe these protocols and provide a foundation for care with site-specific instructions. The purpose of this study was to determine if existing EAPs in Montana Class AA secondary schools met best practice recommendations (BPR). **Methods:** A cross-sectional study design and convenience sampling technique was used to target Montana Class AA secondary schools (enrollment size larger than 779 students). The Montana Secondary School Best Practice EAP survey (MSSBPEAPS) consists of 37 closed ended questions and was developed based on current BPRs concentrating on appropriate health care coverage, emergency planning, environmental

related considerations, sudden cardiac arrest, catastrophic neck injuries, and emergency medical conditions. The MSSBPEAPS was piloted to establish content validity. The MSSBPEAPS was disseminated electronically to athletic trainers employed at the 14 Montana Class AA secondary schools with a request to complete the MSSBPEAPS and attach their most current EAP. Eleven responses were submitted. Responses were eliminated if more than 5 questions were unanswered or if an EAP was not attached, leaving 5 responses eligible for review for a response rate of 36% (n=5/14). The remaining 5 survey results and EAPs were blinded then scored independently by two members of the research team. A scoring rubric to quantitatively assess survey responses and EAP congruence with BPRs was developed, whereby points were awarded for meeting outlined criteria. The weighted scores were tabulated to calculate an aggregate score and schools were then ranked based on the aggregate score achieved. **Results:** The mean aggregate score for all Montana Class AA secondary schools was 63.8 +15.7, with the

highest aggregate score achieving 75.3 points out of a possible 100. The lowest aggregate score was 37.3 points. Scores for each school across all weighted sections can be found in Table 1. Sudden cardiac arrest had the highest adoption of BPRs with an average score of 76% across the 5 participating schools. The lowest adoption of BPRs was found in emergency medical conditions with an average score of 8% across all 5 schools. **Conclusions:** While Montana Class AA secondary schools provide evidence of development and implementation of EAP, there is significant room for improvement to meet BPR. Strengths were identified in the development of the EAP to include policies regarding environmental illness, cardiac arrest, and catastrophic neck injuries; however, areas of improvement are warranted in documentation, mitigation of risk, and emergency medical conditions. Additional investigation is necessary to determine to what extent athletic trainers use BPR to develop their EAP as well as to identify any barriers that exist that prohibit implementation.

Table 1. Adoption of emergency planning best practice recommendations in Montana class AA secondary schools

Section	Score	Points Possible	School 1	School 2	School 3	School 4	School 5	Mean ± SD
Emergency Action Planning	Survey	14	9	6	9	4	11	8 ± 3
	Rubric	36	33	29	28	20	23	27 ± 5
	Combined	50	42	35	37	24	35	35 ± 7
Environmental Related Polices	Survey	12	12	11	12	7	8	10 ± 2
	Rubric	7	6	6	7	0	7	5 ± 3
	Combined	20	17	17	19	7	16	15 ± 5
Sudden Cardiac Arrest	Survey	7	6	7	7	7	6	7 ± 1
	Rubric	3	0	0	3	0	0	1 ± 1
	Combined	10	6	7	10	7	6	7 ± 2
Catastrophic Neck Injuries	Survey	5	5	5	5	0	0	3 ± 3
	Rubric	5	5	5	5	0	5	4 ± 2
	Combined	10	10	10	10	0	5	7 ± 4
Emergency Medical Conditions	Survey	6	0	1	0	0	0	0
	Rubric	4	0	1	0	0	0	0
	Combined	10	0	2	0	0	0	0 ± 1
Totals	Survey	44	31	30	32	18	35	29 ± 7
	Rubric	56	44	41	43	20	25	35 ± 11
	Combined	100	75	71	75	38	60	64 ± 16

Adherence to State Concussion Legislation in High Schools With Varying Levels of Access to Certified Athletic Trainers

Resch JE, Walton SR, Broshek DK, Goodkin HP, Comstock RD, Broglio SP, McGuine TA: The University of Virginia, Charlottesville, VA; The University of Colorado Anschutz, Aurora, CO; The University of Michigan, Ann Arbor, MI; The University of Wisconsin, Madison, WI

Context: All 50 states and the District of Columbia have passed concussion legislation to mitigate young athletes' premature return-to-play following injury. Adherence to concussion legislation as it relates to exposure to a certified athletic trainer (AT) has yet to be examined. The current study's objective was to examine school level adherence to state concussion legislation in Wisconsin and Virginia high schools with access to full-time (HiAT) or, part-time (MidAT) basis, or low (LowAT [one day a week or no AT]) AT coverage. **Methods:** Data were collection occurred between the 2015-2016 and 2016-2017 sport seasons. Wisconsin

and Virginia state concussion laws were reviewed for commonalities which included (Q1) distribution of "a concussion information sheet" to athletes, (Q2) athletes must return a signed "concussion information sheet" prior to participating in sport, (Q3) athletes must be removed from activity if suspected of having a concussion, and (Q4) an athlete removed from activity suspected of having a concussion must receive written clinical clearance to return to activity. Participating high school concussion policies were reviewed online for HiAT (n = 14), MidAT (n = 11) and LowAT (n = 12) categorization with a subsequent phone interview to increase clarity if needed. In HiAT and MidAT schools, the AT served as the point-of-contact. In schools with no AT, the principal or athletic director served as a point-of-contact. Kruskal-Wallis tests were used to compare school adherence to each item. Post hoc analyses were performed using Mann-Whitney U tests. All analyses were performed with $\alpha=0.05$. **Results:** Significant differences were not observed across schools for Q1 ($\chi^2(2, N=35) = 5.15, p = 0.08$). A significant difference was observed for Q2 ($\chi^2(2, N=35) = 7.59, p = 0.02$). HiAT schools (13/14 [93%]) had greater adherence to

Q2 than LowAT (9/12 [75%]) schools ($z = -2.54, p = 0.01$). No differences were observed between schools for Q3 ($\chi^2(2, N=35) = 5.085, p = 0.079$) A significant difference was also observed for Q4 ($\chi^2(2, N=35) = 8.84, p = 0.01$) with greater adherence by HiAT schools (13/14 [93%]) compared to LowAT (10/12 [83%]) schools ($z = -1.62, p = 0.003$). Responses for all items may be found in Table 1. **Conclusions:** HiAT schools were significantly more likely to adhere to legislative requirements for education of parents and athletes and to obtain written clinical clearance to return to play following a suspected concussion. Our results support the employment of at least a part-time AT in the high school setting to potentially reduce the likelihood of poor outcomes following a concussion through enhanced adherence to state concussion legislation.

Table 1. The total number of schools in compliance (%) with the reviewed state law item. †= $p \leq 0.05$ compared to HiAT schools.

AT Exposure	State Legislation Item			
	Q1	Q2	Q3	Q4
HiAT (n=14)	14 (100)	13 (93)	14 (100)	13 (93)
MidAT (n=11)	11 (100)	10 (91)	11 (100)	11 (100)
LowAT (n=12)	9 (75)	9 (75)†	12 (100)	10 (83.3)†

Knowledge and Health Behavior of School Nurses' Related to Emergency Action Plans Adoption in Secondary School Athletics

Scarneo SE, DiStefano LJ, Murata Y, Register-Mihalik JK, Stearns RL, Casa DJ: University of Connecticut, Storrs, CT; Nagoya University, Chikusa-ku, Nagoya, Japan; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Recent literature shows a lack of an athletics-based emergency action plan (AEAP) adoption in secondary schools (SS). Interventions that address multiple levels of the socio-ecological framework (SEF) have demonstrated higher effectiveness than those that address only one level. Thus, school nurses play an important role in management of sport injuries. Therefore, the purpose of this abstract is to describe school nurses' knowledge and health behavior related to AEAP adoption in SS (e.g. organizational level). **Methods:** We conducted a descriptive, cross-sectional study design evaluating the knowledge of SS nurses on the AEAP. Nurses working in the SS setting

(n=1,228) were asked to complete an online survey through Qualtrics in the spring of 2018. Five recommendations for meeting minimum best practices for AEAPs were derived from the "NATA Position Statement: Emergency Planning in Athletics". Survey questions were structured following the Precaution-Adoption Process Model (PAPM), a health behavior model that examines respondent's health behavior. If respondents stated they were 'not adopting' or 'unaware' of AEAP adoption in Q1, they were not asked Q2-5. One-hundred and thirty-one nurses (98.5% Female, 52±11 years) responded to the survey (response rate=10.6%). Frequencies were tabulated for each recommendation and presented as three groups (adopting, not adopting, unaware of adopting) of the responding schools. Results for participant's health behavior (PAPM scale) are also presented. **Results:** Thirty-nine (29.8%) school nurses stated their SS had developed a written AEAP for managing serious and/or potentially life-threatening sport-related injuries. Sixty-one (46.6%) of nurses did not know if their school had an AEAP. Of the nurses that responded their school did not have an

AEAP (n=31, 23.7%), 12 (9.2%) reported their SS does not currently have an AEAP, and are not considering having one; 18 (13.7%) reported their SS does not currently have one but they are considering doing this; 0 reported their SS considered having an AEAP, but decided not to; 1 (0.8%) reported their SS has plans to implement in the next 6 months. Of the remaining four components, the component "The AEAP is posted at every venue" had the most variability in the PAPM stages (Table 1). **Conclusions:** The results of this project show a large number of nurses employed in SS are unaware of the current adoption AEAPs. Of those that had knowledge about their AEAP, a majority of respondents stated they were considering adoption an AEAP in the future. These findings depict a need for improved interventions across the SEF, specifically at the organizational level with all personnel who are involved with health and safety (e.g. school nurse) to aid in the increased adoption of AEAPs in SS. Future research should investigate interventions addressed at multiple level of the SEF as it relates to AEAP adoption.

Table 1. Nurses responses to each of the five questions in the Precaution Adoption Process Model (PAPM). If respondents stated they were "Not Adopting" or "Did not Know" to Q1, they were not asked about the components of the EAP. Values are presented as n (%).

PAPM Stages	I don't know	Not Adopting				Adopting	
	Unaware	Unengaged	Undecided	Decided not to act	Decided to Act	Acting	Maintaining
Q1. Has a written emergency action plan for managing serious and/or potentially life-threatening sport-related injuries (n=131)	61 (46.6)	12 (9.2)	18 (13.7)	0 (0)	1 (0.8)	3 (2.3)	36 (27.5)
<i>If answered "Adopting" (n= 39) to Q1, respondents were shown the following questions:</i>							
Q2. Distribute and reviews the EAP to all relevant athletics staff members annually (n=32)	8 (25.0)	0 (0)	2 (6.2)	0 (0)	0 (0)	0 (0)	24 (75)
Q3. Includes information for healthcare professionals providing medical coverage included in the review and rehearsal of the plan. (n=32)	10 (31.2)	2 (6.2)	0 (0)	0 (0)	0 (0)	0 (0)	20 (62.5)
Q4. Has a venue specific EAP. (n=35)	19 (54.2)	4 (11.4)	0 (0)	0 (0)	0 (0)	0 (0)	12 (34.2)
Q5. Posts the EAP at every venue (n=33)	18 (54.5)	4 (12.1)	3 (9.0)	1 (3.0)	0 (0)	0 (0)	7 (21.2)

Education Best Practices Forum: Dance Injuries: Biomechanics, Screening Tools, and Treatments

Tuesday, June 25, 2019, 7:30AM-8:30AM, Mandalay Bay D; Moderator: Erin Chapman, DAT, MS, ATC
Discussants: Jatin Ambegaonkar, PhD, ATC; Jena Hansen-Honeycutt, DAT, ATC

Free Communications, Rapid Fire Oral Presentations: Running Mechanics: Clinical and Laboratory Measures

Tuesday, June 25, 2019, 9:00AM-10:15AM, Mandalay Bay D;

Moderator: Jennifer Earl-Boehm, PhD, ATC, FNATA

Mirror Gait Retraining on Kinematics in a Healthy Female Runner: A Case Study

Trzyna T, Grooms DR, Simon JE, Starkey C, Wayner R: Ohio University, Athens, OH

Background: Patellofemoral pain syndrome (PFPS) is one of the most common running related injuries. Evidence from a growing number of cross-sectional studies suggests that females with PFPS run with greater hip internal rotation and hip adduction. Neuromuscular reeducation through gait retraining has been successful in altering faulty hip mechanics during running in runners with PFPS by targeting hip adduction, contralateral pelvic drop, and hip internal rotation. However, it is unknown if gait retraining can be used as a potential prevention therapy to improve mechanics in a healthy individual with potential PFPS risk. This Level 3 CASE study examines the effects of a gait retraining program on the biomechanics of a runner who did not report having symptoms related to PFPS, but exhibits the biomechanics that have been prospectively linked with development of PFPS. **Patient:** A single female runner (30 years, 1.7 m, 66.36 kg) running 6-10 mile/week over the span of at least 3 days, volunteered to complete a running intervention. The patient had no previous injury history to her lower extremities, and an unremarkable knee evaluation. **Intervention or Treatment:** The participant was asked to run on a treadmill at a self-selected pace while instrumented 3D kinematic data was obtained as baseline data. During the 2-week, 8-session gait retraining protocol she was asked to run at a self-selected pace in front of a mirror receiving both visual and verbal feedback to correct improper gait mechanics. Feedback was removed during the last 4 sessions. Once the protocol was complete, she was asked to return for post-intervention kinematic

data collection for comparison to baseline data. Raw values are presented for pre- and post-measurements of outcome measures. **Outcomes or Other Comparisons:** On the right and left limb, peak hip adduction showed the greatest improvement (left: 47.21% and right: 42.95% reduction in peak motion, respectively). Pelvic drop showed an improvement of 42.52% reduction in peak motion on the right limb and 26.59% reduction on the left limb. Peak hip internal rotation decreased by 73.79% on the right limb and 73.17% on the left limb. Hip internal rotation total excursion showed an increase in both limbs from baseline. The reductions seen in hip adduction, hip internal rotation, and contralateral pelvic drop are greater than average percent changes in previous studies (23% and 16.6%). Reductions in contralateral pelvic drop were also greater previous studies (24%). **Conclusions:** Gait retraining in a female runner with abnormal gait kinematics, who was not exhibiting symptoms of patellofemoral pain, resulted in improvements of abnormal gait mechanics from baseline measures. This study shows promising results in investigating effects of gait retraining on a healthy population as a potential means to correct mechanics that may contribute to PFPS. Further research is necessary in examining a healthy population and determining the long-term efficacy of this treatment technique to potentially prevent PFPS development. **Clinical Bottom Line:** The success of gait retraining that was developed as a therapy for PFPS to potentially prevent the development of PFPS may allow clinicians to decrease the incidence of PFPS in runners.

Navicular Drop in Collegiate Distance Runners

Johns VK, Bradney D, Aronson P, Lucas J: University of Lynchburg, Lynchburg, VA

Context: Although previous research has shown that navicular drop increases with fatigue of the foot intrinsics, it is unclear whether this occurs in a functional setting. Deviations from normal longitudinal arch height can cause failure of the weight-bearing system of the foot, and therefore lead to injury. The purpose of this study was to evaluate navicular drop (ND) and arch height (weight-bearing and non-weight-bearing) in collegiate distance runners before and after a distance run and an interval workout. Our hypothesis was that navicular drop distance, weight-bearing arch height (WBAH), and non-weight-bearing arch height (NWBAH) would change after completing a running workout, and this change would be greater after a distance run compared to an interval workout. **Methods:** Fifteen (10 male and 5 female, age range 18-22 years) members of a collegiate cross-country team volunteered to participate in our study. We measured navicular drop (cm) before 2 team practices: one distance run (60-80 mins) and one interval workout (12x500m). We marked the navicular tuberosity with a marker, and measured the distance to the floor with the participant seated (NWBAH). We then asked the participant to stand with weight evenly distributed between both feet, and remeasured the distance to the floor (WBAH). The difference between these measures served as navicular drop distance. We took baseline measurements prior to warmup, and post-workout measurements within 5 minutes of the conclusion of activity. We used a 2x2 repeated measure ANOVA to analyze the difference in navicular drop, NWBAH, and WBAH between time (pre-test and post-test) and workout

type (distance run and interval workout). **Results:** Results indicated a significant interaction between workout and time for WBAH ($F_{1.0,14.0} = 9.33$, $p = .009$, $\eta^2 = .40$). Post hoc results revealed post-workout WBAH ($4.82 \pm .16$ cm) were significantly lower than pre-workout measurements ($5.18 \pm .55$ cm, $p < .001$) during the interval workout type. No other pairwise comparisons were significant ($p > .05$). The main effect for time was significant ($F_{1.0,14.0} = 6.51$, $p = .02$, $\eta^2 = .32$). Post hoc tests showed post-workout WBAH ($4.95 \pm .62$) was lower than pre-workout height ($5.12 \pm .56$; $p = .02$). The main effect for workout type was not significant for WBAH ($F_{1.0,14.0} = .43$, $p = .52$, $\eta^2 = .03$, $1-\beta = .09$). The interaction between time and workout type was not significant for ND ($F_{1.0,14.0} = .38$, $p = .55$, $\eta^2 = .03$, $1-\beta = .09$) or NWBAH ($F_{1.0,14.0} = 3.42$, $p = .09$, $\eta^2 = .196$, $1-\beta = .41$). **Conclusions:** We speculate that the greatest change in arch height was seen after an interval workout due to the differences in shoes between the two workout types (spikes during interval as opposed to normal running shoes for distance) Additionally, we believe the change in WBAH after both workout types are likely due to anatomical changes of the foot due to functional fatigue of the intrinsic foot muscles. Studies should continue to explore the clinical implications and applications of changes in arch measurements after activity in an effort to determine potential injury predisposition.

Runners With Exercise-Related Lower Leg Pain Exhibit Increased Contact Time and Strength Deficits

Koldenhoven RM, Virostek A, Higgins M, Hertel J: University of Virginia, Charlottesville, VA

Context: Running is a popular form of physical activity that commonly leads to overuse injuries such as exercise-related lower leg pain (ERLLP). ERLLP encompasses medial tibial stress syndrome, stress fractures, chronic exertional compartment syndrome, and tendinopathies of the lower leg. The purpose of this study was to compare running biomechanics in a natural environment using wearable sensors and clinical measures of lower extremity strength and range of motion (ROM) between runners with and without ERLLP. **Methods:** We performed a case-control study in both laboratory and field settings. Runners aged 18-45 who regularly ran greater than 10 miles per week for at least the past 3 months were included. ERLLP individuals had lower leg pain with activity for at least 2 weeks preceding study participation. Eighteen participants (Healthy: 3M, 6F, age = 20.8 ± 1.1 years, height = 166.3 ± 7.8 cm, BMI = 21.7 ± 1.9 ; ERLLP: 4M, 5F, age = 21.8 ± 6.9 years, height = 172.8 ± 9.3 cm, BMI = 23.8 ± 1.7) completed the study and were fit with wearable sensors (RunScribe™, Half Moon Bay, CA) to wear during their normal training runs for one week. On average, 18,000 steps were analyzed per participant. The primary biomechanical measures were pronation excursion, pronation velocity, braking g's, impact g's, step rate, stride length, contact time, and stride pace. Foot, ankle, knee, and hip strength and ROM were assessed using a handheld dynamometer and goniometer, respectively. Paired t-tests were used to compare all measures between limbs where no differences were identified and the data from both limbs were then combined. Independent t-tests for all demographic and biomechanical measures identified

differences for BMI and stride pace between groups and were controlled for in subsequent analyses. For each biomechanical dependent variable, a one-factor ANCOVA with the independent variable of group at two levels (ERLLP and healthy) was performed with BMI and stride pace entered as covariates. For strength and ROM measures, separate one-factor ANCOVAs were performed with BMI entered as a covariate. The level of significance was set a priori as $p < 0.05$. **Results:** The ERLLP group had significantly higher BMI (Healthy 21.7 ± 2.0 , ERLLP 23.8 ± 1.7 ; $p = 0.03$) and slower stride pace (Healthy 4.3 ± 0.5 m/s, ERLLP 3.7 ± 0.4 m/s; $p = 0.01$). Individuals with ERLLP had longer contact time (Healthy 284.6 ± 18.7 ms, ERLLP 309.8 ± 30.6 ms; $p = 0.03$), and decreased ankle inversion (Healthy 2.3 ± 0.3 N/kg, ERLLP 1.7 ± 0.6 N/kg; $p = 0.03$), hip flexion (Healthy 5.3 ± 0.7 N/kg, ERLLP 3.9 ± 1.1 N/kg; $p = 0.05$), and knee extension (Healthy 6.2 ± 2.0 N/kg, ERLLP 3.9 ± 1.2 N/kg; $p = 0.05$) strength. No other significant differences were identified ($p > 0.05$). **Conclusions:** Contact time was greater in runners with ERLLP than healthy runners. Ankle inversion, hip flexion, and knee extension strength were weaker in individuals with ERLLP compared to healthy runners. These areas of deficit may be areas for clinicians to intervene during the management and treatment of runners with ERLLP to improve their outcomes.

Expanded Pain Sensitivity and Altered Bilateral Kinematics in Runners With Iliotibial Band Syndrome

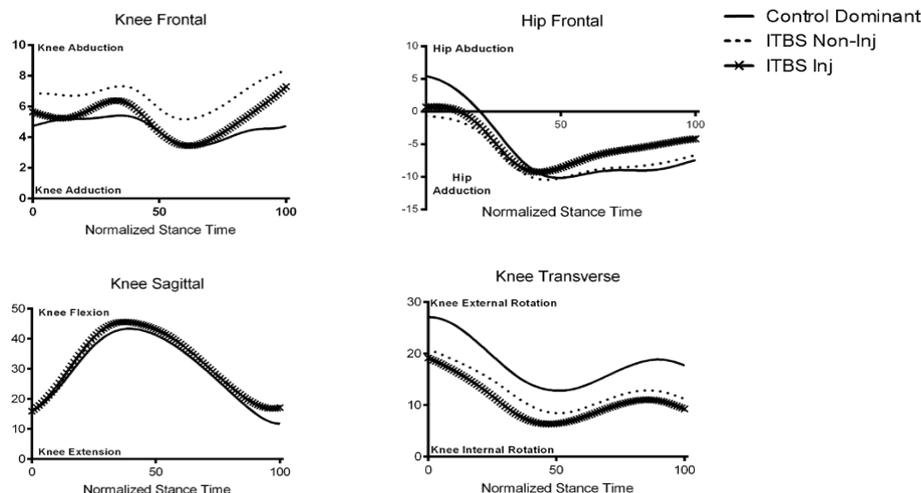
Hamstra-Wright KL, Jones MW, Courtney CA, Maignel D, Ferber R: University of Illinois, Chicago, IL; Northwestern University, Chicago, IL; George Washington University, Washington DC; University of Calgary, Calgary, AB, Canada

Context: Runners with iliotibial band syndrome (ITBS) display symptoms similar to chronic tendinopathy along with hip strength deficits and distinct hip and knee gait patterns compared to runners without ITBS. Although altered central pain processing has been demonstrated in various chronic tendinopathies, central pain processing and its relationship to motor control has not been measured in ITBS. Therefore, the purpose of our study was to examine pain sensitivity, hip abductor and adductor muscle strength, and gait kinematics in runners with and without ITBS. **Methods:** We conducted a case-control study in a laboratory setting. Nine female runners (36 ± 11 yrs; 1.66 ± 6.8 m; 63.4 ± 10 kg) with unilateral ITBS and eight female runners (33 ± 12 yrs; 1.67 ± 5.4 m; 61.4 ± 6.8 kg) with no history of ITBS participated. We diagnosed ITBS through

clinical examination and pressure pain threshold (PPT) at the painful region of the distal ITB. Participants reported their pain level “during running the past week” using the 11-point valid and responsive Numeric Rating of Pain Scale. We quantified pain using PPT at five locations (kg of pressure): bilateral 1st web space of the foot and tibialis anterior; unilateral 1st web space of the contralateral hand. We measured isometric hip abductor and adductor strength using hand-held dynamometry, normalizing for body weight, height, and torque (dimensionless). Lastly, we collected hip and knee 3D joint angles (degrees) while participants ran on a treadmill at a self-selected speed. To measure differences in PPT and hip strength between groups [ITBS injured leg (inj), ITBS non-injured leg (non), control dominant leg (Con)], we used 1-way ANOVAs with post hoc Bonferonni testing. We calculated discrete hip and knee joint angles during the stance phase and performed a waveform analysis of the frontal, sagittal, and transverse planes. **Results:** At the 1st web space in the foot, ITBS runners had bilaterally diminished thresholds of pain compared to Con (ITBS-inj: 1.54 ± 0.51 , ITBS-non: 1.54 ± 0.55 , Con: 4.01 ± 2.30 kg, $P = 0.00$). At the tibialis anterior, ITBS-inj (2.33 ± 1.10 kg) displayed lower pain thresholds compared

to Con (6.13 ± 4.89 kg, $P=0.03$). Isometric hip strength was not different between groups ($P=0.50-0.60$). At the hip, ITBS-inj and ITBS-non were more adducted at touchdown than Con (Discrete - ITBS-inj: -0.68 ± 4.91 deg, Con: 5.44 ± 2.08 deg; Figure 1). At the knee, ITBS-inj and ITBS-non were also more internally rotated during loading and abducted and flexed at toe-off compared to Con (Figure 1). **Conclusions:** ITBS runners showed evidence of expanded somatic pain sensitivity similar to other chronic orthopedic conditions, which existed in the absence of differences in hip strength between groups but concomitant with atypical gait patterns compared to healthy controls. Individuals working with ITBS runners may see bilateral pain symptoms and gait deviations even with unilateral symptoms, highlighting the importance of bilateral training and rehabilitation.

Figure 1. Waveform analysis of knee and hip motion in the frontal, sagittal, and transverse planes during stance phase.



Investigating Hip and Trunk Kinematic and Strength Differences Between Those With a History of Exertional Medial Tibial Pain and Healthy Controls

Hocking A, Ericksen H, O'Connor K, Earl-Boehm J: University of Wisconsin-Milwaukee, Milwaukee, WI

Context: Exertional medial tibial pain (EMTP) is one of the most prevalent injuries in females, particularly in runners. Increased trunk and hip motion and decreased hip external rotation and abduction strength are related to injury in the athletic population, but there is limited evidence specifically in female runners with a history of EMTP. The purpose of this study was to investigate differences in hip strength, hip kinematics, and trunk kinematics between female runners with a previous history of EMTP and healthy controls. **Methods:** Cross sectional, case control design. Twenty-one female runners (27.8 ± 6.3 yrs; 64.5 ± 7.9 kg; 171.6 ± 7.2 cm) who were training for a race of a 10K or more within the next 6 months were placed into two groups depending on

their past history of EMTP (11- healthy control and 10-EMTP group). The EMTP group was asymptomatic at the time of testing, but had to have reported symptoms for at least 3 weeks within the last 24 months. Participants completed questionnaires about their demographics, training routine, and perceptions about running. Reflective markers were placed on the trunk and lower extremity of the previously injured leg of the EMTP group and the non-dominant leg of the control group. 3D kinematic data were collected using a 10-camera motion capture system and standard protocol. Five overground running trials at 4.0-4.5 m/s were collected and angular excursion during the stance phase of hip adduction, internal rotation, and extension and trunk flexion and lateral lean were averaged across the trials. Strength of the hip abductors external rotators, and extensors were collected during 3 MVIC's using a handheld dynamometer and stabilization straps. An independent t-test was performed to identify differences in hip strength and joint angles between the EMTP and control groups ($p < 0.05$). **Results:** No significant differences in normalized hip strength nor hip and trunk kinematics were found between the history of EMTP and

control groups (Table). **Conclusions:** Hip strength and hip and trunk motion were not different in this sample of runners with a history of EMTP and controls. A history of EMTP, rather than current symptoms, was selected to remove the confounding factor of pain influencing running mechanics. However, due to the wide timeframe for the occurrence of EMTP, and broad definition of EMTP our sample was very heterogenous. While only 2 participants reported performing and rehabilitation for their EMTP, it is possible that their strength and biomechanics may have been different now than during their symptomatic period. Future research attempt to control for more factors such as training history. While these results don't support the theory that hip strength and biomechanics are related to EMTP, future research should continue to examine running biomechanics in combination with other factors that could influence lower extremity loading.

Hip strength and angular excursion during running for Exertional medial tibial pain (EMTP) and control (CON) groups.

	Mean \pm SD		t	df	p
	EMTP	CON			
Hip Abduction Strength	36.2 \pm 10.8	36.7 \pm 8.4	0.1	19	0.9
Hip Extension Strength	42.5 \pm 14.0	37.2 \pm 7.7	-1.1	19	0.3
Hip External Rotation Strength	10.8 \pm 2.2	9.6 \pm 1.1	-1.6	19	0.1
Hip Adduction ROM	12.7 $^{\circ}$ \pm 6.9 $^{\circ}$	11.8 $^{\circ}$ \pm 3.6 $^{\circ}$	-0.3	19	0.7
Hip Internal Rotation ROM	7.2 $^{\circ}$ \pm 3.3 $^{\circ}$	7.2 $^{\circ}$ \pm 4.3 $^{\circ}$	-0.003	19	0.9
Trunk Flexion ROM	3.3 $^{\circ}$ \pm 1.7 $^{\circ}$	2.8 $^{\circ}$ \pm 1.8 $^{\circ}$	-0.8	19	0.6
Trunk Lateral Lean ROM	2.9 $^{\circ}$ \pm 1.6 $^{\circ}$	2.3 $^{\circ}$ \pm 1.7 $^{\circ}$	0.9	19	0.5

Effects of a 4-Week Short Foot Exercise Program On Running Kinetics In Recreational Runners

Castaneda M, Emineth KK, Kernozek T, Aminaka N: University of Wisconsin, La Crosse, WI

Context: Improving the integrity of the medial longitudinal arch of the foot through short foot exercise (SFE) can reduce force and pressure experienced in that region, and potentially prevent lower extremity injuries in runners. However, the effects of SFE have not been studied extensively in the running population. The objective of the study was to examine the effects of 4-week SFE on running kinetics before and after prolonged run in recreational runners. Another aim of the study was to examine if the effects of the SFE program remains for 4 weeks after cessation of the exercises. **Methods:** Fifteen recreational runners (8F/7M, 20.93 ± 1.6 yrs, 171.87 ± 10.7 cm, 67.28 ± 9.3

kg) volunteered for data collection in a controlled lab setting on three occasions, at baseline (BL), 4 weeks post exercise program (PE), and 4-week follow-up (FU). At each visit, navicular drop and plantar pressure data using Novel Pedar insole sensor system were recorded before and after a 5-mile run at 80% 5K pace. During the 4-week SFE period, participants completed two short foot strengthening exercises every day, with increasing difficulty weekly. Dependent variables include navicular drop (in mm), and the medial longitudinal arch region peak force (%BW) and pressure (kPa) during the stance phase of running gait. Independent variables include time (BL, PE, FU) and run (pre-run, post-run). For each dependent variable, a separate 3x2 repeated measures ANOVA was performed. The significant level was set at p **Results:** Navicular drop significantly improved after 4 weeks SFE but returned closer to the baseline values at the follow-up (Table 1; F=10.19, p=0.002). While

navicular drop increased at post-run compared to pre-run regardless of time (p=0.033), interaction among time and run was not statistically significant (p=0.344). Peak force and pressure in the medial longitudinal arch region did not yield any statistically significant data regardless of time, run, or interaction (p>0.05). **Conclusions:** The 4-week SFE program resulted in improved static arch integrity measured by navicular drop. However, it did not result in any changes in dynamic arch functions (foot force and pressure). The 4-week period may not be enough to change running biomechanics drastically, but improvement in navicular drop is promising for preventing future running related injuries. It is important to note that the improvement in navicular drop was not maintained at 4 weeks after the cessation of the program. Continued exercise is recommended for maintaining the improvement.

Table 1: Navicular drop measurements (mm). BL = baseline, PE = 4 weeks post short-foot exercise program, FU = 4 weeks post cessation (follow-up).

	BL	PE	FU
Pre-run	8.47±3.83	6.12±2.09	8.03±2.93
Post-run	9.64±2.73	7.74±3.41	8.71±2.95

Treadmill Versus Outdoor Running: Prediction Using A Random Forest Classifier On Biomechanical Measures Of 181,909 Steps

Kramer NA, Hertel J: University of Virginia, Charlottesville, VA

Context: Wearable sensors can measure gait biomechanics outside of laboratory settings, thus allowing for assessment of the effects of different terrains and intensities on key biomechanical measures. With large enough datasets, machine learning techniques may be used to predict various outcomes. Our purpose was to assess if a random forest classifier could be applied to biomechanical measures captured by wearable sensors to predict whether running steps were performed outdoors or on a treadmill. **Methods:** Six young adult distance runners (4 females, 2 males) completed their normal training runs while wearing heel-mounted footpod sensors (RunScribe™, Half Moon Bay, CA) during a 7-day period. Participants completed at least one outdoor and one treadmill run. For each step, the sensors

quantified 8 spatiotemporal (velocity, cadence, step length, cycle time, contact time, flight time, contact ratio, flight ratio), 4 kinematic (loading response pronation excursion, maximum pronation velocity, propulsion supination excursion, footstrike type), and 2 kinetic (impact g, braking g) measures. Recorded steps from all completed runs were concatenated into a single dataset. Using the Python module SciKit Learn, a random forest classifier was utilized for prediction of steps performed during outdoor or treadmill runs. All 14 biomechanical measures were entered into the classifier. The algorithm was trained on 70% of the data and then tested on the remaining 30%. This division of data was randomly generated by the machine. Verification of the random forest classifier was reported using mean accuracy, which is the average of how well the classifier performed on the training data, and testing score, which is how well the algorithm performed on the testing data. **Results:** A total of 181,909 steps (131,971 outdoor, 49,938 treadmill) were collected from 32 runs (22 outdoors, 10 treadmill). The mean accuracy of the random forest classifier in predicting whether individual steps

came from outdoor or treadmill runs was 94.5% in the training data, and the testing score was 91.9%. The Table details the importance rank in the predictive model for each biomechanical measure. Importance rank is a unitless measure generated from the random forest analysis to represent which predictor variables are more closely related with the dependent variable. Means and standard deviations for each biomechanical measure in the outdoor and treadmill runs are reported in the Table. **Conclusions:** A random forest classifier applied to biomechanical measures collected with wearable sensors was able to predict whether steps occurred while running outdoors or on a treadmill with over 90 percent accuracy. The three highest ranked predictors in the classifier were all frontal plane kinematic measures. Future research should attempt to apply machine learning techniques, such as random forest classifiers, to assess whether biomechanical measures can distinguish between steps taken by injured and uninjured distance runners.

Table: Importance rank and descriptive statistics for biomechanical measures.

Feature	Importance Rank	Outdoor Steps (n=131,971) Mean (SD)	Treadmill Steps (n=49,938) Mean (SD)
Maximum Pronation Velocity (°/s)	0.144	668.4 (436.2)	393.2 (262.6)
Pronation Excursion During Loading Response (°)	0.122	11.4 (11.4)	10.8 (7.9)
Supination Excursion During Propulsion (°)	0.117	8.5 (12.6)	8.0 (10.3)
Step Length (m)	0.116	1.3 (0.2)	1.4 (0.3)
Footstrike Type*	0.083	5.6 (3.1)	4.7 (2.6)
Velocity (m/s)	0.071	3.7 (0.7)	3.8 (0.9)
Cycle Time (ms)	0.063	702.5 (72.3)	738.0 (71.6)
Cadence (steps/min)	0.058	172.2 (13.4)	163.8 (12.9)
Braking g	0.044	10.8 (3.1)	9.3 (3.0)
Contact Time (ms)	0.040	277.5 (79.5)	303.8 (92.2)
Contact Ratio	0.040	66.9 (31.3)	72.4 (35.7)
Flight Ratio	0.038	22.9 (9.2)	20.7 (10.3)
Flight Time (ms)	0.037	73.5 (50.5)	65.0 (61.0)
Impact g	0.027	11.1 (3.4)	10.0 (3.4)

* Footstrike type is a unitless metric in the RunScribe™ algorithm that is on a scale from 0 to 15 with lower values representing rearfoot strike, middle values representing midfoot strike, and higher values representing forefoot strike.

Unique Outdoor Running Activities Captured Using Wearable Sensors in Adult Competitive Runners

DeJong AF, Hertel J: University of Virginia, Charlottesville, VA

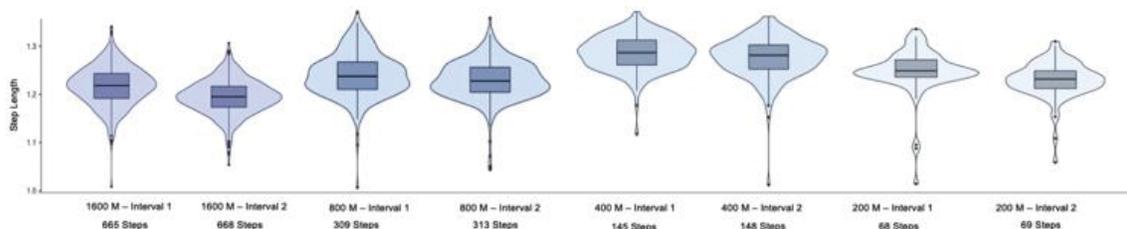
Context: Laboratory gait analyses are frequently used to quantify running mechanics, however treadmill-based analyses cannot effectively mimic outdoor training and racing demands. Wearable sensors offer a means to transcend laboratory settings using lightweight technology capable of measuring biomechanics in natural environments.

Methods: Heel-mounted footpod sensors (RunScribe™, Half Moon Bay, CA) measured individual runners' biomechanics during unique outdoor running demands. Participants completed a week's worth of typical running wearing the sensors and maintained self-reported running logs. Individual runners (4 females, 1 male; 32.8±6.6 years) completed hill sprints (Runner1) and track interval workouts (Runner2), and competed in a 21-kilometer road race (Runner3). Two runners competed in the same 5-K trail race (Runners4 and 5). Step-by-step datasheets from

each activity were extracted. Walking events were identified from the flight ratio variable data falling to zero and were eliminated from analysis. The 21-K race was broken down into four sub-sections (5-, 10-, 16-, and 21-K, total steps=9,972), and the 5-K race was broken into thirds (miles 1, 2, and 3, Runner4 total steps=2470, Runner5 total steps=2527). Step rate (SR) and step length (SL) were analyzed in each activity using means with 95% confidence intervals (CIs), and violin plots with overlaid box plots (Figure) to identify spatiotemporal patterns during the individual training and racing situations. **Results:** SR and SL were greater during the uphill sprints of the hill intervals compared to downhill across repetitions (SRuphill = 191.7 ± 2.9 steps/min, SRdownhill = 161.8 ± 0.8 steps/min; SLuphill = 1.30 ± 0.04 m, SLdownhill = 0.97 ± 0.05 m). SR and SL also were greater with shorter track interval distances (SR1600 = 182.1 ± 2.2 steps/min, SR800 = 186.2 ± 3.2 steps/min, SR400 = 191.1 ± 3.6 steps/min, SR200 = 200.9 ± 4.1 steps/min; SL illustrated in Figure). SL decreased during the second repeat of all track intervals (see Figure). Average SL decreased over the second half of the 21-kilometer race

(SL5K = 1.24 ± 0.04 m, SL10K = 1.24 ± 0.03 m, SL16K = 1.21 ± 0.03 m, SL21K = 1.15 ± 0.04 m). During the first and final thirds of the 5-kilometer trail race, average SR was slightly higher than the middle third (Runner4: SRMile1 = 173.8 ± 7.9 steps/min, SRMile2 = 172.2 ± 6.5 steps/min, SRMile3 = 174.4 ± 9.0 steps/min; Runner5: SRMile1 = 175.9 ± 9.4 steps/min, SRMile2 = 170.9 ± 7.6 steps/min, SRMile3 = 177.0 ± 10.8 steps/min), and the same trends were found for SL (Runner4: SLMile1 = 1.15 ± 0.18 m, SLMile2 = 1.05 ± 0.13 m, SLMile3 = 1.13 ± 0.18 m; Runner5: SLMile1 = 1.17 ± 0.19 m, SLMile2 = 1.13 ± 0.11 m, SLMile3 = 1.14 ± 0.17 m). **Conclusions:** The wearable sensors allowed for identification of spatiotemporal patterns in running activities that would not have been feasible using laboratory gait analysis technology. SL and SR progressively increased across track intervals and at the beginning and end of a trail race, while SL decreased over the course of a 21-K race. These data lend insight into individuals' adaptations to external demands of distance running encountered in field settings.

Figure. Step length data across two speed intervals at varying distances (1600, 800, 400, and 200 meters) performed on a standard track.



Free Communications, Rapid Fire Oral Presentations: Employment in the Secondary School Setting for the Athletic Trainer

Tuesday, June 25, 2019, 10:30AM-11:30AM, Mandalay Bay D; Moderator: Samantha Scarneo, PhD, ATC

Facilitators and Influencing Factors to the Use of Athletic Trainers in Secondary Schools

Pagnotta KD, Clines SH, Welch Bacon CE, Eason CM, Huggins RA, Van Lunen BL: Thomas Jefferson University, Philadelphia, PA; Sacred Heart University, Fairfield, CT; A.T. Still University, Mesa, AZ; Lasell College, Newton, MA; Korey Stringer Institute, University of Connecticut, Storrs, CT; Old Dominion University, Norfolk, VA

Context: Student-athletes competing at the secondary-school level often lack appropriate medical care during participation in school sponsored athletic programs. Athletic trainers (ATs) are qualified healthcare professionals that can fill this role. Previous literature has identified barriers to hiring ATs in this setting, however the rationale supporting the decision to use ATs in schools remains unexplored. Understanding this phenomenon has the potential to guide future research and strategies on improving access to ATs and enhance student-athlete safety. The purpose of this study was to gain an understanding of athletic director's perceptions of ATs working in the secondary school setting as they relate to the needs of the school and athletic program, with emphasis on the initiation and maintenance of athletic training positions. **Methods:** A qualitative methodology was utilized for this investigation. Recruitment was guided by data saturation. Ten high school athletic directors employed by schools with full-time ATs completed one-on-one telephone interviews. All interviews were guided by a semi-structured interview guide, digitally recorded, and transcribed verbatim by a professional transcription service. Data analysis followed the consensual qualitative research approach using a team of three core researchers, an internal auditor, and external auditor. Data credibility was established through peer review, field

notes, member checking, and multiple analyst triangulation. **Results:** The decision to utilize ATs within secondary schools was influenced by various personnel and community organizations, including the school board, parents, and local hospitals or rehabilitation clinics. School district and athletic conference policies also played a role in the decision to utilize the services of ATs within athletic programs. Justification for requiring the employment of ATs included specialized training of ATs in areas such as acute care, injury prevention, and concussion management; all of which were perceived to enhance student-athlete safety and decrease the school's liability. Participants viewed ATs as ideal athletic healthcare providers and did not support coaches as appropriately trained individuals to fulfill a medical role. Financial and logistical challenges were also identified. The primary challenge to both initiating and maintaining AT positions were budget concerns. Logistical challenges such as workspace for the AT and high student-athlete to AT ratios were also discussed. **Conclusions:** The decision to utilize ATs within secondary school athletic programs is multifactorial and influenced by various individuals, organizations, and policy. School board members were identified as the final decision makers regarding the use of ATs within their schools. Challenges exist for athletic programs even after initiating athletic training positions. However, athletic directors believe that continued support from the community and the increased sense of safety generated by having trained athletic healthcare professionals within schools will aid athletic training advocates in maintaining athletic training positions within schools.

The Influence of Median Income on Athletic Trainer Services In Florida Secondary Schools

Baker BM, Huggins RA, Scarneo SE, Coleman KA, Endres BD, Casa DJ: University of South Florida, Tampa, FL; University of Connecticut, Storrs, CT

Context: Previous research nationwide has determined 66% of secondary schools (SSs) have access to athletic training (AT) services. In the state of Florida, 70% of SSs have access to AT services. A lack of funding has been identified as a key barrier to the hiring of an AT by SS administrators however, the impact of socioeconomic status (SES) on having AT services remain unknown. The purpose of this study was to examine the association between AT services and SES. **Methods:** This cross-sectional survey-based questionnaire examined the level of AT services in SSs throughout the United States (US). AT services data from the Athletic Training Locations and Services (ATLAS) database from June 2015 to April 2018 were used. Data for Florida schools was sourced from the National Center for Educational Statistics and median income (MI) of families was extracted from the 2015 US Census Bureau. SSs were categorized into high (>200% of the state median income), middle (67% to 200%), and low (< 67%) SES based on Florida's MI. Separate 2x2 chi-square analyses, fisher's exact calculation's when necessary ($x^2 < 5$), and odds ratios (ORs) with 95% confidence intervals (CI) were calculated. A-priori levels were set at $p < 0.05$. Sensitivity, specificity, negative likelihood ratio, and positive likelihood ratio tables were created using Microsoft Excel. **Results:** The frequency distribution of secondary schools in Florida presented as follows: high (3.1%), middle (88.2%), and low (8.7%). Findings indicate that schools located in high SES communities were at a greater odds of having AT services, compared to low SES communities (OR=3.50;

[CI 0.95-12.96]; $c^2=3.84$; $p=0.05$; One tailed $=0.040$ Two tailed $=0.065$) and middle SES communities (OR =4.02; [CI 1.19-13.60]; $c^2=5.8$; $p=0.016$). When comparing low vs middle SES, we find that low SES were at a greater odds of having access to AT services compared to middle (OR=2.00; [CI 0.68-1.93]; $c^2=0.26$; $p=0.610$). High income schools had a higher likelihood of having AT services compared to low income (Sn=0.31; Sp=0.88; PLR=2.71; NLR=0.77). High income schools had a higher likelihood of having access to AT services compared to middle income schools (Sn=0.40; Sp=0.99; PLR=2.79; NLR=0.97). Middle income schools had a negligible difference in likelihood compared to lower income schools (Sn=0.91; Sp=0.10; PLR=1.01; NLR=0.84). **Conclusions:** The results of this study suggest that schools in high SES communities have greater odds of having access to AT services than middle income or lower income schools in the state of Florida. These findings suggest that SES impacts the odds of a school having AT services and targeted efforts to improve the AT services provided to middle and low SES communities should be conducted. Future research should examine the impact of SES on AT services in other states to determine if other states are similar.

Socioeconomic Status Impacts Athletic Healthcare in Secondary Schools in The Eastern Athletic Trainers' Association

Huggins RA, Scarneo SE, Coleman KA, Endres BD, Baker BM, Casa DJ: University of Connecticut, Storrs, CT; University of South Florida, Tampa, FL

Context: Research quantifying athletic trainer (AT) services has determined that 75% of secondary schools (SSs) have access to AT services in states within the Eastern Athletic Trainers' Association (EATA). SS administrators in schools without AT services have determined that a lack of funding was a key barrier to the provision of AT services and furthermore, a recent investigation identified median income (MI) and free reduced lunch as being significantly associated with access to AT services. Given these findings, the purpose of this study was to examine the odds of a school having healthcare provided by an AT and socioeconomic status (SES) within the EATA states. **Methods:** This cross-sectional survey-based questionnaire examined the level of AT services in SSs throughout the United States (US). AT services data from the Athletic Training Locations and Services (ATLAS) database from June 2015 to April 2018 were used. Data for each school in the following states (CT, MA, ME, NH, NJ, NY, PA, RI, and VT) were obtained from the National Center for Educational Statistics while MI for households were extracted from US Consensus Data based on the SSs zip code. Middle class (MID) was defined as a MI between 67-200% of the state's MI, lower class (LOW) was defined as <67% and upper class (HIGH) defined as >200% of the state's MI. Separate 2x2 chi-square analyses, odds ratios (ORs), and prevalence ratios (PRs) with 95% confidence intervals (CI) were calculated. A-priori levels were set at $p<0.05$. **Results:** Of all SSs in the EATA region with athletics programs (100%; $n=3238$), 75% ($n=2416$) have AT services while 25% ($n=822$) do not.

The frequency distribution of SSs by SES were: HIGH (2.7%, $n=88$), MID (84.5%, $n=2736$), and LOW (12.8%; $n=414$). Findings indicate that HIGH SES schools were at a greater odds of having AT services, compared to LOW SES schools (OR=10.46; [CI: 4.15-26.34]; $X^2=35.74$; $P<0.001$) and MID SES schools (OR=5.24; [CI: 2.11-12.99]; $X^2=15.96$; $P<0.001$). Similarly, MID SES schools were at greater odds of having access to ATs than LOW SES (OR=1.99 [CI: 1.61 to 2.48]; $X^2=40.09$; $P<0.001$). The proportion of schools with AT services was highest in the HIGH SES schools, compared to both MID (PR=1.24, [CI: 1.17-1.31]) and LOW (PR=1.54, [CI: 1.40-1.69]) schools. **Conclusions:** Twenty five percent of SSs in the EATA provide no athletic healthcare in the form of an AT to their student athletes. These findings suggest that SES is a key factor in determining those without. Schools in HIGH SES communities had greater odds of and prevalence of having access to AT services than middle or low income schools giving merit to targeted efforts and funding to assist those athletes without AT services.

The Landscape of Athletic Training Services in Public and Private Secondary Schools: Student Athletes and Sports Offered

Coleman KA, Huggins RA, Endres BD, Mazerolle SM, Casa DJ: University of Connecticut, Storrs, CT

Context: Athletic trainers (ATs) provide invaluable sports medicine services to the secondary schools (SS). With SS interscholastic athletic participation on the rise, and large numbers of adolescents participating in these sports, SSs are being encouraged to employ certified ATs to ensure their student-athletes (SAs) are receiving proper medical care. Currently, there is limited information regarding the landscape of AT services in relation to the number of SAs, the number of ATs and the number of sports offered in the SS setting. There are two main objectives for this study: 1) to describe the landscape of public (PUB) and private (PVT) athletic settings including the number of sports, number of SAs, and the number of ATs, and 2) to determine the SA to AT ratio (SA:AT) and sports offered to AT ratio (sport:AT) for PUB, PVT, and nationwide samples. **Methods:** ATs who provided services to

a U.S. SS with a school-sanctioned interscholastic athletics program, offering at least one grade between 9-12, were invited to complete an online questionnaire, entitled the Athletic Training Locations and Services (ATLAS) survey. SS ATs who completed the survey between June 2015 and October 2018 were included in the analysis. Variables of interest for each school included the number of ATs, the number of SAs, and the number of sports offered. Of the total school nationwide with AT services (n=13803), 50.89% responded (n=7024). Of those, 1141 were PVT ATs and 5883 were PUB ATs. Data were not normally distributed for any dependent variable; thus, Mann Whitney U tests were used to assess for differences in AT services across school types. **Results:** The table provides the median and range of the dependent variables. Significant differences between school type were observed for number of ATs (p<.001), number of SAs (p<.001), number of sports offered (p<.001), AT:SA (p<.001), and AT:sports (p<.001). Specifically, PVT schools had significantly more ATs than PUB [all data presented as mean rank] (PVT: 3656.11, PUB: 384.65, U: 3192389.00), and PUB schools had significantly more SAs (PUB: 3673.78, PVT: 2680.95, U: 2407457.50), sports (PUB: 3582.06,

PVT: 3153.86, U: 2947039.00), SA:AT (PUB: 3709.40, PVT: 2497.27, U: 2197876.50), and sports:AT (PUB: 3595.68, PVT: 3083.61, U: 2866885.50) than PVT. **Conclusions:** PUB SSs have less ATs than PVT, but have more SAs and sports offered, leading to higher SA:AT and sports:AT ratios. These ratios serve as a benchmark for state AT associations and SS administrations when comparing current medical services for their SAs to national industry standards. Additionally, these findings can inform current practicing ATs in regards to how their current workload compares to the national levels.

	n	ATs	SAs	Sports	SA:AT Ratio	Sports:AT Ratio
Public	5883	1 (1 – 6)	350* (18 – 9000)	18* (2 – 60)	300:1* (13.5 – 4500)	15:1* (1.50 – 50)
Private	1141	1 (1 – 5)	250 (22 – 3000)	16 (2 – 60)	200:1 (12.5 – 3000)	13:1 (1 – 60)
National	7024	1 (1 – 6)	350 (18 – 9000)	18 (2 – 60)	285.5:1 (12.5 – 4500)	15:1 (1 – 60)

Table 1. Characteristics of the Public and Private Secondary School Athletic Setting. Values are presented as median (range). (*) = significantly different than PVT (p < 0.05).

Secondary School Athletic Trainers, Employment Type, Setting, and Reported Time Spent on Job-Related Tasks

Filep EM, Huggins RA, Coleman KA, Endres BD, Casa DJ: University of Connecticut, Storrs, CT

Context: Secondary school (SS) athletic trainers (ATs) employment type, setting, and time spent completing tasks remains unquantified. The purpose of this study was to examine differences between time spent on job-related tasks in SS ATs by employment type and employment setting. **Methods:** SS ATs who completed the Athletic Training Locations and Services (ATLAS) survey from July 2017 to October 2018; (n=3222) were included in the analysis. Variables included employment type full-time (FT), defined as working 30 hours/week, 5 days/week and 10 months/year, or part-time (PT), anything less than FT. Participants who did not complete the question were eliminated due to response bias. Employment settings included: school district employee

(SD), school district employee with teaching responsibilities (SDT), medical/university facility (MUF), and independent contractor (IC). Respondents quantified the percentage of time they spend in the following job-related tasks: acute care (AC), treatment/rehab (Tx/R), practice/game coverage (Px/G), and administrative tasks (ADM). Due to the distribution of the data, non-parametric measures were used to analyze the average percent of time completing tasks. Differences between employment type and setting were tested using Mann-Whitney U tests. **Results:** The average reported percentage of time spent completing tasks is displayed in Table 1. Approximately 56.3% of SS ATs (n=1813) reported employment by MUF and independent of employment type, the largest percentage of time is spent performing Px/G related services (40.2%) followed by AC (25.7%). Significant differences were observed between FT (n=2460) and PT (n=762) employment type and the time spent in Px/G (U=780176.0; mean rank= 1817.6; p =0.000). FT SS ATs in all settings spent a higher percentage

of their time in Tx/R (U=675704.5; mean rank= 1717.82; p =0.000) and ADM (U=789078.0; mean rank= 1671.7; p =0.000) than their PT colleagues. **Conclusions:** A majority of respondents were employed by MUF. Independent of job setting, PT ATs spent most of their time providing Px/G coverage, which may impact the consistency and quality of care provided to the athletes in a given school week. Relatively speaking, FT ATs dedicated more time to the rehabilitation and treatment of injuries and illnesses and more time providing on-field services at Px/G. These findings may translate to improved injury outcomes and presence of medical care during emergency or life-threatening events. More research needs to be completed on the actual amount of time SS ATs report working versus their contracted hours.

Table 1. Average Percentage of Time Completing Tasks Reported by Athletic Trainers in the ATLAS Survey. *Significant difference in percentage of time spent completing tasks (not including AC) between FT and PT (p≤0.05, p=0.000)

Employment Type & Setting	n	AC (%)	Tx/R (%)	Px/G (%)	ADM (%)
Full Time	2460	25.3	20.6*	39.4*	14.7*
SD	712	25.4	23.3	35.4	15.9
SDT	342	24.8	21.5	37.9	15.8
MUF	1492	25.5	19.0	41.6	13.9
IC	75	24.0	21.4	41.0	13.6
Part Time	762	27.2	16.0*	43.4*	13.4*
SD	147	24.4	16.6	41.1	17.9
SDT	77	28.3	17.8	39.6	14.3
MUF	321	28.7	15.4	44.1	11.8
IC	56	23.9	15.2	50.9	10.1
Total	3222	25.7	19.7	40.2	14.4

The Impact of Athletic Trainers on the Incidence and Management of Concussions in High School Athletes

McGuine TA, Schwarz A, Post E, Pfaller A, Hetzel S, Brooks MA, Broglio S: University of Wisconsin, Madison, WI; University of Michigan, Ann Arbor, MI

Context: In many US high schools, the Athletic Trainer (AT) has the responsibility to identify and manage Sports Related Concussion (SRC) injuries that are sustained by interscholastic athletes. While the availability of ATs varies a great deal between schools, it has not been determined how the level of AT availability affects the reported incidence and management of SRCs. The lack of uniform AT availability in US high schools increases the likelihood that SRCs sustained by interscholastic athletes are not promptly identified or appropriately managed. The objective of this study was to determine how the level of AT availability affects the reporting and management of SRCs sustained by interscholastic athletes. **Methods: Design:** Prospective cohort study. **Subjects:** N = 2,459 (female = 37.5%, age 16.1 + 1.2 yrs.) high school athletes from 31 Wisconsin high schools that were categorized as either having a Low (LoAT), Mid (MidAT) or High (HiAT) level of AT availability. The level of AT availability for each school was determined based on the number of athlete participants the AT was expected to serve per hour they were onsite at the high school (athletes/AT hour). ATs at each school recorded the incidence, days lost from sport and post-SRC management through return to sport. The incidence of SRC reporting between AT categories was examined with a multivariate Cox-Proportional Hazard model. Fisher's Exact tests were used to determine if post-SRC management differed based on AT availability. **Results:** The incidence of reported SRCs was lower for the LoAT schools (2.4%) compared to the MidAT (5.6%, HR = 2.59, p = 0.043) and HiAT (7.0%, HR = 3.33, p = 0.002) schools. The median

time before the first AT interaction was longer for LoAT schools (24.0 hours) compared to MidAT school (0.5 hours; post-hoc p = 0.012) and HiAT schools (0.2 hours, post-hoc p = 0.023). The number of Post SRC interactions were significantly different in all groups (LoAT = 2 interactions, MidAT = 3, and HiAT = 4; all post hoc p < 0.05). Days lost were greater for MidAT and HiAT (both 14 days lost) schools compared to LoAT schools (11.5 days lost, post-hoc p = 0.231 and p = 0.029, respectively). Athletes at LoAT schools were less likely to undergo a return to play protocol (SRCs n = 9/18, 50.0%) compared to MidAT (SRCs n = 44/47, 93.6%, post-hoc p = 0.001) or HiAT athletes (SRCs n = 64/64, 100%, post-hoc p < 0.001). **Conclusions:** This study demonstrates that the level of AT availability influences the reported incidence of SRCs as well as post SRC management activities. This data is important since unreported or mismanaged SRCs pose a significant burden to the short and long term health of interscholastic athletes.

Influence of Assessor on Arizona Secondary School AMCAT Score

Mesman DL: University of Phoenix, Phoenix, AZ; Grand Canyon University, Phoenix AZ

Context: Many schools remain deficient with integration of appropriate medical care recommendations, which are imperative for the protection of adolescent athletes' health. Objective: Investigate the difference between athletic healthcare assessors' Appropriate Care Index (ACI) scores as measured by the Appropriate Medical Care Assessment Tool (AMCAT). **Methods: Design:** Quantitative Survey. **Setting:** Assessors' in Arizona high schools (HS) governed by the Arizona Interscholastic Association (AIA). **Patients or Other Participants:** Assessors in 263 AIA HS's, 259 Athletic Directors (AD) and 149 Athletic Trainers (AT) equaling 408 assessors obtained from AIA's public website. The total response rate was 27.2% with 111 total surveys (20.1% AD, N=52; 39.6% AT, N=59). **Interventions:** Assessors' (AD's and AT's) and school demographics (athletic trainer presence, athletic trainer employment type, number of athletic trainers per school, location of school boundaries, size of the school, distance to medical facilities, budget for medical supplies, and success of the football program) served as the independent variables. Assessors responded to the AMCAT via Survey Monkey®. ACI scores were associated with medical care assessed in the AMCAT survey. Validity with an expert panel established a priori and a Cronbach's alpha of .70 for reliability of questions were included in the survey instrument. **Main Outcome Measures:** A mean value averaged for the 10 recommendations in the AMCAT calculated the Assessors' ACI scores. Statistical analysis was performed with one-way / two-way ANOVA's and t-test in SPSS software. **Results:** Results identified athletic directors with athletic trainers (AD+) and athletic trainers (AT) were more likely to have higher ACI scores than schools without athletic trainers (AD-). Assessors' AD+ ACI score

N=38, M=.798, SD=.092; AD- ACI score N=14, M=.572, SD=.140; $F=55.662$, $p<.001$. A significant difference in descriptive statistic of one assessor's ACI score per school was found with AT availability, the number of ATs at the school, AT budget, the number of football championships since 1970, the location of the nearest hospital, and classification of the school. A significant difference with assessor's (AD+, AD-, AT) interaction with socioeconomic status and budget was compared with the assessor's ACI score (SES, $F=3.762$, $p=.002$; Budget, $F=2.521$, $p=.026$). **Conclusions:** The findings revealed that assessor categories and school demographics (socioeconomic status and budget) influence the provision of appropriate medical care. A significant difference between athletic directors with and without access to an athletic trainer exists. Assessors' decision-making and interpretations of the value of an athletic trainer may significantly influence appropriate healthcare practices. The study may contribute to the existing body of knowledge by addressing the issue of appropriate medical care in secondary school athletics and the role of assessors' interpretations of the value of athletic trainers on the level of healthcare provisions.

Free Communications, Rapid Fire Oral Presentations: Current State of the Throwing Shoulder

Tuesday, June 25, 2019, 11:45AM-12:30PM, Mandalay Bay D; Moderator: Ellen Shanley, PhD, PT, OCS

Do Baseball Players With Soft Tissue GIRD Have a Thicker Posterior Capsule?

Thomas SJ, Sheridan S, Reuther KE: Temple University, Philadelphia, PA; Philadelphia Phillies, Philadelphia, PA; Columbia University, New York, NY

Context: Baseball players often present with clinical Glenohumeral Internal Rotation Deficits (GIRD). Clinical GIRD is thought to include tissue specific adaptations, including humeral retroversion (HR), posterior rotator cuff tightness, and increased posterior capsule thickness (PCT). It has been suggested that correcting clinical GIRD with the amount of HR (soft tissue GIRD) will determine if soft tissue deficits are present. However, it is unknown if glenohumeral posterior capsule contributes to these soft tissue adaptations. Therefore, the purpose of this study was to determine if baseball players with soft tissue GIRD have a thicker posterior capsule compared to those without soft tissue GIRD. **Methods:** A single group post-test only study design was

used, which was performed in a clinical setting. Fifty collegiate and professional baseball players with no current injury or surgery in the past six months were divided into soft tissue GIRD ($n = 22$, age = 20.9 ± 2.7 years, mass = 93.5 ± 8.2 kg, height = 187.9 ± 5.4 cm) and no soft tissue GIRD ($n = 28$, age = 21.8 ± 3.5 years, mass = 93.3 ± 8.7 kg, height = 190.0 ± 5.2 cm) groups. Glenohumeral internal rotation (IR) was measured bilaterally with a Saunders Digital Inclinometer (The Saunders Group Inc. Chaska, MN). Patients were positioned supine with the scapula stabilized. Clinical GIRD was then calculated as the bilateral difference in IR (Table 1). HR and PCT was measured with an ultrasound system (Sonosite Titan, Sonosite Inc., Bothell, WA). HR was measured supine with the arm abducted to 90° and elbow flexed to 90° . PCT was measured seated with the arm at the side in neutral rotation. All methods have previously established excellent reliability. Groups were determined if soft tissue GIRD was present or absent following HR correction (clinical GIRD + HR bilateral difference). Independent sample t-tests were

performed to compare dominant arm, non-dominant arm, and the bilateral difference in PCT between the GIRD and no GIRD groups. **Results:** The GIRD group had no significant differences for dominant (GIRD = 2.91mm, no GIRD = 2.78mm, $p=0.9$) and non-dominant PCT (GIRD = 2.2mm, no GIRD = 2.19mm, $p=0.9$), but significantly more PCT bilateral difference compared to the no GIRD (GIRD = 0.36mm, no GIRD = 0.06mm, $p=0.0001$) group. **Conclusions:** Healthy baseball players often present with alterations in clinical ROM. It has been well documented that HR contributes to this alteration in ROM, however evidence for soft tissue adaptations is limited. This study found that the bilateral difference in PCT was greater in the group with soft tissue GIRD. It is important for clinicians to know that the bilateral difference in PCT is an important metric to calculate. In addition, knowledge of specific tissue adaptations will help guide optimal treatment strategies.

Table 1

Variable	Calculation
Clinical GIRD	Dominant arm IR – Non-dominant arm IR
HR bilateral difference	Dominant arm HR – Non-dominant arm HR
Soft Tissue GIRD	Clinical GIRD + HR bilateral difference
PCT bilateral difference	Dominant – Non-dominant arm PCT

Long-Term Loss of Motion Following Labral Surgery: A Level 3 Clinical CASE Study

Myers AN, Howard JS: Appalachian State University, Boone, NC

Background: Glenohumeral(GH) labral tears have been reported to be the third most common shoulder-related season-ending injury. Typical treatment and recovery includes surgery followed by an extended rehabilitation program. Among upper-extremity athletes 38-84% have been reported to return-to-pre-injury level following arthroscopic labral repair. However, failure to regain ROM can result in a lengthy and painful recovery period. Care can also be complicated when environmental factors prevent continuity among treating providers. **Patient:** A collegiate softball player, age 22, presented with ongoing GH ROM deficits. One year prior she began having pain with throwing resulting in participation restrictions. After failing non-operative therapy, including rehabilitation and injection, for four months, she was then referred for surgery. Procedure 1 was an anterior labral fixation in January 2017. Failure to adequately progress in ROM resulted in a second procedure consisting of manipulation under anesthesia(MUA) in April 2017. Due to physician relocation, this procedure was performed by a separate physician. **Intervention or Treatment:** Due to continued pain and limited ROM a second MUA with capsular release, bursectomy, removal of labral anchors, and humeral head chondroplasty was performed by an outside physician in July 2017. ROM gains were only maintained for three days. Typically, ROM is restored within 12 weeks following repair. Despite aggressive rehabilitation and multiple MUAs over a year, no improvements in pain/motion were obtained. In January 2018, procedure 4 (performed by a new team physician) was an examination under anesthesia with minimal debridement and slight manipulation, as the patient had near full ROM once sedated. Rehabilitation began that afternoon

with aggressive ROM and stretching. This was facilitated by an interscalene regional block and infusion pump to deliver local anesthetic for three days. Pain was substantially improved compared to any point since initial injury. Rehabilitation continued 5 days/week with vigorous stretching, joint mobilizations, and strengthening exercises. Scapular stabilization was emphasized as a prerequisite to progress to throwing and return-to-play. An extended return-to-throwing progression was initiated 1 month following procedure 4. Whole body mechanics were emphasized to address observed compensations. A hitting progression began approximately 10 weeks post-operatively. **Outcomes or Other Comparisons:** ROM was successfully maintained throughout rehabilitation. The athlete never fully returned to practice without limitations, but was able to take the field for the first pitch during Senior Day. No underlying cause for what was determined to be excessive formation of scar tissue and adhesions with hyperalgesia was ever identified. Continued pain management following the 4th procedure was instrumental in maintaining motion. Additionally, during this rehabilitation protection of the past labral repair was no longer a concern as those anchors had been removed. Although, the outcome of this case was not ideal, it exemplifies the challenges of returning an athlete to pre-injury activity level following labral repair. While return-to-play prospects are generally considered good, rates as low as 38% have been reported in high-level baseball players. **Conclusions:** There was no specific mechanism of injury, and no clear surgical indications based on MRI; however, following 4 months of unsuccessful rehabilitation, a surgery that was anticipated to allow the patient to return-to-softball the following season was pursued. It was unforeseeable that she would have an undesirable outcome and ultimately undergo three additional procedures, never fully returning. Furthermore, this case was complicated by the involvement of 4

different physicians combined with a newly hired athletic trainer. **Clinical Bottom Line:** This study demonstrates that although general function and pain levels are commonly improved following labral repair, a smooth rehabilitation and return-to-play is far from guaranteed. Both athletic trainers and patients should be aware of the widely variable rates of return-to-sport associated with shoulder surgery in upper extremity athletes.

The Effects of Restricted Glenohumeral Horizontal Adduction Motion on Shoulder and Elbow Kinetics in Collegiate Baseball Pitchers

Laudner K, Wong R, Meister K: Illinois State University, Normal, IL; Texas Metroplex Institute for Sports Medicine and Orthopedics, Arlington, TX

Context: Decreased glenohumeral (GH) horizontal adduction ROM among baseball pitchers has been associated with various shoulder and elbow pathologies. Yet, no research have examined the effect of this tightness on shoulder and elbow kinetics during the pitching motion. The objective of this study was to determine if pitchers with -10° or less horizontal adduction ROM would have greater shoulder and elbow pitching kinetics compared to pitchers with greater ROM. **Methods:** We used a cross-sectional research design, conducted in a biomechanics laboratory, to test 56, asymptomatic, NCAA Division I baseball pitchers. Twenty-five participants had -10° or less horizontal adduction ROM in their throwing shoulder (restricted ROM group: age= 19.4 ± 1.4 years; height= 186.8 ± 5.0 cm; mass= 88.1 ± 6.5 kg). The remaining 31 participants had greater than -10° of horizontal adduction (control group: age= 19.5 ± 1.1 years; height= 186.7 ± 5.4 cm; mass= 89.0 ± 8.2 kg). We used a digital inclinometer to measure GH horizontal adduction, internal rotation, and external rotation ROM while in 90° of abduction. We measured shoulder and elbow pitching kinetics of the throwing arm using a three-dimension, high-speed video capture system. A priori testing showed all measurements had strong intra-rater reliability ($r > 0.93$). Dependent variables included maximum shoulder and elbow distraction force measured as a percent of a participant's body weight (%BW), as well as shoulder abduction, shoulder horizontal adduction, shoulder external rotation, elbow flexion, and elbow valgus torque as a percent of a participant's body

weight x height (%BWxH). We used separate two-tailed t-tests to determine significant differences between groups ($p < 0.05$). **Results:** The restricted group presented with a significant bilateral difference in total arc of motion ($p = 0.001$), while the control group had no difference ($p = 0.07$). This suggests that the loss of horizontal adduction in the restricted group was at least partially due to tissue tightness. The GH horizontal adduction ROM for the restricted and control groups were $-15.4^\circ \pm 4.7^\circ$ and $0.1^\circ \pm 8.0^\circ$, respectively. The pitching kinetics for the restricted motion group were: shoulder distraction = $113.6 \pm 14.3\%$ BW; shoulder abduction torque = $6.5 \pm 2.5\%$ BWxH; shoulder horizontal adduction torque = $6.1 \pm 1.4\%$ BWxH; shoulder external rotation torque = $4.2 \pm 1.5\%$ BWxH; elbow distraction force = $97.7 \pm 14.4\%$ BW; elbow flexion torque = $4.7 \pm 1.5\%$ BWxH; elbow valgus torque = $5.8 \pm 1.0\%$ BWxH. The kinetics for the control group were: shoulder distraction = $109.9 \pm 22.3\%$ BW; shoulder abduction torque = $5.1 \pm 2.7\%$ BWxH; shoulder horizontal adduction torque = $5.0 \pm 1.6\%$ BWxH; shoulder external rotation torque = $3.7 \pm 1.8\%$ BWxH; elbow distraction force = $89.6 \pm 20.1\%$ BW; elbow flexion torque = $3.5 \pm 1.3\%$ BWxH; elbow valgus torque = $5.1 \pm 1.2\%$ BWxH. There were no significant between group differences for shoulder external rotation torque or shoulder and elbow distraction ($p > 0.08$). There were significant differences for shoulder abduction torque ($p = 0.04$), shoulder horizontal adduction torque ($p = 0.009$), elbow flexion torque ($p = 0.004$), and elbow valgus torque ($p = 0.02$). **Conclusions:** Our results demonstrate that collegiate pitchers with -10° or less of horizontal adduction ROM in their throwing shoulder create significantly more shoulder abduction and horizontal adduction torque, as well as more elbow flexion and valgus torque during the pitching motion than those with more ROM.

WITHDRAWN

Acute and Longitudinal Effects of Pitching on Passive Range of Motion in Division I Athletes

Jelmini JD, Price MP, Meyer CJ, Greenwood LD: Texas A&M University, College Station, TX

Context: The unique characteristics of the shoulder are well established in a baseball population. However, conflicting findings within the literature prove difficult to firmly support if acute alterations in shoulder range of motion (ROM) change periodically over the course of a regular season. Moreover, it is unclear how pitch volume or pitch type may acutely influence shoulder or elbow passive ROM. Therefore, the purpose of this study was to assess passive ROM measurements acutely over time and how this acute change alters over the course of a baseball season. **Methods:** Seven healthy male NCAA Division I baseball pitchers were measured prior to the start of the season. Each pitcher was assessed for passive shoulder and elbow range of motion (ROM), with measurements taken after each pitching bout during the season. Baseline measurements were taken prior to the season (approximately January) and were subsequently evaluated throughout the duration of the regular season. All measurements were taken prior to the performance of any stretching, warm-up, exercise, or throwing program. Each pitcher was assessed for passive shoulder and elbow ROM, with measurements taken after each pitching bout during the season. Pitching bouts were allotted to early season, mid-season, or late season. In addition to ROM measurements, pitch volume, pitch type, and ball velocity were also collected for analysis. An analysis of variance (ANOVA) with repeated measures was performed to compare each variable at baseline to each subsequent post-pitch measurement. Statistical significance was accepted at an alpha level of 0.05. **Results:** Following a pitching bout, passive shoulder external rotation decreased by 7% ($p = 0.000$)

during the early season. However, passive shoulder internal rotation was significantly reduced during the early season (-37% ; $p = 0.001$), mid-season (-30% ; $p = 0.000$), and late season (-42% ; $p = 0.000$). Further, total motion also decreased during the early season (-12% ; $p = 0.000$), mid-season (-6% ; $p = 0.000$), and late season (-9% ; $p = 0.000$). In terms of pitch type, increasing the volume of fastballs thrown had a moderate correlation with loss of passive shoulder external rotation during the late season ($r = -0.705$). Increasing the volume of curveballs thrown had a moderate correlation with total motion lost during the late season ($r = -0.665$) as well as with passive elbow extension lost during mid-season ($r = -0.760$).

Conclusions: Passive range of motion (ROM) is significantly impacted immediately after throwing. This decrease continues to be present throughout all parts of the baseball season. Moreover, a moderate correlation of fastballs and curveballs to losses in passive ROM indicates that attention to pitch type may be warranted, particularly during the middle and latter parts of the baseball season.

Multiple Day Humeral Rotation Strength Deficits Following a Baseball Pitching Bout in Adolescent Pitchers

Pexa BS, Ryan ED, Hackney AC, Berkoff DJ, Giuliani HG, Myers JB: University of North Carolina at Chapel Hill, Chapel Hill, NC; Tampa Bay Rays Baseball Organization, St. Petersburg, FL

Context: Glenohumeral rotation strength deficits are linked to injury in baseball pitchers and may occur following baseball pitching. However, no studies have examined the time-course of glenohumeral rotation strength recovery. If strength deficits occur following pitching and do not recover before a subsequent throwing bout, the pitcher may be at higher risk of injury. The purpose of this study was to determine the changes in isometric glenohumeral internal and external rotation strength prior to and following a baseball pitching bout on the dominant and non-dominant limbs. **Methods:** The study utilized a repeated measures design. Thirty-two adolescent baseball pitchers (age: 16.2 ± 0.9 yrs, range: 15-18 yrs, height: 179.2 ± 10.6 cm, mass: 73.0 ± 9.4 kg) performed isometric strength assessments of glenohumeral internal and

external rotation on the dominant and non-dominant limbs. Assessments were performed field-side with a portable, calibrated tension dynamometer around competitive games. Participants were assessed prior to pitching, immediately following pitching, and on days 1, 3, and 5 post-pitching. To attain internal and external rotation peak force, participants laid prone on a plinth with the shoulder abducted 90 degrees and the elbow bent 90 degrees so the forearm was perpendicular to the ground. Participants pulled against a padded handle into internal and external rotation for three trials. The handle was attached to a tension dynamometer via a chain, and the tension dynamometer was anchored to an immovable object. Force signals were sampled at 2000Hz and filtered with a zero-phase shift 4th order Butterworth filter. Peak force was recorded as the highest 100ms epoch, and the average peak force across the three trials was used for analyses. Reliability and precision was established with pilot testing ($ICC_{2,3}=0.94$, $SEM=14.7N$). Two separate within-subject 2x5 (limb x time) ANOVAs were utilized to assess the changes in external and internal rotation strength within limb and time. Post-hoc testing was performed with Bonferroni corrections. **Results:**

For internal rotation, there was a significant interaction between limb and time ($F_{4,124}=4.208$, $p=0.003$). Dominant limb internal rotation strength decreased immediately post-pitching ($122.0 \pm 50.9N$, $p<0.001$) and day 1 post-pitching ($133.8 \pm 51.7N$, $p=0.002$) when compared to pre-pitching ($149.5 \pm 50.2N$, TABLE 1). Post-hoc testing indicated no change in non-dominant internal rotation strength between any time points. For external rotation, there was no significant interaction or main effect for limb, but there was a significant main effect for time ($F_{4,124}=4.01$, $p=0.004$). External rotation strength significantly decreased immediately post-pitching ($88.3 \pm 27.6N$, $p<0.001$) when compared to pre-pitching ($102.3 \pm 37.6N$, TABLE 1). **Conclusions:** Glenohumeral internal and external rotation strength decreases in adolescent baseball pitchers following a baseball pitching bout, and these changes could persist into the days following pitching. Adolescent baseball pitchers should avoid pitching on the same day or on consecutive days, as the decreased shoulder strength may increase injury risk.

TABLE 1. ISOMETRIC PEAK FORCE DESCRIPTIVE STATISTICS BY LIMB AND TIME

		Pre-Pitching	Post-Pitching	Day 1	Day 3	Day 5
ER	DOM	101.84 ± 37.56	87.65 ± 27.51	97.67 ± 38.01	101.74 ± 29.63	99.30 ± 21.92
	NDom	102.77 ± 38.34	89.07 ± 28.05	96.32 ± 30.60	101.51 ± 25.73	102.21 ± 25.70
	Total	102.31 ± 37.65	88.36 ± 27.59*	97.00 ± 34.23	101.62 ± 27.53	100.75 ± 23.74
IR	Dom	149.59 ± 50.23	122.02 ± 50.98*	133.81 ± 51.71*	144.00 ± 45.12	147.87 ± 43.10
	NDom	134.62 ± 40.68	127.46 ± 44.75	128.38 ± 48.72	137.08 ± 44.24	136.45 ± 36.73
	Total	142.10 ± 45.96	124.74 ± 47.66	131.10 ± 49.62	140.54 ± 44.47	142.16 ± 40.14

ER: External Rotation, IR: Internal Rotation, Dom: Dominant Limb, NDom: Non-Dominant Limb.

*Indicates significant difference from Pre-Pitching time.

Free Communications, Rapid Fire Oral Presentations: Injury Risk and Healthcare Considerations Among Tactical Athletes

Wednesday, June 26, 2019, 7:00AM-8:00AM, Mandalay Bay D; Moderator: Timothy Mauntel, PhD, ATC

The Effects of Body Composition and Physical Fitness on IET Road Marches

McGinnis KD, McAdam JS, Sefton JM: Auburn University, Auburn, AL; University of Alabama, Birmingham, AL

Context: Road march training is a key component of Initial Entry Training (IET) Programs in the United States Army, since military mission success is often dependent on a soldier's ability to transverse long distances carrying required tactical equipment. However, twenty-four percent of IET injuries are due to road march training events, possibly due to all IET soldiers completing road marches with a standard weight (35lbs) and at a standard walking speed (~3mph). Since IET recruits vary in body composition and physical ability we wanted to determine if overweight and/or unfit soldiers might be more likely to sustain an injury during road marches. **Methods:** A quasi-experimental design was used to determine how body composition, physical fitness and height effect posture and physiological intensity across a 16-kilometer (16K) road march. Twenty-six male IET soldiers (Age: 22.6 ± 3.2 , Ht: 173.8 ± 7.1 , Wt: 76.6 ± 12.2) completed a 16k road march as part of IET. Posture and physiological intensity were measured using a Zephyr Bioharness. Body composition was evaluated using BMI, measured two days following the 16k road march. Participants were placed into one of two groups; overweight or healthy weight. Physical Fitness was assessed using the Army Physical Fitness Test (APFT), completed eight days prior to the 16k road march. Participants were placed into two groups; pass/fail. A factorial multivariate analysis of variance (MANOVA) was then used to assess how BMI and physical fitness affected posture and physiological intensity throughout the road march. A one-way MANOVA was used

to determine what effect height had on posture and physiological intensity. **Results:** Multivariate testing indicated no interaction between BMI and physical fitness for posture or physiological intensity [Wilks-lambda = 0.99, $F(1,2) = 0.2$, $p = 0.82$]. Multivariate testing for main effects indicated that a main effects was not present for physical fitness [Wilks-lambda = 0.97, $F(1,2) = 1.28$, $p = 0.28$]. However, there was a main effect for BMI [Wilks-lambda = 0.78, $F(1,2) = 13.20$, $p < .001$]. Univariate testing showed that there was a main effect of BMI on posture [$F(2,25) = 7.90$, $p = .006$] and physiological intensity [$F(2,25) = 11.6$, $p = .001$]. Univariate testing for main effects indicate that there was no significant effect of height on posture [$F(2,25) = 1.96$, $p = .16$] or physiological load [$F(2,25) = 0.79$, $p = .38$]. **Conclusions:** On average participants with healthy BMI had an 11% more forward posture than overweight participants. This indicates that participants of normal BMI may be more susceptible to an injury possibly due to the rucksack equaling a large portion of their weight. However, overweight participants averaged higher workload intensities. There was no effect of physical fitness or height on posture or physiological intensity throughout the road march.

Self-Reported General Health and Fitness Among U.S. Service Members Entering Secondary Training

Clifton DR, Dartt C, de la Motte SJ: Uniformed Services University, Bethesda, MD

Context: During U.S. Military entry-level training (ELT), nearly 25% of males and 50% of females will sustain a musculoskeletal injury (MSK-I), and 25% of those will go on to be separated from service. For those who do graduate, residual deficits that influence health and fitness may be present during advanced levels of training, however the general health and fitness of these individuals is unknown. Novel MSK-I risk mitigation and performance optimization efforts in secondary training (ST) may be needed to address the unique health statuses at advanced levels of training. Therefore, the purpose of this study is to describe the general health and fitness of U.S. SM entering ST. **Methods:** Approximately 10 days after completing ELT, enlisted U.S. military personnel ($n=439$, age= 19.30 ± 1.73 years) entering ST consented to participate and completed a questionnaire that included five questions about general health and fitness. The five questions were related to 1) overall health status, 2) change in health status from the previous year, 3) history of an MSK-I during ELT, 4) whether they are currently experiencing musculoskeletal pain, and 5) their level of fitness relative to other individuals their age. Counts and percentages of responses to the five questions were evaluated using contingency tables. Associations between injury during ELT, as well as current musculoskeletal pain, and responses to overall health status, change in health status from the previous year, and fitness level were assessed using Chi-squared and Fisher's exact tests. **Results:** The majority of participants reported their overall health as very good/excellent (73.8%), that their overall health

was better than the previous year (74.5%), and that their fitness level was better than other individuals their age (74.5%). MSK-I during ELT was reported by 12.5% of participants, and 6.4% of participants reported experiencing current musculoskeletal pain at the initiation of ST. Those who suffered an MSK-I during ELT were more likely to have pain at the start of secondary training (odds ratio [OR]=4.52, 95% confidence interval [CI]=1.90, 10.24, $p<0.001$). Individuals who reported currently experiencing musculoskeletal pain were also more likely to report their health as worse than the previous year (OR=5.15, 95% CI=1.88, 12.82, $p=0.002$). **Conclusions:** Military personnel entering ST may begin training with an altered general health status resulting from MSK-I suffered during ELT. Results from this study indicate that 6-7% of individuals entering ST experience current pain and that they are more likely to experience pain if they suffered an MSK-I during ELT, indicating residual deficits from MSK-I during ELT may be present. Identifying common residual deficits from MSK-I occurring during ELT may help inform MSK-I risk mitigation and performance optimization programs implemented during secondary training to improve the health and wellness of U.S. military personnel.

The Impact of Limited Flexibility and Previous Musculoskeletal Injury on Likelihood of Injury in U.S. Service Members During Secondary Training

Cone BL, Tra J, Dartt C, Clifton DR, de la Motte SJ: Uniformed Services University, Bethesda, MD

Context: Musculoskeletal injuries (MSK-I) are a major health problem facing the U.S. Military: they account for over 2 million annual medical encounters. Sustaining any MSK-I early in a military career can lead to long-term consequences (e.g. osteoarthritis) or early medical discharge from service. Associations between risk of MSK-I and risk factors such as flexibility limitations and previous MSK-I have been evaluated previously in entry-level training (ELT), but their association with MSK-I in secondary training (ST) is unclear. The purpose of this study was to determine whether limited lower extremity (LE) flexibility and history of LE MSK-I during ELT would be associated with LE MSK-I during subsequent ST. **Methods:** Enlisted male U.S. Service members entering ST ($n=244$, age= 19.2 ± 1.7 years) were recruited to participate as part of a larger study. At initiation of ST, LE flexibility was assessed by using an Active Straight Leg Raise (ASLR) test performed according to standard Functional Movement Screen procedures. ASLR performance was dichotomized into poor (score of 0, 1, or R/L asymmetry) and good (2 or 3, no asymmetry) performance categories for analysis. At initiation of ST, Service members were asked to self-report any MSK-I sustained during ELT. MSK-I was defined as an injury to any bone, muscle, tendon, ligament, and/or cartilage, and participants specified on a digitized human figure where the MSK-I occurred. The same procedure was used at the completion of a three month cycle of ST to assess MSK-I sustained during ST. Analysis was limited to MSK-I reported in the lower back, hip, thigh, knee, lower leg, and foot/ankle regions. Rare-event logistic regression was used

to determine the association between ASLR performance, MSK-I during ELT, and the likelihood of MSK-I during ST, independent of age. Alpha level was determined a priori at 0.05. **Results:** Of the 244 Service members, 22 (9.01%) reported a LE MSK-I during ELT and 27 (11.1%) reported a LE MSK-I during ST. Previous LE MSK-I at ELT was significantly associated with LE MSK-I during ST (odds ratio [OR]=6.22, 95% confidence interval [CI]=2.15, 17.40, $p=0.001$). ASLR performance was not significantly associated with LE MSK-I during ST (OR=1.45, 95% CI=0.52, 3.71, $p=0.43$). **Conclusions:** Previous LE MSK-I at ELT was associated with LE MSK-I during ST, which is consistent with existing literature suggesting that previous MSK-I is a predictor of future MSK-I. Limited LE flexibility does not appear to be a predictor of future injury in the early-career military training population. Identifying modifiable risk factors for MSK-I may help in the design of risk mitigation programs created specifically for a military population. Efforts to develop such programs should focus on possible modifiable risk factors other than LE flexibility which may have greater effects on reducing training-related MSK-I rates among U.S. Service members.

Perception-Action Coupling Assessment and Training of ROTC Cadets

Williams AM, Johnson ME, Amos HL, Wilkerson GB, Acocello SN: University of Tennessee, Chattanooga, TN

Context: Deficiencies in cognitive and visual-motor processes may expose military personnel to elevated injury risk. Dual-task assessment and training may offer the potential for improved perception-action coupling. The purpose of this study was to assess the power of various metrics derived from tests of perception-action coupling for discrimination between Ranger Qualification Training(RQT) and Standard Physical Training(SPT) cadet subgroups, and the extent to which visual-motor reaction time(VMRT) training could enhance performance capabilities. **Methods:**

A cohort study design was used to assess 35 ROTC cadets (20.5 ±3.1 years; 69.6 ±3.5 cm; 174.0 ±32.2 kg). Fifteen were enrolled in the RQT program, 20 were enrolled in the SPT program. Both subgroups performed dual-task VMRT training (Dynavision D2™) involving simultaneous verbal responses to various cognitive tasks during sessions conducted twice weekly over a 6-week period. Pre- and post-training assessments included single-task VMRT(VMRT-ST), dual-task VMRT(VMRT-DT) tests, and a whole-body reactive agility(WBRA) task that involved 20 lateral side-shuffle movements in response to virtual reality targets presented on a monitor (TRAZER® Sport Simulator). WBRA metrics included RT(ms) and test duration (seconds). The Sports Fitness Index(SFI) was used to quantify musculoskeletal function (0-100 scale), with lower scores reflecting persisting effects of previous injuries. The Depression, Anxiety, and Stress Scale (DASS) was used to quantify psychological status (0-67 scale). Receiver operating characteristic and logistic regression analyses were used to predict RQT status, as well as SFI >80 (median value). Repeated measures analysis of variance and standardized response

mean (SRM) values were used to assess performance improvements following training. **Results:** A 3-factor model including WBRA total time ≤60s, DASS ≤17, and VMRT-ST ≤890 ms predicted baseline RQT status (≥2 factors positive: $\chi^2(3)=17.22$; $P=.001$; OR=15.17), whereas post-training status was predicted by a 2-factor model including VMRT-DT ≤825 ms and WBRA duration ≤60 s (both factors positive: $\chi^2(2)=14.81$; $P=.001$; OR=9.33). Optimal SFI at baseline was predicted by a 2-factor model including WBRA duration ≤66 s and VMRT-ST ≤805 ms (both positive: $\chi^2(2)=16.64$; $P<.001$; OR=15.17). A significant difference between trials was found for VMRT-ST ($P<.001$; RQT SRM=1.03; SPT SRM=1.17) and VMRT-DT ($P<.001$; RQT SRM=1.24; SPT SRM=1.21). A significant group x trial interaction effect was found for SFI (>80 versus ≤80) and WBRA duration ($P=.032$; >80 SRM =-0.04; ≤80 SRM=1.32). **Conclusions:** Tests of perception-action coupling appear to be valuable for discrimination between RQT and SPT cadets, as well as identification of individuals who would derive greatest benefit from dual-task VMRT training. A noteworthy finding was substantially improved WBRA performance for cadets with SFI ≤80 after VMRT-DT training with the upper extremities, which suggests that a central nervous system adaption may have been induced. Collectively, the findings support the assessment and training of perception-action coupling for optimization of military performance capabilities.

Shoulder and Cervical Musculoskeletal Asymmetries in Naval Special Operation Forces With Shoulder Injury: A Prospective Cohort Study

Beethe AZ, Lovalekar M, Mi Q, Keenan K, Nindl BC, Beals K: University of Pittsburgh, Pittsburgh, PA; Fitchburg State University, Fitchburg, MA

Context: The tasks and demands for military personnel are different from athletes. Population-specific injury prevention research can provide proper techniques to reduce incidence of injury. The purpose of this study was to determine if shoulder and cervical strength (ST) and flexibility (FLX) asymmetries precede shoulder injury in Naval Special Operation Forces (SOF). **Methods:** This was a prospective cohort study, observing shoulder injury one-year following ST and FLX asymmetry laboratory measures. ST was measured using a Biodex Dynamometer

and FLX using a digital inclinometer. Asymmetry was measured using the lower ST or FLX value divided by the greater. If measures were in the coronal plane, a ratio comparing anterior to posterior was used. Students in Seal Qualification Training (SQT; N=150) and Crewmen Qualification Training (CQT; N=149), as well as Operators in Special Warfare Combatant-craft Crewmen (SWCC; N=112) and Sea Air and Land Operators (SEALs; N=120) were observed, with 19 total self-reported shoulder injuries. Subjects were frequency matched by group, with three healthy (N=57, 26.05 ± 4.6 years, 178.25 ± 7.4cm, 85.5 ± 10.5kg) to one injured (N=19, 25.3 ± 3.5years, 180.4 ± 7.2cm, 86.1 ± 7.3kg). If values were normally distributed, independent t-tests were used to compare means between injured and non-injured groups, and Wilcoxon-Rank Sums test was used if non-parametric. Significance was set a priori <0.05. **Results:** See Table 1 for a breakdown of all variable statistics. SOF who

sustained shoulder injury demonstrated significantly greater shoulder external rotation ST asymmetry (p=0.037) and higher cervical flexion-to-extension FLX ratio (p=0.007) than SOF without shoulder injury. **Conclusions:** This study demonstrated greater shoulder external rotation ST asymmetry precedes shoulder injury in SQT, CQT, SWCC, and SEALs military personnel. Interestingly, cervical flexion-to-extension FLX ratio was increased in the injured group; however, it is not clear if this difference is due to increases in cervical flexion FLX or decreases in cervical extension FLX. It is plausible that increased cervical flexion laxity, which may be a consequence of decreased cervical posterior stability or poor posture, may account for this increase in the injured group. From this study, athletic trainers can decrease incidence of SOF shoulder injury through proper screening as well as execution of appropriate ST and FLX exercises.

Table 1. Comparison Between Non-injured and Injured Group

	No Injury				Injury				Wilcoxon Rand Sum p- value
	N	Mean	Median	StD	N	Mean	Median	StD	
Shoulder External Rotation Strength Asymmetry	56	0.9277	0.9547	0.06369	17	0.8802	0.9087	0.09828	0.037*
Shoulder Internal Rotation Strength Asymmetry	56	0.8920	0.9181	0.08084	17	0.8462	0.8387	0.11035	0.126
Shoulder Protraction Strength Asymmetry	20	0.8650	0.8697	0.10266	10	0.8259	0.8022	0.10419	0.337
Shoulder Retraction Strength Asymmetry [^]	20	0.8488	0.8842	0.12270	10	0.7965	0.8666	0.17215	0.475
Shoulder Elevation Strength Asymmetry	20	0.8888	0.8934	0.07299	10	0.9007	0.9213	0.08766	0.502
Cervical Rotation Strength Asymmetry (kg)	15	0.9218	0.9365	0.07783	5	0.9305	0.9131	0.02890	0.612
Cervical Lateral Flexion Strength Asymmetry [^]	15	0.9044	0.9271	0.07003	5	0.9493	0.9443	0.03585	0.191
Shoulder External Rotation Flexibility Asymmetry	56	0.9329	0.9435	0.05107	18	0.9457	0.9532	0.04247	0.315
Shoulder Internal Rotation Flexibility Asymmetry	56	0.8605	0.8855	0.12144	18	0.8695	0.9249	0.13762	0.571
Cervical Flexion:Extension Flexibility Ratio [^]	29	0.6739	0.6667	0.14090	7	0.8335	0.8235	0.10918	0.007*
Cervical Rotation Flexibility Ratio	15	0.9518	0.9681	0.06670	2	0.8984	0.8984	0.00358	0.611
Cervical Lateral Flexion Flexibility Asymmetry ⁺	15	0.9087	0.9231	0.06212	5	0.9223	0.9122	0.06812	0.684
Posterior Shoulder Tightness Asymmetry	56	0.9617	0.9675	0.03304	18	0.9720	0.9820	0.02687	0.157
Torso Rotation Flexibility Asymmetry [^]	10	0.9659	0.9696	0.02163	7	0.9274	0.9405	0.05236	0.106

[^]Independent t-test *p<0.05

Perceived Barriers to Musculoskeletal Injury and Illness Reporting in the Fire Service

Potts KA, Thews KN, Winkelmann ZK, Eberman LE, Games KE: Indiana State University, Terre Haute, IN

Context: Firefighters are at an increased risk of musculoskeletal injuries, particularly those caused by overexertion and strain. Firefighter health and career longevity may be negatively affected by inadequate injury-reporting behaviors. It is unknown whether firefighters report their injuries and what prevents them from reporting. The objective of this study was to identify structural and cultural barriers firefighters face when reporting musculoskeletal injuries in the fire service. **Methods:** We used a cross-sectional survey design to sample active and career firefighters. The online survey tool was adapted from a previous focus group study comparing the perceptions of fire chiefs and firefighters on the factors that contribute to musculoskeletal injuries in the fire service. Our variables of interest included perceived structural and cultural barriers to reporting musculoskeletal injuries and the perceived level of challenge of each barrier. The survey consisted of 32-items containing a list of cultural and structural barriers. Cultural barriers included factors that shape and guide a firefighter's life within the service, while structural barriers included factors that are beyond one's personal control and part of the environment. The perceived level of challenge was rated for each selected barrier using a 4-point Likert scale ranging from "no difficulty" to "extremely challenging". The survey was content validated by athletic trainers in the fire service and active fire chiefs. Pilot testing was completed with a local fire department not included in the analysis. We recruited firefighters through public databases, snowball sampling, and word of mouth. A total of 314 active career

and volunteer firefighters from across the United States completed the survey. Respondents (age=40 ± 9 y) were predominantly male (n=283/314, 90.1%), with an average of 17 years of experience serving a city community (n = 118/314, 37.6%). Descriptive statistics were calculated. **Results:** The most frequent barriers to musculoskeletal injury reporting included accepting pain as a natural part of the job (n=167/314, 53.1%) and the change in duty status (n = 144/314, 45.8%). Firefighters identified the fear of the worst-case scenario (n = 84/314, 26.7%), medical services provided as not helpful (n = 46/314, 14.6%), lack of benefits (n = 32/314, 10.1%), and the commitment to their family (n = 44/314, 14.0%) as extremely challenging barriers to reporting. Firefighters identified a lack of education of healthcare services (n=34/314, 10.8%) only as a slightly challenging barrier. **Conclusions:** Firefighters indicated cultural barriers as more challenging than structural barriers to reporting musculoskeletal injuries. While firefighters seldom report a lack of education as a barrier, the most frequent and most challenging barriers allude to the fact that long-term health consequences of musculoskeletal injury may not be apparent to this population. Athletic trainers may be able to assist in the cultural shift within the fire service to support firefighters in educating and managing musculoskeletal injuries related to the job.

The Structural and Cultural Barriers to Reporting Musculoskeletal Injuries From the Lens of Fire Chiefs

Clark CL, Potts KA, Winkelmann ZK, Eberman LE, Games KE: Indiana State University, Terre Haute, IN

Context: Individuals in the fire service consistently place themselves at risk for musculoskeletal injury while protecting the community they serve. Firefighters are considered tactical athletes due to the physical fitness and coordination with additional equipment required to perform tasks of the job. Firefighters sustain a multitude of work-related injuries, yet many of these injuries go unreported and untreated. Previous research has generally identified barriers to reporting injuries in the fire service; however, previous work does not identify specific barriers to reporting musculoskeletal injury. The purpose of this study was to examine the structural and cultural barriers to reporting musculoskeletal injuries in the fire service from the leadership's perspective. **Methods:** We completed a cross-sectional study using a web-based instrument via Qualtrics® (Provo, UT). The instrument consisted of thirty possible barriers with a follow-up item for participants to describe how challenging each selected barrier is on a 4-point Likert-scale (1 = slightly challenging, 2 = moderately challenging, 3 = very challenging, 4 = extremely challenging). The instrument was content and face validated with a panel of fire chiefs and healthcare providers prior to distribution. We recruited a random sample of 2085 fire chiefs who were members of the International Association of Fire Chiefs. **Results:** Fire chiefs (n = 102) accessed the survey and over half of respondents completed the survey (n= 54/102, 52.9% completion rate). The most common barriers to reporting musculoskeletal injuries, according to fire chiefs, was firefighter's accepting pain as a natural part of the job (n=31/54, 57.4%), firefighters' perceptions that they may

be jeopardizing their current and/or future career (n=27/54, 50.0%), and a change in duty status (n=22/54, 40.7%) and were considered moderately challenging (mode=2). Although identified less frequently, fire chiefs identified a feeling of letting fellow firefighter's down (n=23/54, 42.6%) and firefighter's embarrassment of their condition (n=22/54, 40.7%) as very challenging (mode=3). Lack of benefits (n=6/54, 11.1%), firefighter's commitment to their families (n=5/54, 9.3%), and medical services provided not being helpful (n=3/54, 5.6%) were extremely challenging (mode=4), but occurred less frequently. **Conclusions:** Fire chiefs identified accepting pain as part of the job, letting other firefighters down, and the embarrassment of the condition as frequent and moderately challenging cultural barriers to reporting musculoskeletal injuries. Fire chiefs also identified the structural barriers of benefit packages and lack of helpful medical services as the most challenging barriers to overcome. As athletic training services expand in the fire service, athletic trainers must work with multiple stakeholders including municipalities, occupational health providers, and firefighter labor unions to streamline the reporting structure to minimize challenging structural barriers. Additionally, athletic trainers will need to vigorously work to minimize and eliminate the cultural barriers and stigma related to reporting musculoskeletal injuries in the fire service.

Shoulder Best Practices Forum: Incorporating Patient-Reported Outcome Measures into Pediatric Care: Is Your Instrument Appropriate for Youth and Adolescent Athletes?

Wednesday, June 26, 2019, 8:00AM-9:00AM, Mandalay Bay D; Moderator: Ellen Shanley, PhD, PT, OCS
Discussants: Ashley Marshall, PhD, ATC; Kenneth Lam, ScD, ATC

Free Communications, Rapid Fire Oral Presentations: Planning for and Managing Emergencies

Wednesday, June 26, 2019, 9:30AM-10:15AM, Mandalay Bay D;

Moderator: Ron Courson, PT, ATC, NRAEMT, CSCS

Describing Sport-Related Genitourinary Injuries in Males Reporting to Emergency Departments: A National Electronic Injury Surveillance System Report

Janik GK, Lam KC: King's College, Wilkes-Barre, PA; A.T. Still University, Mesa, AZ

Context: Through the National Electronic Injury Surveillance System (NEISS) a sample of United States emergency departments was analyzed over a 5-year period for sport-related genitourinary injuries in order to identify common characteristics and develop prevention strategies. By understanding the common characteristics of sports-related genitourinary injuries (SRGI), athletic trainers (ATs) can identify and recommend prevent strategies to specific populations. The objectives of this study focused on the ATs' ability to identify and describe the common characteristics and risk factors of SRGI. Also, ATs will be able to recognize, manage, and developed prevention strategies in order to limit long-term consequences associated with SRGI.

Methods: This was a retrospective study that analyzed data from the National Electronic Injury Surveillance System (NEISS). Data was collected for 5 consecutive years (2012-2016). The final aggregated database for this study included sex, age, diagnostic codes, race and sport / activity and mechanism of injury. The study used descriptive statistics (frequency counts, percentages) to describe common diagnoses, demographics, associated sports, and the common mechanisms for SRGI. Exclusion was made to recreational activities, activities not related to traditional sports or strength and conditioning, and/or those with missing information.

Results: From 2012-2016 a total of 1,893 pubic region injuries were recoded within the NEISS. Based on our inclusion/exclusion criteria 876 cases were excluded from the database resulting in a total of 1007 SRGI included in our study. The most frequently reported race for SRGI were listed as "white" (38.3%) between 15-24 years of age (62.3%). The most common diagnoses of SRGI was listed as pain, trauma or injury to the scrotum or testicles (65.6%). The sports and activities with the highest percentage of SRGI included

strength and conditioning (23.9%), basketball (17.9%) and football (15.0%). Direct contact accounted for 55.4% of SRGI. **Conclusions:** Overall, over 60% of SRGI were found in high school and college aged individuals (10-24 year olds). The clinical relevance from this study revolves around the importance of ATs recognizing the common demographics, diagnosis, sport / activity along with the common mechanism of injury of each sport /activity to be best prepared to provide care. By doing so ATs can development prevention strategies for SRGI and better avoid injury and permeant damage. A significant finding in this study, and not previously reported in any study, was that SRGI is more likely to be reported during non-sport participation such as strength and conditioning and with non-contact (90.9%). Further, this information provides data that ATs can use to know which sports/activities are better suited to endorse protective cups to prevent direct traumatic injuries while also recommending supportive undergarments in those sports/activities where non-contact injuries are more common.

TABLE 4. Sport / activity and mechanism of injury of sport-related genitourinary presenting to emergency departments from 2012-2016.

Sport / Activity	Contact (% , n=)	Non-contact (% , n=)	Total (% , n=)
Strength and Conditioning	9 (22)	91 (219)	24 (241)
Basketball	61 (110)	39 (71)	18 (181)
Football	69 (103)	31 (47)	15 (150)
Soccer	77 (105)	23 (32)	14 (137)
Baseball	78.5 (73)	21.5 (20)	9 (93)
Swimming	81.5 (53)	18.5 (12)	7 (65)
Wrestling	69 (22)	31 (10)	3 (32)
Lacrosse	90 (28)	10 (3)	3 (31)
Softball	75 (15)	25 (5)	2 (20)
Ice Hockey	61 (11)	39 (7)	1.8 (18)
Track	22 (2)	78 (7)	.009 (9)
Volleyball	88 (7)	12 (1)	.008 (8)
Tennis	50 (3)	50 (3)	.006 (6)
Bowling	0 (0)	100 (4)	.004 (4)
Cross Country	0 (0)	100 (4)	.004 (4)
Golf	33 (1)	67 (2)	.003 (3)
Gymnastics	50 (1)	50 (1)	.002 (2)
Skiing	50 (1)	50 (1)	.002 (2)
Water Polo	100 (1)	100 (1)	.001 (1)
Total	55 (558)	45 (449)	100 (1007)

An Analysis of Certified Athletic Trainers' Ability to Provide High-Quality Cardiopulmonary Resuscitation (CPR) Over Hockey Shoulder Pads

Lyman KJ, Estabrooks AG: North Dakota State University, Fargo, ND

Context: Certified Athletic Trainers (ATCs) are expected to perform high-quality CPR for athletes regardless of whether the athlete is wearing protective athletic equipment. Current American Heart Association (AHA) recommendations do not include guidelines regarding the immediate removal of protective equipment before administering compressions. No previous research has been conducted investigating the effectiveness of chest compressions over hockey shoulder pads

Methods: Controlled laboratory study at a research university. Fifty participants (25 females, 25 males, mean age = 34.8 ± 10.9) were recruited via word of mouth and email. All participants were BOC certified athletic trainers (mean 11.41 ± 9.7 years of certification) who were also CPR/First-Aid certified. ATCs completed a one-minute compression-only CPR proficiency test on a medium-fidelity manikin (Resusci Anne QCPR). Once proficient, each ATC completed CPR according to 2015 AHA guidelines on the manikin, which had been fitted with hockey shoulder pads. CPR quality was measured with the Resusci Anne Wireless SkillReporter (Laerdal Ver 2.0.0.14). CPR data included the following dimensions of compressions: overall score, mean rate, chest compression fraction, mean depth, % chest recoil, and % compressions with appropriate depth. Data were analyzed (SPSS ver 24) using multiple linear regressions with follow-up t-tests to compare differences of CPR performance between covariates, which included: age, gender, body mass index, education level, years of CPR certification, years certified as an athletic trainer. **Results:** Overall CPR score was $69.08\% \pm 21.65$. Overall score separated by gender was

significant ($p=0.008$, $d=0.65$) with men outperforming women. 56% of ATCs did not compress at the recommended depth of 51 mm. Mean compression depth was 48.16 ± 8.57 mm. Men compressed an average of 51.52 mm while women compressed 44.8 mm ($p=.036$, $d=0.85$). Women compressed at an appropriate rate 62.48% of the time while the male average was 80.84% ($p=.022$, $d=0.71$). BMI was a significant predictor of overall performance ($R^2=.085$). Level of education did not predict overall performance. **Conclusions:** 56% of all ATCs were unable to compress at an average depth that qualified as the minimum standards for CPR. Results indicate ATCs are unable to provide quality CPR over hockey pads. Men compressed more deeply and at an appropriate rate. In addition, male ATCs with a higher BMI are more likely to provide high-quality CPR over hockey shoulder pads; however, the range and standard deviation are large. Thus, the removal of hockey shoulder pads is recommended prior to performing CPR to ensure adequate depth and rate are achieved.

The Effect of Lacrosse Protective Equipment on Time to First Compression and First Automated External Defibrillator Shock

Boergers RJ, Bowman TG, Tang J, Thomas S, Quatela S, Wyckoff V: Seton Hall University, South Orange, NJ; University of Lynchburg, Lynchburg, VA

Context: Lacrosse is a high-velocity collision sport in which there is a large potential for catastrophic injury. In the event of an acute cardiac event, cardiopulmonary resuscitation (CPR) will need to be performed, however the equipment may inhibit intervention. Recently, on field equipment removal has been suggested, however initiation of compressions over the shoulder pads has been shown to have similar quality (compression depth and rate) to being performed over a bare chest. Initiating the first compression cycle over the pads followed by a pad retraction should expedite the time to first compression and time to first automated external defibrillator (AED) shock. In managing acute cardiac events, expedited time to first compression and first AED shock have been shown to improve patient outcomes. The purpose of this study was to determine if different chest access techniques affect the time to first compression, time to first AED shock, and quality of CPR.

Methods: We used a crossover repeated measures design. All data were collected in a simulation laboratory. Twelve (8 Females, 4 Males: 34.5 ± 8.2 years old) licensed athletic trainers participated. Participants in pairs of two performed 3 minutes of 2-rescuer CPR with AED intervention according to 2015 American Heart Association standards. Participants completed a total of 4 trials [2 chest access techniques x 2 rescuer roles (rescuer 1, rescuer 2)] on a Resusci Anne Q-CPR manikin (Laerdal Medical Corporation, Wappingers Falls, NY). Manikins were outfitted with a Cascade R helmet and Warrior Burn shoulder pads. The

independent variable was: chest access technique [shoulder pad retraction with helmet removal (RT) vs. full shoulder pad and helmet removal (FR)]. In the shoulder pad retraction technique, compressions were performed over the lacrosse shoulder pads for the first cycle, followed by retraction. All data collection sessions were counterbalanced. The dependent variables were time to first compression (s), time to first AED shock (s), compression depth (mm), and compression rate (#/min). Paired samples t-tests were used to evaluate the mean differences between chest access techniques on the dependent variables. **Results:** There was a significant difference in time to first compression between the two chest access techniques ($p < .001$, FR = 50.9 ± 21.4 s, RT = 17.7 ± 4.3 s), however there was no significant difference in time to first AED shock ($p = 0.62$, FR = 95.0 ± 11.5 s, RT = 97.3 ± 18.4 s). Additionally, there were no significant differences in compression depth ($p = 0.23$, FR = 55.7 ± 4.3 mm, RT = 56.6 ± 4.6 mm) or compression rate ($p = 0.30$, FR = 110.0 ± 14.1 /min, RT = 115.8 ± 21.5 /min) between the two chest access techniques. **Conclusions:** Initiating CPR over lacrosse shoulder pads followed by retraction reduces the time to first compression without compromising quality of CPR compressions. Emergency responders should consider initiating CPR over lacrosse shoulder pads initially followed by retraction to reduce the delay to first compression.

A Novel Approach to Loop-Strap Cutting Utilizing a Motorized Oscillating Saw as Compared to a Traditional Cutting Tool

Rotondi MF, Powers ME, Gildard M: Ithaca College, Ithaca, NY; Marist College, Poughkeepsie, NY

Context: Airway access is a necessary skill requiring clinician proficiency. When accessing the airway of a football athlete, a variety of tools can be used to either remove or cut the facemask hardware. While removal is preferred, there are times when cutting tools must be used. The preferred cutting tool is usually the tool that creates the least amount of motion, while requiring the least amount of effort and time. We hypothesized that a motorized oscillating tool (MOT) may provide a faster and safer method for hardware cutting. **Methods:** A crossover design was used to compare the time required and motion created while cutting facemask loop straps using a MOT and a more traditional cutting tool. Six credentialed athletic trainers currently covering football (age = 35.2 ± 4.9 y, clinical experience = 11.3 ± 4.3 y) reported to the research laboratory and were assessed under two conditions, MOT and a traditional cutting tool of their own preference (CUT). At least 48 hours prior to testing, each clinician participated in a familiarization session in which they were familiarized with the MOT and practiced cutting loop straps with both tools. On the day of testing, three trials of each condition were completed on a simulated unresponsive patient with the order of conditions randomized. A second clinician was responsible for maintaining head stabilization during removal. Sagittal, frontal and horizontal plane motions were assessed using a Polhemus Fastrak electromagnetic tracking system. The maximal angular change in each direction and the total angular excursions in all three planes were compared between MOT and CUT. Removal time using a standard stopwatch was also assessed.

Dependent t-tests with an alpha level set a priori at .05 were used for comparisons. **Results:** No differences were observed when comparing the total sagittal ($t_5 = .301$, $p = .776$), frontal ($t_5 = 2.19$, $p = .08$) and horizontal ($t_5 = 1.22$, $p = .276$) excursions or the individual directions within them. Likewise, no differences were observed when comparing removal time ($t_5 = 2.16$, $p = .083$) between MOT (45.02 ± 6.77 s) and CUT (76.32 ± 36.06 s). However, when comparing the individuals trials ($F_{2,10} = 7.26$, $p = .011$), the 2nd (66.48 ± 24.58 s) and 3rd (61.88 ± 30.70 s) trials with the CUT were significantly faster than the 1st (100.61 ± 57.08 s). No differences were observed when comparing trials during the motorized tool condition. Additionally, the 1st MOT trial (46.70 ± 11.14 s) was significantly faster than the 1st CUT trial. **Conclusions:** The MOT is an acceptable option among conventional cutting tools. Traditional manual tools showed a learning effect based on time, while the motorized tool did not. This is clinically relevant, as only a single opportunity exists when performing this skill during an actual emergency situation. Our data support the MOT over the CUT, at least when considering time for removal during a single initial trial.

The Effect of Practice on Facemask Removal Timeliness With Lacrosse Helmets Used for at Least One Season of Play

Frick KA, Bowman TG: Buena Vista University, Storm Lake, IA; University of Lynchburg, Lynchburg, VA

Context: In the case of a catastrophic cervical spine incident, facemask removal (FMR) is a critical skill for healthcare providers working with helmeted athletes. Facemasks may need to be removed in order to provide patients with rescue ventilations. Previous studies have shown that practice improves FMR on new helmets; however no studies have examined FMR on used helmets. FMR failure has been shown to be common on used lacrosse helmets for a variety of reasons. Therefore, the purpose of this study was to observe the effect of practice when completing FMR on lacrosse helmets used for at least one season of play. **Methods:** Sixteen participants, including 7 certified athletic trainers and 9 athletic training students, volunteered for this study. During the first session demographics of each of the participants was assessed including height, weight, average grip strength, and years of certification (certified athletic trainers) or years in the athletic training program (athletic training students). Participants were randomly assigned to remove the facemask of 2 different models of lacrosse helmets (Cascade Pro7, Cascade R, Brine Triumph, and the Warrior TII) and instructed on the associated removal method using either the cordless screwdriver (CSD) or the CSD and the Bent-Handle Model (BHM) gate cutter. After completion of FMR, participants rated the difficulty of the process using the Borg's Rating of Perceived Exertion Scale (RPE). Participants completed FMR four times over four weeks with the same helmets and associated FMR methodology. Session (week 1, week 2, week 3, week 4) served as the independent variable. Time to remove the facemask and RPE scores served as the dependent variables. We determined

the effect of session on FMR time and RPE using ANOVAs. **Results:** Session significantly altered FMR time ($F_{3,36}=4.435, P=.009, \eta^2=.270$), but not RPE ($F_{3,36}=1.554, P=0.217, \eta^2=.115, 1-\beta=.374$). Follow-up post hoc tests with Bonferroni corrections revealed significantly faster FMR times during week 4 (mean= 49.20 ± 16.00) compared to week 1 (mean = $76.50 \pm 29.32, P=.048$, mean difference = $27.31, CI_{95}$ for difference = $.15-54.47$). **Conclusions:** Our participants significantly improved FMR time over the course of 4 weeks with the biggest mean difference occurring between week 1 and week 4. Additionally, participants had difficulty with some of the weathered hardware of the used helmets increasing difficulty which we believe lead to our findings of no significant differences for RPE. Based on the data collected from this study, we recommend practicing FMR of lacrosse helmets once a week for at least 4 weeks to attain a significant improvement and decrease overall time of FMR potentially leading to improved patient outcomes during catastrophic injury.

A Comparison of Spinal Motion in an Equipment Laden Patient During Three Different Transfer Techniques

Martinko J, Powers ME, Henry KJ, Gildard M: Marist College, Poughkeepsie, NY

Context: Changes to many EMS protocols have decreased the use of the spine board (SB) in favor of a cervical collar and ambulance stretcher for spinal motion restriction. The SB or scoop stretcher (SS) is commonly used to transfer the patient from the ground to the stretcher, however they are immediately removed following transfer. It is possible that lifting and lowering a patient directly onto the ambulance stretcher (LS) using a lift-and-slide method would eliminate the risk of unwanted motion when placing the patient on or removing the SB or SS. **Methods:** A randomized single-blind cross-over design was used to compare cervical motion during patient transfer using the SB, SS and LS. Seven healthy football athletes (age= 19.9 ± 1 y, height= 184.3 ± 7.5 cm, mass= 107 ± 19.1 kg) reported for a single session and were transferred supine from the ground to an ambulance stretcher while wearing football equipment. Phase-1 of the SB transfer consisted of a 6-plus-person lift-and-slide. The SB was then used to lift and lower the participant onto the stretcher. In the final phase, the lift-and-slide was used to remove the SB. SS transfer had three similar phases. The LS only utilized the second phase, which consisted of the 6-plus-person lift-and-slide to lift the participants and lower them directly onto the stretcher. Three trials were completed for each condition and the order of conditions was randomized. The rescuers performing the moves were a combination of certified athletic trainers, emergency medical technicians and athletic training students. Cervical motion was assessed during each phase using a Polhemus Fastrak electromagnetic tracking system. The total angular excursions in all three planes were compared between SB and SS during

the first and third phases using dependent t-tests and between all three techniques during the second phase using an analysis of variance with repeated measures. For all statistical tests the alpha level was set at .05. **Results:** No significant differences in any motions were observed during phase-1 when comparing the SS and SB. However, significantly greater sagittal plane motion ($F_{2,12}=25.75, p=.001$) was observed during the LS ($11.2\pm 1.9^\circ$) as compared to the SS ($6.3\pm 0.9^\circ$) and SB ($7.4\pm 1.8^\circ$). A significant difference was also noted during phase-3 ($t^6=5.38, p=.002$) as the SB ($9.8 \pm 3.6^\circ$) resulted in more motion than the SS ($4.5 \pm 1.2^\circ$). Similar observations were made during frontal and transverse plane motions. **Conclusions:** Our data suggests that the SS transfer can be performed with the least amount of motion in comparison to the SB and LS. The LS requires greater lifting height which likely caused increased motion. However, the differences were less than 5° , thus the clinical significance can be questioned. Given that two out of three phases are eliminated, the LS might still be the safer technique.

Free Communications, Rapid Fire Oral Presentations: Intervention Strategies for Chronic Ankle Instability

Wednesday, June 26, 2019, 10:30AM-11:15AM, Mandalay Bay D; Moderator: Patrick McKeon, PhD,

A Randomized Controlled Trial Investigating the Effects of a 4-Week Ankle Rehabilitation Program on Dynamic Balance in High School Athletes With Chronic Ankle Instability

Cain MS, Goerger BM, Ban RJ, Linens SW: University of North Carolina at Chapel Hill, Chapel Hill, NC; Georgia State University, Atlanta, GA

Context: Research shows rehabilitation programs incorporating resistance band and balance board exercises are effective at improving dynamic balance for individuals in the adult population with Chronic Ankle Instability (CAI); however, it is unknown if 4-weeks of these interventions causes the same changes in adolescent patients. The purpose of this study was to determine the effects of three rehabilitation programs on dynamic balance in adolescent patients with CAI. **Methods:** Randomized Controlled Trial. High School Athletic Training Facility. Convenience sample of CAI individuals (n=43, 20 males and 23 females, 16±1years, 171.75±12.05cm, 69.38±18.36kg), block randomized into four intervention groups. Treatment programs consisted of 3-sessions a week for 4-weeks. Strength training group performed 3-sets of 10-repetitions of ankle plantarflexion/dorsiflexion/inversion/eversion with resistance band, progressing to more difficult band each week. Balance board group performed 5-trials of clockwise/counterclockwise rotations changing direction every 10-seconds during each 40-second trial. Patient started on level 1 and could progress to level 5. Combination group completed both strength training and balance board programs during each session. Control group did not complete any exercises. Dynamic balance was assessed prior to and following intervention. Star Excursion Balance Test (SEBT) required patients to reach maximally with the uninvolved leg while maintaining a balanced single-leg

stance on the involved leg for 3 trials. 4x2 mixed-model ANOVAs were used for data analysis ($\alpha = .05$). Tukey's HSD post-hoc tests were conducted on significant interactions. Minimum significant difference (MSD) scores were used as a threshold to evaluate each pairwise pre-to-post mean difference comparisons [$MSD = q((MSe/n)^{1/2})$]. Dependent measures were average reach distance normalized to patient's anatomical leg length for each reach direction. Increased reach distance percentage indicated improved performance. **Results:** Significant group by time interactions were found for medial ($F_{3,39} = 4.74, p = 0.007$), posteromedial ($F_{3,39} = 3.64, p = 0.021$) and posterolateral ($F_{3,39} = 3.35, p = 0.029$) reach directions. Post-hoc testing showed improvement in SEBT pre-to-post change measures for all treatment groups compared to control group. MSD score of >8% (0.08) was used for each of the three reach directions with significant interactions. Pre-to-post change scores were medial (0.08 ± 0.07), posteromedial (0.10 ± 0.08) and posterolateral (0.11 ± 0.08) for the treatment groups and medial (-0.01 ± 0.07), posteromedial (0.01 ± 0.08) and posterolateral (0.03 ± 0.08) for the control group. All treatment groups had pre-to-post scores that surpassed the MSD value for posteromedial (8-12%) and posterolateral (8-14%) reach directions. **Conclusions:** Improvement in dynamic balance following intervention was demonstrated for all treatment groups on posteromedial and posterolateral reach directions compared to control group. While there was a significant interaction for the medial direction, scores did not surpass MSD for any of the treatment groups compared to the control group. Both strength and balance board training are beneficial at improving dynamic balance as evaluated by the SEBT. Future research with a focus on intervention comparative effectiveness is needed.

Eccentric Training With Anodal Transcranial Direct Current Stimulation Increases Muscle Activation in Individuals With Chronic Ankle Instability

Bruce AS, Howard JS, van Werkhoven H, McBride JM, Needle AR: Appalachian State University, Boone, NC

Context: Increased recurrence rates post-ankle sprain suggest current rehabilitation methods may be insufficient in preventing future sprains. Neuroplasticity-related changes in individuals with chronic ankle instability (CAI) require neuromodulatory interventions capable of enhancing muscle activation. Brain stimulation techniques, with eccentric strengthening, may improve functional outcomes by facilitating neuroplasticity adaptations and improving motor learning. We aimed to determine the effects of eccentric ankle strengthening with anodal transcranial direct current stimulation (atDCS) on balance and function in individuals with CAI. **Methods:** A randomized controlled trial design was implemented within a university laboratory. Twenty-two individuals with CAI (defined by history of ankle sprain and Identification of Functional Ankle Instability instrument) were recruited and randomly allocated into an intervention group (21.8 ± 2.7 yrs, 169.6 ± 10.9 cm, 73.2 ± 16.7 kg, 5M/6F) and sham group (22.3 ± 3.1 yrs, 173.5 ± 7.7 cm, 79.3 ± 10.3 kg, 3M/8F). Main outcome measures included dynamic postural stability indices (DPSI) during a hop-to-stabilization, with peak-normalized muscle activation prior to and after landing from tibialis anterior (TA) and peroneus longus (PL); and time to perform 10 side-to-side hops over a 10cm line. Outcome measures were assessed at baseline and 2-weeks. All participants received 5 training sessions consisting of four sets of ten repetitions of eccentric inversion motions (from

10° everted to 20° inverted at 10°/s; 60% peak torque) on an isokinetic dynamometer. Before each strengthening protocol, participants were instrumented with aTDCS. Intervention group participants received 1.5mA of cortical stimulation for 18-minutes, while sham group participants received no stimulation. Changes in outcome measures were assessed with group-by-time factorial analyses of variance, with a significance level of 0.05. **Results:** DPSI did not change across groups or times ($F < 1.579$, $p > 0.227$); however, DPSI directional components changed over time for all participants ($F = 4.055$, $p = 0.027$). Balance improved in the mediolateral plane over the intervention ($p = 0.048$), but decreased in the antero-posterior plane ($p = 0.022$). TA activation decreased from baseline to 2-weeks ($F = 7.349$, $p = 0.015$), but was not different across groups. PL activation revealed a significant time-by-group effect ($F = 5.735$, $p = 0.029$), indicating increased PL activation after ground contact with aTDCS (Δ : $15.2 \pm 5.5\%$ Peak, $p = 0.014$), but not sham (Δ : $3.1 \pm 5.5\%$ Peak; $p = 0.579$). Side-to-side hop performance improved in both groups ($F = 5.674$, $p = 0.030$; baseline: 11.8 ± 4.8 s; 2-weeks: 10.0 ± 2.6 s). **Conclusions:** Our results show eccentric training at the ankle may be efficient in improving balance components in the trained plane (i.e. frontal) and functional performance in individuals with CAI. The addition of aTDCS with this training may improve the efficiency of PL, a primary ankle stabilizer, within a crucial 250-ms window after contact, when injury is most likely to occur. Further research should explore the broad effects of these interventions on peripheral and central nervous systems in populations with joint instability.

Effects of Instrument Assisted Soft-Tissue Mobilization on Neuromuscular Control for Chronic Ankle Instability

Croft BD, Aronson PA, Evans EI, Bowman TG: University of Lynchburg, Lynchburg, VA

Context: Chronic ankle instability (CAI) can occur following multiple ankle injuries. CAI causes deficits in ankle mobility and stability due to adhesions in the surrounding muscles and ligaments. Sensory receptors within the joint are also damaged causing delays in muscle activation and sensory feedback. One muscle that has been found to have decreased neural excitability in individuals with CAI is the fibularis longus. Instrument assisted soft-tissue mobilization (IASTM) is a manual therapy technique used to assist in the breakdown and absorption of scar tissue, mobilization of fascia, and tissue healing. The effects of IASTM on range of motion and power have been tested, however, evidence of its effects on neuromuscular control (NMC), particularly in individuals with CAI, is limited. The objective of our study was to examine the effects of the application of IASTM to the fibularis longus on NMC in individuals with CAI. **Methods:** Our study was a crossover design, performed in an athletic training clinic. The independent variables were session (application of IASTM, control) and time (pre- and post-test). The dependent variable was the Y-balance test (YBT) reach. The patient population consisted of a volunteer sample of males and females with CAI ($n = 15$, 7 females, 8 males, age = 26.07 ± 9.18 years, mass = 87.33 ± 24.07 kg, height = 178.83 ± 12.83 cm). Participants completed the ankle instability instrument to determine if they had CAI. IASTM was applied to the fibularis longus muscle using Técnica Gavilán® instruments for 90 seconds during the intervention, and participants sat for 2 minutes during the control. Pre-test and post-test measurements were taken using the YBT (0.91 intertester reliability), all values were normalized to leg length, with the best score

of 3 trials used for analysis. We analyzed results using a 2-way repeated measures ANOVA. **Results:** The interaction between session and time for anterior reach was significant ($F_{1,14} = 5.256$, $P = .038$, $\eta^2 = .273$). Post hoc tests revealed farther reach distances at post-test (71.02 ± 9.45) compared to pre-test (66.57 ± 10.87) when IASTM was applied ($P = .02$, $CI_{95} = .71 - 8.19$). However, the interaction between session and time was not significant for posteromedial ($F_{1,14} = .251$, $P = .624$, $\eta^2 = .018$, $1 - \beta = .075$) or posterolateral ($F_{1,14} = 1.166$, $P = .298$, $\eta^2 = .077$, $1 - \beta = .172$) reach directions. **Conclusions:** In those with CAI, IASTM applied to the fibularis longus for 90 seconds improved anterior reach of the YBT, but did not change posterolateral or posteromedial reach distances. Our findings suggests that IASTM to the fibularis longus does not immediately improve all aspects of dynamic neuromuscular control. However, the 3.5 cm increase in anterior reach could decrease the risk of non-contact injury if there is asymmetry between injured and uninjured limbs.

Evaluating Postural Control on Ankle Acupuncture

Yang J, Wang HM, Yen KT, Chen AC: China Medical University, Taichung, Taiwan; China Medical University Hospital, Taichung, Taiwan; Cheng Shiu University, Kaohsiung, Taiwan

Context: Ankle sprains are among the most common injuries and also have a high rate of recurrence. People with chronic ankle instability (CAI) have been connected to postural stability impairments. While acupuncture has been used to reduce pain and increase muscle strength, little is understood about the use of acupuncture on postural control. Objective: To assess the effect of one twenty minute acupuncture treatment on postural control. **Methods:** Design: Interventional study. Setting: Controlled laboratory. Patients or Other Participants: 20 male participants (1.79 ± 0.08 m, 76.3 ± 13.0 kg, 22.0 ± 2.6 yrs) with history of ankle sprain in the past 6 months and a diagnosed unstable ankle (time-in-balance < 25s), and without any acute symptoms. Interventions: On a single day participants performed single-leg stance on a force plate, Balance Error Scoring System (BESS), and ankle range-of-motion (ROM) measurement by goniometry. All measures were taken before and immediately after 20 minutes of ankle acupuncture. Main Outcome Measures: Balance was quantified by length of time balancing (seconds) for center-of-pressure deviation, velocity, and 95% confidence ellipse area, with errors for the BESS. ROM was measured for dorsi/plantar flexion and inversion/eversion in degrees. Paired samples t-tests examined balance and ROM data before and after ankle acupuncture. **Results:** There were no differences of center-of-pressure deviation (800.6 ± 239.9 mm Vs 719.5 ± 187.9 mm, $p = .084$; 1409.6 ± 559.4 mm Vs 1318.4 ± 300.3 mm, $p = .405$), velocity (39.8 ± 11.9 mm/s Vs 35.6 ± 9.4 mm/s, $p = .080$; 77.4 ± 26.6 mm/s Vs 69.3 ± 15.8 mm/s, $p = .092$), and 95% confidence ellipse area (1147.8 ± 896.7 mm² Vs 872.8 ± 378.3 mm², $p = .204$; 2790.8 ± 1400.9 mm² Vs 2831.6 ± 2317.6 mm², $p = .939$) before and after ankle acupuncture on

open-eyes and closed-eyes single-leg stance. There was significant difference on BESS (16.0 ± 5.6 Vs 12.7 ± 4.6 , $p = .001$), especially injured limb standing on an unstable surface (1.25 ± 1.6 Vs 0.8 ± 1.2 , $p = .032$) before and after ankle acupuncture. There were no differences on dorsi/plantar flexion ($63.9 \pm 10.5^\circ$ Vs $64.5 \pm 11.4^\circ$, $p = .664$) and inversion/eversion ($56.6 \pm 13.6^\circ$ Vs $56.7 \pm 11.7^\circ$, $p = .943$) before and after ankle acupuncture. **Conclusions:** BESS score decreases after ankle acupuncture, indicating the improvement of functional balance in the injured limb. This work suggests that acupuncture has a short-term effect on postural control, especially for more challenging balance tasks. Future work should focus on the underlying mechanism(s) of acupuncture on postural control and the long-term impact.

Effects of Blood Flow Restriction on Muscle Activation in Individuals With Chronic Ankle Instability

Killinger B, Lauver J, Donovan L, Goetschius J: Adrian College, Adrian, MI; Coastal Carolina University, Conway, SC; University of North Carolina at Charlotte, Charlotte, NC

Context: Blood flow restriction (BFR), a muscle training technique that uses a tourniquet to limit blood flow to-and-from exercising muscles, has been shown to enhance strength and hypertrophy adaptations to submaximal exercises. BFR may provide an opportunity to enhance traditional therapeutic exercises in patients with chronic ankle instability (CAI). The purpose of this study was to examine whether BFR can induce greater muscle activation during submaximal ankle eversion and dorsiflexion resistance exercises in individuals with CAI compared to resistance exercises without BFR. **Methods:** This study included a crossover design performed in a laboratory setting. Participants included a convenience sample of nineteen ($n=19$) young adults with a history of CAI (10 female/9 male, 21.8 ± 2.8 years, 78.1 ± 16.1 kg, 174.7 ± 11.8 cm, 4.5 ± 3.9 ankle sprains). Primary independent variables were the exercise conditions (BFR or control) and the exercise sets (sets 1-4). For the BFR condition, an inflatable tourniquet cuff was applied proximal to the knee and inflated to 80% of blood flow occlusion. For the control condition, the cuff was applied but not inflated to allow normal blood flow. Conditions were counterbalanced between two visits. For each condition, participants performed four sets (30, 15, 15, 15) of isometric eversion and dorsiflexion resistance exercises at 30% of maximum voluntary isometric contraction (MVIC). Contractions were performed at a 2:2 second work-rest ratio using a metronome, with 45-second inter-set rest and 5-minutes rest between exercises. Normalized electromyography

muscle activation (% of MVIC) of the fibularis longus and tibialis anterior was calculated during each set of eversion and dorsiflexion exercises, respectively. Comparisons between conditions and sets were performed using 2x4 repeated measures ANOVAs, Tukey's post-hoc and Cohen's d effect-sizes with 95% confidence intervals (confidence intervals excluding zero were considered clinically important). Results presented below represent the main-effects comparisons between conditions. **Results:** Average muscle activation across the four sets of eversion exercises was significantly greater ($P=.03$) with BFR ($29.3\pm 14.0\%$) compared to control ($23.7\pm 13.6\%$); however, the effect-size was small and non-clinically important ($d=0.41$ [-0.24 to 1.05]). Average muscle activation across the four sets of dorsiflexion exercises was significantly greater ($P=.01$) with BFR ($45.5\pm 9.1\%$) compared to control ($37.8\pm 12.0\%$), with a moderate and clinically important effect-size ($d=0.72$ [0.07 to 1.38]). **Conclusions:** Muscle activation was greater during submaximal resistance exercise with BFR in participants with CAI; with greater and more clinically important effects during dorsiflexion exercises than eversion exercises. These findings provide evidence supporting positive acute effects of BFR on muscle function in CAI patients. During ankle rehabilitation, greater muscle activation during each bout of resistance exercises may promote enhanced adaptations in muscle strength and hypertrophy over multiple clinical visits. This study's BFR protocol provides a framework for future research examining the training effects of BFR exercise on muscle adaptations in CAI patients.

Free Communications, Rapid Fire Oral Presentations: Prevalence and Rehabilitation Outcomes of Mental Health Conditions in Active Populations

Wednesday, June 26, 2019, 5:15PM-6:30PM, Mandalay Bay D; Moderator: Kelsey Bains, MA, ATC

Validation of a Depression Screening Tool in Collegiate Student-Athletes

Green B, Keenan L, Ingram Y, Daltry R: West Chester University of Pennsylvania, West Chester, PA; Lock Haven University of Pennsylvania, Lock Haven, PA

Context: The NATA and the National Collegiate Athletic Association (NCAA) have published consensus recommendations on addressing mental health in student-athletes, including screening for depression. However, to date, no depression screening tool has been validated in a student-athlete population. Currently, athletic trainers must use cut-off scores validated for other populations when screening for depression in student-athletes. Additionally, research assessing prevalence of depression in student-athletes will not accurately represent the prevalence without utilizing the optimal cut-off score specific to this population. Therefore, the purpose of this study was two-fold: to provide the optimal cut-off score for a depression screening tool in the collegiate student-athlete population, and to determine the prevalence of depression symptoms in the sample.

Methods: All student-athletes at two NCAA Division II institutions were invited to participate in this study; 875 participants (response rate 92.8%; mean age 19.68 ± 1.41 years; 48% male, 52% female) consented and completed a depression screening tool, the Patient Health Questionnaire-9 (PHQ-9), during their pre-participation exam (PPE). Based on a stratified random sampling technique, 290 student-athletes were selected for asemi-structured neuropsychiatric interview within two weeks of their PPE. The interview served as a reference standard for meeting diagnostic criteria for major depressive disorder (MDD). Interviews were conducted by graduate counseling students after attending a training session with a licensed

psychologist. Interviewers were blinded to PHQ-9 scores. Internal consistency was determined using Cronbach's α . The receiver operating characteristic (ROC) curve was used to identify the area under the curve (AUC) and sensitivity and specificity of individual cut-off scores. Youden's J analysis was used to identify the cut-off score that maximized sensitivity and specificity. Descriptive statistics were used to determine the prevalence of depressive symptoms. **Results:** The mean PHQ-9 score was 2.14 ± 3.14 . The Cronbach's α of the PHQ-9 was 0.83. The area under the ROC curve was 0.811 (95% CI = .707, .915). Youden's J analysis revealed an optimal cut-off score of 5, which indicated a sensitivity of 0.78 and a specificity of 0.75. Using this cut-off score, the prevalence of clinically relevant depression symptoms in this sample was 17.8% ($n = 156$), compared to 4.0% ($n = 35$) when using the cut-off score of 10, which is the established score for the general population. **Conclusions:** This is the first validation study of any depression screening tool in a student-athlete population. Utilizing evidence-based cut-off scores is vital to effectively screen student-athletes who may be experiencing symptoms of depression and may warrant a mental health referral. The results of this study suggest the optimal cut-off score in student-athletes is lower than the recommended cut-off scores in other populations; explanations for the differences in cut-points, such as underreporting of symptoms, should be explored in future research.

Pilot Study of Mental Health Symptoms in Collegiate Student-Athletes

Simon MB, DeFreese JD, Register-Mihalik JK, Kerr ZY, Barczak N, Pexa BS: The University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Mental health is a key area of concern for collegiate student-athletes. As such, screening for mental health concerns is an important component of the pre-season assessment. Over time, mental health outcomes may vary due to changes in psychosocial stressors such as team training, travel, academics, and social pressures. Additionally, the differences between male and female athletes' mental health symptoms over time is unknown. Therefore, the purpose of this study was to explore potential variations in mental health outcomes related to depression, anxiety, and flourishing mental health in Division I collegiate athletes before and 7-weeks into a competitive season. Further, we investigated whether males and females change differently in these respective outcomes. **Methods:** Under a longitudinal repeated measures study design, 155 collegiate athletes between the ages of

18-23 years old (19.9±1.2 years, 64.9% male, 35.1% female) participated in this study. Varsity Division I athletes examined for this study were from: Men's Lacrosse (31.4%), Men's Soccer (22.6%), Women's Soccer (18.8%), Women's Field Hockey (17.6%), and Women's Volleyball (9.4%). The independent variables were time and gender. The mental health outcomes inclusive of depression, anxiety, and flourishing mental health symptoms were measured at 2 time points (during preseason screenings and approximately 7-weeks later) during a competitive season with the Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder 7-item (GAD-7), and Mental Health Continuum-Short Form (MHC-SF) questionnaires, respectively. The primary outcomes from these measures included: aggregated scores reflecting depressive and anxiety symptoms and flourishing mental health. A 2x2 ANOVA with time and gender with Tukey post-hoc comparisons were conducted for each mental health outcome. Significance was set to $\alpha < 0.05$. **Results:** There was a significant interaction between gender and time for the MHC-SF score ($F_{1,126} = 5.20, p=0.02$), indicating that males demonstrate a significant decrease from baseline (4.44±0.54) to 7-weeks post (4.15±0.76), but females

demonstrate no such change (baseline; 4.22±0.53, 7-weeks post; 4.15±0.62). For GAD-7, males demonstrated an increase in outcome scores from baseline (2.32±0.40) to 7-weeks post (3.81±0.51) and females demonstrate no such change (baseline; 3.82±0.44, 7-weeks post; 3.79±0.56; $F_{1,124}=6.24, p=0.01$). For PHQ-9, there was a significant main effect of time, indicating that outcome scores increased from baseline to 7-weeks post regardless of gender (baseline; 1.54±2.42, 7 weeks post; 3.04±3.44; $F_{1,124}=33.035, p=0.01$). These results can be viewed in Table 1. **Conclusions:** Mental health outcomes related to depression, anxiety, and flourishing mental health increase in severity over time in collegiate athletes. This information may aid clinicians in predicting how their athletes will respond to various stressors with respect to their mental health. It additionally brings awareness to more significant changes occurring in male student-athletes as compared to female student-athletes, indicating the need for serial testing of mental health outcomes in collegiate athletes throughout a season.

	Male	Female
Baseline		
MHC-SF	4.44±0.54*	4.22±0.53
GAD-7	2.32±0.40	3.82±0.44
PHQ-9	0.99±0.24*	2.91±0.39*
7-Weeks Post		
MHC-SF	4.15±0.76*	4.15±0.62
GAD-7	3.81±0.51	3.79±0.56
PHQ-9	2.21±0.32*	3.26±0.50*

Table 1. Mental health outcome scores at baseline and 7-weeks post; *Denotes a significant change in mental health outcome score.

Depression in Adolescent Athletes: Prevalence and Demographics

Long AS, Price DE, Bickett AK, Hardeman G: Atrium Health, Charlotte, NC

Context: Depression prevalence and severity is increasing in the adolescent population. Estimates of depression in the general population of adolescents range from 4-18%. To our knowledge, no group has published the prevalence of depression in high school athletes, nor examined depression prevalence in various demographic categories. The emergence of depression screening on mandatory pre-participation examinations (PPE) provides an opportunity to examine the prevalence in an athletic population. Our purpose is to examine the rate of depression, as reported on the PPE, in an ethnically and socioeconomically diverse sample of secondary school athletes.

Methods: We conducted a cross-sectional, observational study using the PPE to determine depression prevalence in high school athletes participating in a station-based, large-scale PPE. Our sample included athletes (N=2213, male=1,499 female=715) ages 13-18, (M=15.7 years) from both urban and suburban communities. Participants were provided transportation and a comprehensive PPE at no charge. Athletes, with parental consent and supervision, completed, electronically, a series of depression-related questions on the North Carolina High School Athletic Associations' PPE form. Measures included total number of students reporting depression on the PPE and demographics (age, gender, race, school Title I status, and sport). **Results:** Our findings demonstrate 32 (1.4%) of our subjects reporting depression. African American females were the largest group, accounting for 30.3% of all depressed athletes in our sample. Female athletes were 1.9 times more likely to be depressed than males. Non-whites are over twice as likely to be depressed than whites. The sport played most frequently by the depressed group was football. There was a moderate correlation between each

schools' total percentage of low income students and percentage of depressed athletes. ($r=.41$, $P=.021$) **Conclusions:** The prevalence of depression in our sample of high school athletes was below those previously reported in the general adolescent population. Females and non-whites had greater likelihoods of being depressed than males and whites. African American female high school athletes accounted for one-third of those depressed. Although exercise and sport participation have many benefits for mental health, health care providers should be vigilant when screening for depression in athletes, realizing that non-whites, females, and those at low-income schools may be more susceptible. Parental supervision may have limited accurate responses to depression questions. Future research will focus on responses in real time with the athlete only.

Prevalence of Depression and Anxiety Among ROTC College Students

Smith A, Torres-McGehee TM, Jensen M, Emerson D, Potter D: University of South Carolina, Columbia, SC; Texas Tech University, Lubbock, TX; University of Kansas, Lawrence, KS

Context: In the United States, military service branches offer the Reserve Officers Training Corps (ROTC) program to college students as preparatory method to engage in college course work while undergoing physical, mental, and emotional training. This training program occurs in conjunction with normal stressors of an undergraduate degree program which can predispose this population to depression and anxiety. The purpose of this study was to examine the prevalence of depression and anxiety among female and male ROTC students.

Methods: A cross sectional study examined volunteer ROTC college students (n=102, age: 21.5±16.2 years; male: n=75, height: 178.6±7.40 cm, weight: 78.1±9.5 kg; female: n=27, height: 164.9±7.68 cm, weight: 63.7±10.1 kg) at a Southeastern University. As part of a larger study, the independent variable was gender and dependent variables were: depression and anxiety risks. Participants completed a demographic survey (e.g., military background, self-reported height and weight, etc.). The Center for Epidemiological Studies Depression Scale assessed depression risks and consisted of statements that may reflect a person's feelings throughout the week. The Spielberger State-Trait Anxiety Scale assessed the temporary condition of "state anxiety" and the more general and long-standing quality of "trait anxiety" by evaluating feelings of apprehension, tension, nervousness, and worry. Basic descriptive statistics, crosstabulations, and Chi-square analysis were used.

Results: No significant differences were found between gender and depression, state anxiety, and trait anxiety risks. However, overall prevalence for depression for all participants was 26.5% (n=27) with females estimated at 6.9% (n=7) and males at

19.6% (n=20). Within females only, 25.9% (n=7/27) were at risk for depression, and males only 26.7% (20/75). State anxiety scores revealed 6.9% (n=7) above average norm. Trait anxiety scores show 22.5% (n=23) above the average norm. Gender specific state anxiety revealed 1.0% (n=1) for females and 5.9% (n=6) above average norms for males. Gender specific trait anxiety showed 6.9% (n=7) for females and 15.7% (n=16) above average norms for males. **Conclusions:** Regardless of gender, ROTC students displayed risk factors for depression and anxiety. Identifying symptoms of depression and anxiety will lead to overall healthier ROTC training programs while maintaining adequate mental health for recruits. Recommendations should be made for ROTC leaders to be educated on risk factors for depression and anxiety to increase awareness in their student populations. Screening for depression and anxiety prior to enrollment in ROTC programs should be implemented.

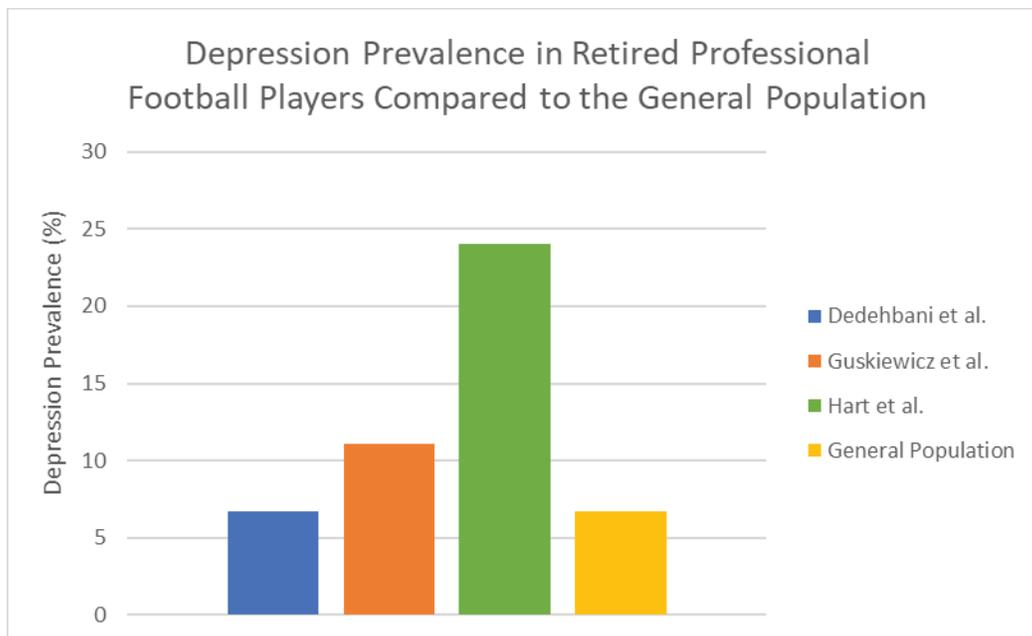
Depression Following Concussion In Retired Professional Football Players

Thomson RP, Carabello DM, Russ AC, Mansell JL: Temple University, Philadelphia, PA

Context: Mental health outcomes following a concussion, such as depression, are often not considered when professional football players retire. The purpose of this systematic review was to evaluate the evidence regarding the link between concussion in professional football players and the prevalence of depression diagnosis. **Methods:** PubMed was searched in February 2018 using the Boolean phrase: “Concussion” AND “Depression” AND “Football”. Titles were reviewed for relevance to the clinical question, followed by the abstract, and then the full text. Articles were excluded or included depending on their relevance to the focused clinical question. Only studies on retired National Football League players in the past 15 years were included. Exclusions were made if studies only included high school or collegiate football players,

or did not include depression prevalence. Depression prevalence (%) was the main outcome measure. The STROBE checklists for cross-sectional and case-control studies were used to assess validity. **Results:** Of the 30 articles identified, 19 were excluded based on the title. Then, 8 were excluded based on their abstract. 3 articles were included. Didehbani et al. found depression prevalence to be 6.67% (2/30 participants). Diagnosis was determined based on player’s self-reported history of depression. Guskiewicz et al. found the prevalence of depression to be 11.1% (269/2434 participants). Depression was determined based on a questionnaire and the Short-Form 36. Individuals that self-reported depression had worse scores on the mental component scale. Hart et al. found depression prevalence to be 24% (8/34 participants). Participants completed the Beck Depression Inventory-II to determine diagnosis. STROBE scores: Didehbani- 21/22; Guskiewicz- 20/22; Hart- 20/22. **Conclusions:** Diagnosed depression prevalence for retired professional football players ranges from 6.67%-24%, while the general population prevalence

is 6.7%. (See Figure) Studies that utilized depression inventories to evaluate the retired players showed higher depression prevalence compared to the studies that only used self-reported depression. However, the actual number of retired professional football players that have depression may be higher, due to lack of recognition. Depression can negatively affect individual’s ability to function in many different aspects of life. Retired professional football players should be regularly screened for depression, so they can be referred for appropriate treatment. Since this is an emerging area of research, lack of information could be a limitation. As more research is conducted, this topic area should be re-evaluated to determine a more accurate prevalence of depression in professional football players. Also, further research should be conducted on high school and collegiate football players to determine the prevalence of depression at other levels of football. SORT Rating: B.



The Effect of Premorbid Anxiety on Rehabilitation Services and Recovery Times Following Pediatric Concussion

Teel EF, Beaulieu C, Friedman D, Galli C, Straub M, Gagnon IJ: McGill University, Montreal, Quebec, Canada; McGill University Health Centre, Montreal, Quebec, Canada

Context: There are mixed findings regarding the effect of anxiety on concussion recovery in children and youth, with some studies showing anxiety increases recovery time. However, the literature is inconsistent in its classification of anxiety (premorbid vs. post-concussion anxiety), focuses heavily on adult populations, and does not mention rehabilitation interventions provided. The effect of premorbid anxiety on the type of rehabilitation services delivered and recovery times in concussed children has been largely unexplored. **Objective:** To determine if individuals with premorbid anxiety require different rehabilitation interventions or recover along different timelines than individuals without premorbid anxiety. **Methods:** Retrospective review of prospectively collected standardized clinical data. **Setting:** Specialty concussion clinic located within a pediatric trauma center. **Patients or Other Participants:** A total of 839 patients (503 females, age= 14.0 ±2.3) presented to the concussion clinic between April 2015 and March 2018 and had complete data for their entire episode of care. **Interventions:** At the initial clinic visit, patients self-reported the presence of premorbid anxiety during intake and were given a clinical exam by a licensed physiotherapist. All patients were prescribed an active rehabilitation intervention (physical activity program and coordination exercises) per clinic standard of care. Vestibular, cervicogenic, and psychological therapies were additionally prescribed if indicated by the clinical examination. Patients were followed longitudinally until they were cleared for full resumption of academic and athletic activities. **Main Outcome Measures:** The association between rehabilitation services (vestibular,

cervicogenic, or psychological interventions) and premorbid anxiety were evaluated using Chi-Square analysis. Time to full clinical recovery (days between concussion and discharge) and total rehabilitation time (days between rehabilitation initiation and discharge) were evaluated using linear regression. Female sex ($\chi^2=6.43$; $p=0.01$) and higher initial post-concussion symptoms ($t_{828}=5.82$; $p<0.001$) were associated with premorbid anxiety; linear regression models controlled for these covariates. **Results:** A total of 417 (49.7%) patients had a premorbid diagnosis of anxiety. Individuals with premorbid anxiety were more likely to be prescribed psychological interventions (30.9% vs. 21.8%; $\chi^2=9.02$; $p=0.003$), but no differences were present for vestibular ($p=0.29$) or cervicogenic rehabilitation ($p=0.44$). In univariate analyses, premorbid anxiety was significantly related to longer rehabilitation (83.5 ±88.7 vs. 70.1 ±79.1 days; $F_{(1,903)}=8.36$, $p=0.004$) and full recovery (123.5 ±98.7 vs. 104.6 ±86.9 days; $F_{(1,903)}=11.35$, $p<0.001$) time. In multivariate analysis, premorbid anxiety failed to reach significance for both rehabilitation ($p=0.12$) and full recovery times ($p=0.054$). **Conclusions:** Individuals with premorbid anxiety are more likely to need psychological interventions post-concussion, but female sex and higher initial post-concussion symptoms are stronger predictors of recovery times in children and youth with concussion. Clinicians should be aware of premorbid psychological states and be prepared to offer care or provide referrals as needed.

Preseason Psychological Distress Affects College Student-Athletes' Health-Related Quality of Life: Findings From the Active Rehab Study

Register-Mihalik JK, Ranapurwala SI, Guskiewicz KM, Gildner P, Klotz A, Marshall SW, McCulloch KL, Mihalik JP, Prim JH, Vander Veeg CB, McCrear M, The Active Rehab Study Consortium: University of North Carolina, Chapel Hill, NC; Medical College of Wisconsin, Milwaukee, WI

Context: Health-related Quality of Life (HRQL) in college student-athletes may be affected by historical and injury related factors. The study purpose was to examine if increased psychological distress reported during preseason testing was associated with worse HRQL in college student-athletes. **Methods:** Student-athletes (n = 1509) from 24 college sports at six Canadian and US college institutions participated in this cross-sectional study [median age = 19 years (range=18-27); 538 (35.6%) female; 243 (16.1%) obese BMI; 553 (36.6%) with 1+ prior concussions; 1154 (76.5%) rostered on a contact sport]. Participants completed a comprehensive baseline assessment in a classroom-style setting that

included the Brief Symptom Inventory 18 (BSI-18) as a psychological distress measure. The HRQL assessment included the Patient-Reported Outcomes Measurement Information System (PROMIS-29), and the Quality of Life in Neurological Disorders (Neuro-QOL) Cognition and Fatigue Scales. Standardized BSI-18 scores (mean=50; Standard Deviation (SD) =10; range=44.3-149.9) were used to categorize all participants into 1 of 4 levels (independent variable was group assignment): 1) within 1 SD below the mean (44.3≤BSI≤50), 2) within 1 SD above the mean (50.2 SD above the mean (BSI=70+). Higher standardized BSI-18 scores indicate greater psychological distress. Primary HRQL outcomes derived from the PROMIS-29 included raw scale scores for Anxiety, Physical Function, Depression, Sleep Disturbance, Social Role/Activities, Pain Interference, and Pain Intensity. The Neuro-QOL Cognition and Fatigue raw scale scores also served as outcomes. Associations between psychological distress and HRQL were adjusted for age, sex, BMI, concussion history, and contact sport participation using linear regression with generalized estimating equations to account for study site clustering (alpha<0.05). **Results:** For standardized BSI-18 scores, 1080 (71.6%) were within 1 SD below the mean; 261 (17.3%) within 1 SD above the

mean; 87 (5.8%) between 1 SD and 2 SD above the mean; and 80 (5.3%) were >2 SD above the mean. Those with the highest standardized BSI-18 scores (BSI>70 or >2 SD above mean) had the worst HRQL scores (Table 1). Most notably, those in the highest BSI-18 score group (BSI=70+ or >2 SD mean group) reported significantly worse cognitive performance (Mean Difference (MD)=-7.1; 95%CI: -7.9,-6.3; P<0.001) and higher fatigue (MD=8.3; 95%: 6.5,10.1; P<0.001) compared to the lowest BSI-18 score group (BSI=44.3-50 or within 1 SD below mean). **Conclusions:** Increased psychological distress is associated with worsened HRQL outcomes including Anxiety, Physical Function, Depression, Sleep Disturbance, Social Role/Activities, Pain Interference, Pain Intensity, Cognitive Function, and Fatigue during preseason baseline assessments. These findings highlight links between perceived psychological distress and HRQL. Athletic Trainers should measure psychological distress and HRQL during preseason assessments to identify individuals who may need intervention or medical follow-up. Funded by a National Football League research grant.

Table 1. Health-related quality of life adjusted^a mean difference (MD) estimates and 95% confidence intervals (CI) for BSI-18 standardized score groups

BSI-18 Score Group ^b	Physical Function ^c			Anxiety			Depression		
	MD	L95	U95	MD	L95	U95	MD	L95	U95
50<BSI≤60	-0.1	-0.2	-0.1	1.0	0.6	1.4	0.5	0.3	0.7
60<BSI≤70	-0.5	-0.8	-0.2	2.5	1.8	3.2	1.2	0.5	1.9
BSI=70+	-0.4	-0.6	-0.1	5.7	5.1	6.3	4.4	3.3	5.4
	Sleep Disturbance			Social Role/Activity ^c			Pain Intensity		
	MD	L95	U95	MD	L95	U95	MD	L95	U95
50<BSI≤60	1.4	1.0	1.9	-0.4	-0.7	-0.1	0.4 ^d	0.0	0.7
60<BSI≤70	2.5	2.2	2.7	-1.4	-1.8	-0.9	0.7	0.4	1.0
BSI=70+	4.2	4.1	4.3	-2.8	-3.4	-2.1	1.2	0.7	1.7
	Pain Interference			Cognition ^{c,e}			Fatigue ^e		
	MD	L95	U95	MD	L95	U95	MD	L95	U95
50<BSI≤60	0.6	0.4	0.9	-2.1	-2.7	-1.4	3.2	2.3	4.0
60<BSI≤70	0.9	0.7	1.1	-6.1	-7.3	-4.9	6.7	4.9	8.6
BSI=70+	1.5	0.9	2.1	-7.1	-7.9	-6.3	8.3	6.5	10.1

^aadjusted for age, sex, BMI, concussion history, contact sport participation; ^breference category is BSI=44.3-50; ^chigher score=better HRQL; ^donly MD not significant; ^efrom Neuro-QOL; L95=lower 95% CI; U95=upper 95% CI;

Poor Surgical Expectations for Patients With Shoulder Instability are Associated With Race and Mental Health

Cascia NG, Jacobs CA, Ortiz S, Hettrich CM, Wolf B: University of Kentucky, Lexington, KY; University of Iowa, Iowa City, IA

Context: Preoperative patient expectations have been shown to be predictive of postoperative outcomes after rotator cuff repair; however, patient expectations have not been assessed for those undergoing surgical correction of shoulder instability. The purpose of this study is to identify patient factors associated with poor expectations prior to shoulder instability surgery. **Methods:** A total of 1010 patients (821 M 189 F; mean age = 24 +/- 9) with preoperative data from the Multicenter Orthopaedic Outcomes Network (MOON) Shoulder Instability (SI) cohort were included. MOON SI includes 11 orthopaedic sites around the United States who collaborate to identify factors associated with inferior outcomes after surgical correction for shoulder instability. Patients in this cohort were diagnosed with either anterior, posterior or inferior primary instability. Independent variables included patient demographics, number of times dislocated, previous rehabilitation, past instability-related surgery, self-reported depression and/or a mental health condition, and patient-reported outcome measures (Personality Assessment Screener, Rand-36, American Shoulder Elbow Surgeon, Marx Activity, Single Assessment Numeric Evaluation, Iowa Quick Screen). Patient expectation scores range from 1 to 5, with 5 being indicative of greater confidence that surgery will improve the patient's condition. Patient expectation was then dichotomized into poor (scores < 4) and high expectations (scores > 4). Continuous variables were compared between those with low vs. high expectations using 2-tailed independent t-tests and categorical variables were compared using chi-square or Fisher Exact tests as appropriate. **Results:** The

association between patient-reported depression and poor patient expectation was statistically significant, chi-square (2, N = 993) = 13.25, p = .05. Race and poor patient expectations also showed statistical significance, chi-square (2, N = 976) = 16.75, p = .002. This indicates that there was a greater proportion of minority patients in the low expectation group than high expectation group. There were no differences in demographics, injury history, prior treatments, or preoperative patient reported outcomes between those with low vs. high expectations. **Conclusions:** This investigation is the first to identify patient factors associated with poor patient expectations prior to shoulder instability surgery. Specifically, these results suggest that preoperative expectations are lower for minority patients and those with mental health disorders. Since preoperative expectations have been found to be predictive of postoperative outcomes after shoulder surgery, healthcare professionals should consider tailoring preoperative patient education protocols for these subsets of patients to potentially improve preoperative surgical expectations and postoperative functional outcomes.

Low Self-Efficacy and Mental Health Disorders Predict Persistent Postoperative Pain 3-Months Following Hip Arthroscopy

Jochimsen KN, Mattacola CG, Noehren B, Duncan ST, Jacobs CA: University of Kentucky, Lexington, KY

Context: Mental health scores have previously been reported to highly correlate with preoperative symptoms in patients with femoroacetabular impingement (FAI), and patients with psychological comorbidities such as depression or anxiety have demonstrated worse postoperative outcomes after hip arthroscopy. However, in order to design evidence-based interventions to improve outcomes for this high-risk subset, we must first identify the specific pain coping behaviors that underpin these poor outcomes. Therefore, the purposes of this study were to 1) determine the effect of preoperative pain catastrophizing, self-efficacy, and kinesiophobia on postoperative pain, and 2) determine if these variables were predictive of postoperative pain. We hypothesized that preoperative pain catastrophizing, low self-efficacy, and kinesiophobia would result in worse postoperative pain, and that these variables would be predictive of an increased risk of developing persistent postoperative pain. **Methods:** A total of 52 patients (41F/11M; age 36.7 ± 12.2 years; BMI 27.1 ± 4.6 kg/m²) with symptomatic FAI undergoing hip arthroscopy consented to participate in this IRB-approved prospective longitudinal study. Preoperatively patients completed the Pain Self-Efficacy Questionnaire (PSEQ), Tampa Scale for Kinesiophobia (TSK), Pain Catastrophizing Scale (PCS), and postoperatively patients completed a 10-point visual analog scale (VAS) for hip pain at rest and during activity. Self-reported mental health disorders and duration of symptoms were recorded. Fisher's exact tests were used to compare the prevalence of increased postoperative pain defined as VAS>3 based on

preoperative thresholds on the PSEQ, TSK, and PCS, odds ratios were calculated, and separate multivariate logistic regressions were used to determine if models could be created to accurately predict the presence of increased postoperative pain three months post hip arthroscopy. **Results:** The odds of developing increased postoperative pain (VAS>3) was 5.6 times higher for patients with high preoperative pain catastrophizing (95% CI 1.3-23.4), 42 times higher for those with low preoperative self-efficacy (95% CI 4.7-371.9), and 26.6 times higher for patients with both (95% CI 5.1-138.4). A model consisting of preoperative PSEQ and self-reported mental health disorders was predictive of postoperative pain at rest ($r^2=.47$) and a model consisting of preoperative PSEQ was predictive of increased postoperative pain during activity ($r^2=.15$). **Conclusions:** Low preoperative self-efficacy and/or high pain catastrophizing increase the odds of persistent postoperative pain after hip arthroscopy for symptomatic FAI. Pain related self-efficacy, a patient's belief in their ability to complete tasks despite their pain, and pain catastrophizing, an exaggerated negative response to pain, are important determinants of long-term recovery and are both viable treatment targets. As such, evidence-based interventions such as patient education and relaxation techniques should be applied in this high-risk population to mitigate the effects of poor preoperative cognitive coping.

Free Communications, Rapid Fire Oral Presentations: Epidemiology and Management of Patellofemoral Pain

Thursday, June 27, 2019, 7:00AM-7:45AM, Mandalay Bay D; Moderator: David Bazett-Jones, PhD, ATC,

The Prevalence of Patellofemoral Pain in the Community

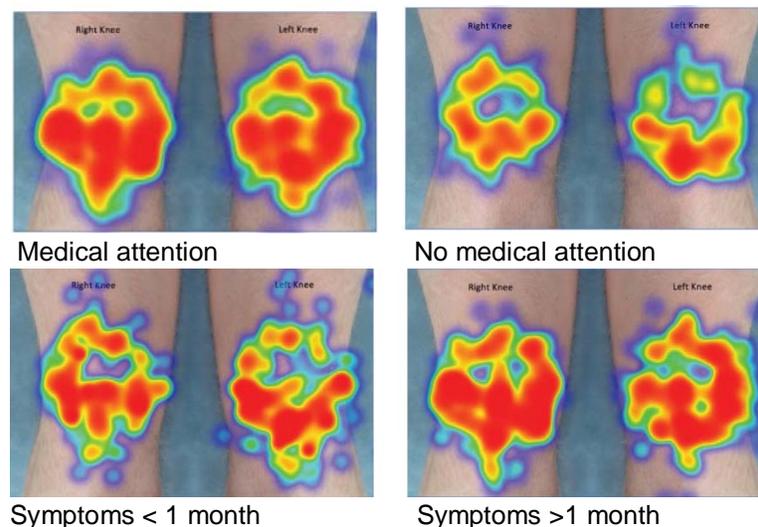
Thorpe JL, Dey P, Earl-Boehm JE: University of Wisconsin, Milwaukee, WI; Edge Hill University, Ormskirk, Lancashire, United Kingdom

Context: Previous studies have established the prevalence of patellofemoral pain (PFP) in athletic and military populations, yet the prevalence of (PFP) in the community within the United States is unknown. The Survey instrument for natural history, Aetiology, and Prevalence of Patellofemoral pain Studies (SNAPPS) was developed to identify PFP prevalence in the community and has been used in the UK and in China. The purpose of this study was to determine the prevalence of PFP in southeastern Wisconsin using SNAPPS, and identify demographic factors that may be associated with having sought medical attention. **Methods:** Cross-sectional survey design utilizing the online version of SNAPPS. Males and females (18-45 years) were recruited using social media, targeted

email invitations, and at community events. 393 (123 males, 270 females; 26.64±7.15 years) of 513 respondents met the inclusion criteria and reported knee pain within the past year. SNAPPS includes questions regarding the clinical history of their knee pain, painful activities, and pain location using a knee pain map. SNAPPS is reliable and valid and can differentiate PFP from other soft tissue injuries of the knee, with 92% sensitivity and 94% specificity. Respondents that scored above the threshold for PFP (a combined score of 6 or greater) were further analyzed. Descriptive statistics were calculated for participant characteristics. Heat-map plots were created to illustrate the frequency of painful locations identified using the knee pain maps (Figure 1). Prevalence of PFP overall, and stratified by gender was estimated. Separate chi-square tests of independence were calculated to compare the prevalence of PFP in men and women, having seen a doctor for knee pain for both genders, as well as in those who experienced symptoms for less than one month and longer than a month. **Results:** Knee pain was more prevalent in females (57.0%) than

males (41.9%). Specifically, PFP was significantly more prevalent in females (31.9%) than males (18.5%) ($\chi^2(1) = 7.52, p = 0.006$). 63.3% of those with PFP reported seeing a doctor for their pain. No significant relationship was found between having seen a doctor for pain and gender ($\chi^2(1)=0.046, p=0.830$). A significant interaction was found between having seen a doctor for pain and symptom duration ($\chi^2(1)=19.325, p=0.000$). Those with symptoms lasting more than one month were 80% more likely to see a doctor for their pain than those with symptoms less than a month (38.6%). **Conclusions:** The prevalence of PFP in this sample is consistent with reports in other populations, occurring in more females than males. Symptom duration appears to influence whether or not to seek medical attention in individuals with PFP. Further research is warranted to explore additional factors that may influence this relationship, given the impact that duration of symptoms has on treatment outcomes in this population.

Figure 1. SNAPPS Heat-map Plots



Performance on a Clinical Dynamic Balance Task is Different in Individuals With Patellofemoral Pain

Baellow A, Jaffri A, Saliba S:
University of Virginia,
Charlottesville, VA

Context: Patellofemoral pain (PFP) is common among the active population and presents commonly during functional activities. Balance and postural control are often required during these activities, yet current research has not clearly identified deficits in balance performance on commonly used balance tasks in this population. Researchers have traditionally used center of pressure (COP) excursion during a single leg static balance and the Star Excursion Balance Test (SEBT) to assess balance deficits in PFP. However, these tests may have limitations in detecting postural deficits in physically active persons. Although the SEBT is used as a measure of dynamic balance, the nature of the reach task may not be functional for activities such as running, jogging, jumping, etc. There is a need to evaluate

the PFP population in a more dynamic, functional way. The Dynamic Leap and Balance Test (DLBT) incorporates base of support changes and dynamic stability (Figure). **Methods:** The purpose of this study is to determine how individuals with PFP perform compared to healthy individuals on the SEBT and the DLBT in a case-control study. 13 PFP pathological (11F, 2M) (170.96±7.12cm, 63.84±12.12kg, 19.77±1.09yrs) and 13 healthy (12F, 1M) (167.54±9.57cm, 68.66±15.45kg, 20.23±1.48yrs) physically active individuals volunteered for this study. The DLBT was assessed with a practice trial and three test trials on the affected PFP limb, and the dominant limb in healthy. Individuals leaped back and forth from a central target to 20 total targets, each target placed at a distance normalized to the individual’s leg length. Individuals were required to stabilize on the central target for two seconds before leaping to the next target. Total time (DLBTtime) and amount of errors (DLBTerrors) were averaged across all 3 trials. SEBT was assessed in three directions: anterior, posterior or medial, and posterior lateral. Three trials in each direction were averaged

and normalized to the individual’s leg length. Independent t-tests were used to compare variables between groups. **Results:** Individuals with PFP took significantly longer to complete DLBT (p=0.007) and significantly more errors (p=0.005) (DLBTtime: 51.92±9.87s, DLBTerrors: 6.69±5.41) than healthy individuals (DLBTtime: 48.89±4.74s, DLBTerrors: 4.79±2.86). There were no statistical differences between groups in the normalized reach distance in any direction of the SEBT (p>0.05). **Conclusions:** Individuals with PFP performed slower and with more errors on the DLBT than healthy individuals. The DLBT was able to identify balance deficits in individuals with PFP, whereas they presented similarly on the SEBT. The DLBT is a clinical and dynamic balance assessment that may be able to identify more subtle deficits in balance performance. Clinicians should consider using the DLBT, with the SEBT, as a battery of balance tasks when analyzing pathological populations in a dynamic fashion.

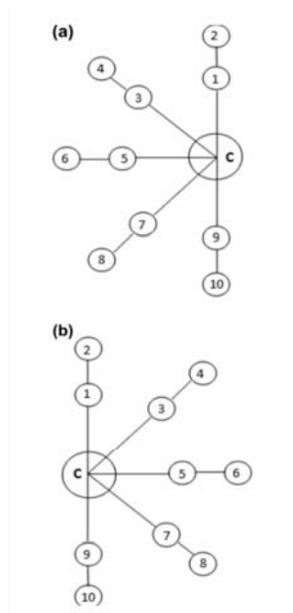


Figure: Dynamic Leap and Balance Test (DLBT)

- (a) DLBT pattern for right dominant/right PFP limb
- (b) DLBT pattern for left dominant/left PFP limb

(1) Anterior short (2) Anterior long (3) Anteromedial short (4) Anteromedial long (5) Medial short (6) Medial long (7) Posteromedial short (8) Posteromedial long (9) Posterior short (10) Posterior long (C) Central target

Effect of Biofeedback Electrical Stimulation on Lower Extremity Kinematics in Females With Patellofemoral Pain

Springer A, Norte GE, Murray A, Glaviano NR: University of Toledo, Toledo, OH

Context: Patellofemoral pain (PFP) is a lower extremity injury often found in the active population. It is theorized to be caused by altered lower extremity movement patterns that place an abnormal stress through the patellofemoral joint. Current treatment strategies to improve these poor movement patterns are ineffective; therefore, it is important to explore other novel interventions. Electrical stimulation has been previously used to targeting the gluteal muscles, yet has not been studied when the stimulus has been administered during a weight-bearing activity to improve the movement patterns. Therefore, the purpose of this study was to determine if a single session of electrical stimulation to the gluteus medius and maximus will alter movement patterns in females with PFP during functional tasks.

Methods: Sixteen females (22.6±3.5 years; 168.9±8.5cm; 69.6±18.3kg) with PFP completed this randomized blinded controlled trial. Participants were randomized to receive either a functional electrical stimulation (100 Hz, 100 microseconds, strong motor response) or a sham treatment (1mA treatment with no motor response) to the gluteus medius and gluteus maximus. Individuals received the electrical stimulation or sham treatment while completing 2 set of 10 stationary lunges. Lower extremity and trunk kinematics (frontal and sagittal plane) were assessed pre and post-intervention during a single leg squat (SLS), drop vertical jump (DVJ) and single leg hop (SLH) task. Pain was measured at baseline and immediately following each functional task, as well as during and after the intervention task. Repeated mixed measure ANOVAs were performed, with alpha set at $p < .05$. **Results:** There were no differences in baseline demographics,

lower extremity or trunk kinematics during all three tasks, or pain between the two groups, $p > .05$. Those in the electrical stimulation group increased their hip adduction during the SLS following the intervention (Pre-intervention: $17.37^\circ \pm 10.04$, Post-intervention: $21.72^\circ \pm 10.66$, $p = .01$). There were no other differences found pre- to post-intervention for DVJ or SLH trunk and lower extremity kinematics between the two groups, $p > .05$. There were no differences in the electrical stimulation or sham group's pain scores following the intervention or during the three functional tasks compared to their baseline scores. **Conclusions:** A single electrical stimulation treatment to the gluteus medius and gluteus maximus produced little difference in lower extremity or trunk kinematics during three functional tasks. Those who received the electrical stimulation did have an increase in their squatting hip frontal plane kinematics. Strong motor electrical stimulation may result in muscle fatigue, which would contribute to greater frontal plane kinematics during functional tasks. Other forms of electrical stimulation or longer interventions should be evaluated on both lower extremity and trunk kinematics or pain scores in females with PFP.

Comparing Kinesio® Tape to KT Tape® for Individuals With Patellofemoral Pain (PFP)

Marcus BL, Lyman KJ, Hanson TA, Gange KN: North Dakota State University, Fargo, ND; Butler University, Indianapolis, IN

Context: Kinesiology tape is a common therapeutic intervention for musculoskeletal injuries, although its effectiveness is disputed among healthcare providers. The primary purpose was to investigate differences between brands of tape when the Kinesio® Taping Space Correction Method was applied to subjects with PFP. **Methods:** Designed as a randomized, double-blind study in a laboratory at a research university. Twenty-eight adults (9 males, 19 females; 24.93 ± 10.73 years) with PFP participated. Inclusion criteria comprised the presence of PFP quantified by a Kujala Patellofemoral Scoring System (KPSS) score between 40 and 65 out of 95. Initial baseline KPSS scores ($M = 62.6 \pm 8.7$) outlining PFP severity and Visual Analogue Scale (VAS) scores ($M = 3.3 \pm 1.3$) were obtained, followed by baseline measurements ($M = 23.1 \pm 3.0$ mm) of the space between the patella and medial femoral condyle using Terason t3200™ Diagnostic Ultrasound. Participants were randomly assigned to a group with one of the following interventions: (1) Kinesio® Tape with tension, (2) Kinesio® Tape without tension, (3) KT Tape® with tension, and (4) KT Tape® without tension. After ten minutes with the tape, a second ultrasound measurement ($M = 23.4 \pm 3.1$ mm) was recorded. Twenty-four hours later, a second KPSS score ($M = 76.4 \pm 8.8$) and VAS score ($M = 1.6 \pm 1.8$) were documented, and a final ultrasound measurement ($M = 23.4 \pm 3.1$ mm). Using SPSS version 24 (IBM, Armonk, NY), pre-/post-test measurements of the patellofemoral joint space were recorded with diagnostic ultrasound and patient outcome surveys. Three separate repeated measures ANOVA were conducted to compare ultrasound measurements between

groups, KPSS scores, and VAS scores ($p < .005$). **Results:** Descriptive statistics indicate KPSS scores significantly increased after kinesiology tape was applied ($M = 76.4 \pm 8.8$, $p = .001$) although no statistically significant difference was observed across groups ($p = .068$). For the KPSS, an increase in score represents a decrease in pain and dysfunction. VAS scores also significantly decreased following the tape application ($M = 1.6 \pm 1.8$, $p = .002$) although, again, no significant differences were noted across groups ($p = .998$). The ultrasound measurements at baseline ($M = 23.1 \pm 3.0$ mm), 10 minutes ($M = 23.4 \pm 3.1$ mm), and 24 hours ($M = 23.4 \pm 3.1$ mm) were not found to differ across conditions or group ($p = .902$ and $p = .416$, respectively). **Conclusions:** The Kinesio® Taping Space Correction Method alleviated symptoms of PFP observed in improvements in KPSS and VAS. Though not statistically significant, patellofemoral joint space did increase in all groups. The current research cannot suggest overall interchangeability between brands, although for this specific application, both Kinesio® Tape and KT Tape® yielded similar positive patient outcomes.

Free Communications, Rapid Fire Oral Presentations: Preparing and Supporting the Newly Credentialed Athletic Trainer

Thursday, June 27, 2019, 8:00AM-9:00AM, Mandalay Bay D; Moderator: Thomas Bowman, PhD, ATC

Transition to Practice: Challenges and Facilitators to Professional Identity Development Following Graduation From a Professional Master's Level Program

Kilbourne BF, Bowman TG, Mazerolle SM, Barrett JL: Emory & Henry College, Emory, VA; University of Lynchburg, Lynchburg, VA; University of Connecticut, Storrs, CT; Springfield College, Springfield, MA

Context: The transition from supervised, athletic training student, to independent clinician can be a challenging event for athletic trainers as they develop their own professional identity. Understanding the challenges and mechanisms used to overcome these challenges may help better prepare new athletic training graduates for transition to autonomous clinical practice. **Methods:** A purposive sample of 14 graduates (7 male, 7 female, age=25.6±3.7 years) from 9 different professional master's athletic training programs participated in this qualitative study. Participants were interviewed at two different time points (4-6 months and 10-12 months) during their first year of autonomous clinical practice as an athletic trainer. Participants were employed in a variety of settings including, high school (n=5), college (n=5), performing arts (n=1), or in professional sports (n=2). A semi-structured interview was audio recorded over the phone. Two research questions guided this study: 1) What challenges have you faced regarding your development as an independent practicing athletic trainer? 2) What strategies did you use to help navigate those challenges you faced? Data was transcribed following saturation. Data analysis followed a general inductive approach. Trustworthiness was established through multiple analyst triangulation and peer review. **Results:** Several themes emerged related to challenges faced by newly credentialed

athletic trainers as they develop their professional identity. Participants described the challenges of finding rhythm in the chaos produced by the everyday responsibilities of the profession. Chaos resulted from the frantic pace and lack of personal routines necessary to prevent feelings of being overwhelmed. Participants also pointed to the stress that results from interprofessional conflicts such as "turf battles" and ignorance of stakeholders related to the athletic trainers scope of practice. Additionally, participants spoke to the challenges of finding support for decisions. These decisions ranged from day-to-day operations to diagnosis, treatment, and managing conflict. Strategies used to address these challenges were the use of a mentor network to provide advice, assurance, and perspective. The mentor networks included coworkers, former classmates, preceptors, and social media. Self-reflection through internal dialogue provided participants with motivation, and confidence while navigating through the trial and error of their experience. Participants also used communication to mitigate conflict by educating stakeholders and clarifying priorities and policies. **Conclusions:** These findings improve understanding of the transition to practice experience of new clinicians following completion of a professional master's program. Understanding this experience is the first step in identifying ways educational programs can prepare students and how employers can facilitate this process to improve professional persistence. These findings suggest that programs should provide opportunities to develop their professional identity by allowing students to manage their clinical experience similar to student teachers. Additionally, programs should intentionally expose students to trial and error, by forcing and supporting students through failures.

Career Aspirations of Athletic Trainers in Their First Year of Employment Following Graduation From a Professional Preparation Masters Level Program

Barrett JL, Bowman TG, Mazerolle SM, Kilbourne BF: Springfield College, Springfield, MA; University of Lynchburg, Lynchburg, VA; University of Connecticut, Storrs, CT; Emory & Henry College, Emory, VA

Context: Athletic training programs must prepare students to enter the profession while instilling in them passion and a desire to persist. Athletic training students are known to develop confidence and appropriate professional socialization within their athletic training programs. These components serve to assist in their preparation to enter the workforce. Transitioning to autonomous clinical practice has been a recent topic of substantial attention. The focus on the ability of students to transition successfully to their new positions has stopped short of identifying the impact of the initial year of employment on their perception of continuation in the profession and future career goals. The primary objective of this study was to examine the career aspirations of athletic trainers who had graduated from a professional master's program, and had completed 10-12 months of independent practice. Two research questions guided the study: 1) Do graduates of master's programs plan to stay in the athletic training profession following their first year of employment? 2) Does the first year of employment impact the career aspirations of graduates from professional master's athletic training programs? **Methods:** This qualitative study involved graduates from 9 different professional master's athletic training programs. The participants included 7 males and 7 females (age=25.6±3.7 years). At the time of the interview,

participants were 10-12 months into their first employment position. Work settings included high school, clinic outreach, collegiate, professional sports and performing arts. A semi-structured interview was completed by phone, data was transcribed following saturation. Data analysis followed a general inductive approach. Trustworthiness was established through multiple analyst triangulation and peer review. **Results:** Graduates of professional master's programs in athletic training do not plan to remain with their initial employer beyond 2 years, but do plan to stay in the athletic training profession. 11 of 14 (79%) participants indicated viewing their first job as transitional. These perceptions did not change throughout the first year of employment; participants knew upon taking their first position that it would be used as a springboard or bridge to future positions. Though they viewed their first job as temporary, 11 of 14 (79%) participants identified a desire to continue to engage in clinical practice. **Conclusions:** Though graduates of professional master's programs regard their first years of employment as transitional, the majority do not wish to leave clinical practice. Participants discussed intentions to gain experience in their first years of employment and then move on to experience different work settings or take on higher-level positions with greater responsibilities. Understanding the impact of the first year of employment on future career aspirations for newly credentialed athletic trainers can provide athletic training programs and employers important insight to assist in retention and persistence.

Comparison of New Clinically Trained Faculty Socialization Experiences With New Non-Clinically Trained Faculty in Higher Education

Plant JL, King K, Mazerolle SM: University of Central Florida, Orlando, FL; University of Connecticut, Storrs, CT

Context: Much of the literature regarding professional and organizational socialization experiences of new faculty focuses solely on either clinically trained or non-clinically trained faculty, with minimal research comparing the professional and organizational socialization experiences of amongst the two. The purpose of this study was to gain a retrospective understanding of role inductance among clinically and non-clinically trained faculty members in higher education, to better understand the professional and organizational socialization processes they experience as they enter their faculty position, and to learn their needs as they gain role induction. **Methods:** This is a qualitative, phenomenological research study with a multiple case study approach. Participants were identified through purposive sampling from a large, public, research-based university who met the inclusion criteria: full-time faculty with tenure or renewable contract; one to ten years in their faculty role; earned a terminal degree; and faculty in an education, athletic training, physical therapy, or exercise science program. Data recruitment occurred until saturation was reached. Survey and interview protocols were created based on socialization literature. A link to participate was sent via email with a demographic and educational background survey. Eight participants met the inclusionary criteria for a structured phone interview that was audio recorded and sent to a professional transcriber. The transcriptions were reviewed verbatim, pseudonyms were used, and key statements were identified by both the primary researcher and an additional qualitative researcher. Inter-rater reliability for the coding process was nearly 100 percent. **Results:** Ten clinically

trained and non-clinically trained faculty themes emerged and represented professional and organizational socialization experiences of at least 50% of all participants. Athletic training participants described their experience to be accepted as an academic and connect with students, colleagues, and administrators, and struggled to integrate their identities as clinicians with their faculty identity. Orientation and mentoring were both facilitating and hindering factors for all new faculty. Additionally, each participant realized their graduate education and role modeling did not prepare them for all of the facets that a full-time faculty position entailed. Regardless of discipline, most reported a general lack of practical faculty role preparation. **Conclusions:** Additional research is needed to identify whether the results of this study are representative of other new, full-time faculty within the field of athletic training. It is important to recognize that clinical experience may facilitate the work-role transition; however, it does not provide all of the support and experience needed for the development of skills as faculty members. This study supports previous research findings regarding socialization struggles of new athletic training faculty and the need for improved professional and organizational socialization methods.

Grit: The Perseverance of Recently Credentialed Athletic Trainers During Their Transition to Practice

Rompola RR, Neil ER, Walker SE, Thrasher AB, Eberman LE: Neuromechanics, Interventions, and Continuing Education Research (NICER) Laboratory, Indiana State University, Terre Haute, IN; Ball State University, Muncie, IN; Western Carolina University, Cullowhee, NC

Context: Athletic trainers (ATs) leave the profession for various reasons resulting in a decreasing workforce within the first decade of employment. Work-life conflict has been proposed as a rationale for the declining workforce, but grit is a possible combatant to this phenomenon. Grit is defined as the ability to persevere despite obstacles, discouragement, or distraction to attain a long-term goal or complete a task. The purpose of this investigation was to evaluate grit in newly credentialed ATs.

Methods: A cross-sectional, web-based survey (Qualtrics®, Provo, UT) was sent via e-mail to all 889 ATs who graduated from a graduate-level professional athletic training program and were credentialed between January 2015 and October 2018. 154 participants responded (access rate=17.3%), 147 participants were eligible (response rate=16.5%), and 139 participants completed the tool (completion rate=90.3%). Participants (age=26±3y; female=109/139, 78.4%, male=38/139, 27.3%) predominantly graduated in 2018 (n=91/139, 65.5%) and worked in college/university (n=53/139, 38.1%) and secondary school settings (n=43/139, 30.9%). We used the validated 12-item short Grit scale with two subscales (consistency of interest [CI] and perseverance of effort [PE]). Data were analyzed with descriptive statistics, non-parametric Kruskal-Wallis and Mann-Whitney U tests to compare gender (male, female), type of job (full-time, part-time, graduate assistantship, internship), job setting (clinic, hospital, college/university, secondary school, professional, education/teaching, or combination clinic/secondary school),

and number of fellow healthcare employees (sole provider, 1-2 other healthcare providers, more than 3 healthcare providers) on composite grit, CE, and PE subscales (1=not at all gritty and 5=extremely gritty) using SPSS®. Significance was set at $P<0.05$ a-priori. **Results:** Participants demonstrated a high composite grit score (3.9 ± 0.4), CI score (3.5 ± 0.6), and PE score (4.1 ± 0.5). We did not identify any significant differences between genders ($P>0.05$), type of job ($P>0.05$), and number of fellow healthcare employees ($P>0.05$). We did identify significant differences between job settings on composite grit score ($\chi^2=15.126$, $df=6$, $P=0.019$), whereas participants working in the clinic setting (4.1 ± 0.3 , Mann-Whitney $U=26.500$, $\eta_1=7$, $\eta_2=17$, $P=0.034$), college/university setting (3.9 ± 0.4 , Mann-Whitney $U=290.500$, $\eta_1=53$, $\eta_2=17$, $P=0.027$), and in the professional setting (4.1 ± 0.9 , Mann-Whitney $U=17.500$, $\eta_1=5$, $\eta_2=17$, $P=0.048$) all demonstrated higher grit when compared to those than those working in the combination clinic/secondary school setting (3.7 ± 0.4). Additionally, participants in the college/university setting (3.9 ± 0.4) demonstrated higher grit than those in secondary school setting (3.7 ± 0.5) (Mann-Whitney $U=815.500$, $\eta_1=53$, $\eta_2=43$, $P=0.016$). **Conclusions:** Recently credentialed ATs have high levels of passion for the profession that demonstrate perseverance and a consistency of interest in the job regardless of the potential work-life conflict common in athletic training. The ATs in the combination clinic/secondary school setting reported to be less gritty, which may due to high patient load and length of workday. Although ATs in various settings demonstrated significant differences in grit, the clinical meaningfulness of these differences are menial.

Developing a Comprehensive Theory of Professional Readiness in Athletic Training

Szlosek PAS, Guyer MS, Barnum MG, Mullin EM: Bridgewater State University, Bridgewater, MA; Springfield College, Springfield, MA

Context: Readiness for professional practice is crucial for healthcare professionals, as providers are expected to practice autonomously upon graduation. Although certified athletic trainers have been deemed ready for autonomous practice, new professionals have clinical areas of strength and weakness. To assess professional readiness, a comprehensive theory of professional readiness must be developed. Identifying the crucial factors for success in the field of athletic training could enhance athletic training education, and therefore produce more prepared healthcare professionals. The objective of the study was to develop a comprehensive theory of professional readiness in athletic training. **Methods:** We utilized a qualitative method design based in grounded theory. Participants included newly certified athletic trainers (6-23 months experience) and athletic training supervisors from three work settings: collegiate, secondary school, and

emerging. Participants took demographic questionnaires electronically using Qualtrics Survey Software. One-on-one interviews took place electronically using GoToMeeting audiovisual web conferencing software until data saturation was reached. IBM Statistical Package for the Social Sciences (SPSS, v. 21.0) was used to calculate descriptive statistics for the demographic questionnaires. The researcher transcribed all interviews verbatim and used open and axial coding during data analysis. Trustworthiness was established through reflexivity, triangulation, member checks, and peer reviews. **Results:** We interviewed fourteen newly certified athletic trainers and nine athletic training supervisors. Analysis revealed four overarching themes including organization and administration, interpersonal relations, athletic training attributes, and confidence (Figure 1). Subcategories within organization and administration included administration skills, adaptability, and organization and time management. Within interpersonal relations, subcategories included personality characteristics, communication, and professionalism. Athletic training attributes included two subsections including clinical skills and professional practice. Professional practice included four subsections including critical thinking, professional development, understanding roles, continuing education, and collaborative practice.

development, understanding roles, continuing education, and collaborative practice. Confidence did not contain a subcategory. Within each category of professional readiness, participants discussed varying degrees of readiness among newly certified athletic trainers. Newly certified athletic trainers were more prepared for general day-to-day responsibilities, basic clinical skills such as taping, first-aid, and evaluations, and patient communication. New athletic trainers were less prepared for aspects of organization and administration, communication with parents and coaches, advanced clinical decision-making, work in nontraditional settings, and were not initially confident in the role. **Conclusions:** Readiness for practice is multifaceted. To practice autonomously, athletic trainers must possess organizational and administrative skills, interpersonal skills, clinical skills, attributes of professional practice, and confidence. New athletic trainers were shown to be ready for certain aspects of the profession, but unprepared for others. Future research should focus on methods of improving athletic training education in all areas of professional readiness. Researchers should attempt to identify the reasons why the readiness of new athletic trainers varies in certain areas to make the necessary adjustments in

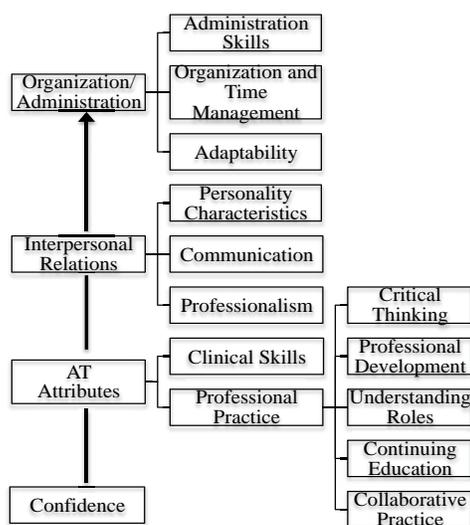


Figure 1. Diagram of the aspects of professional readiness in athletic training.

Newly Credentialed Athletic Trainers' Onboarding Needs During the Transition to Practice
Thrasher AB, Walker SE: Western Carolina University, Cullowhee, NC; Ball State University, Muncie, IN

Context: As new athletic trainers (ATs) transition into their roles, some employers provide extensive orientation and onboarding to assist with the transition to practice and help new ATs understand their role; however, that is not the case with all employers. There is a lack of research outlining the needs of new ATs as they transition to practice, therefore the purpose of this study is to examine onboarding needs during the transition to practice. **Methods:** In this phenomenological qualitative study, seventeen newly credentialed ATs who graduated from professional masters' programs and were in their first three months of employment participated (11 female, 6 male; 25.6 ± 2.2 years; work settings included college, secondary school, and clinic). Data saturation guided the number of participants. Participants were recruited via purposive sampling. Participants were interviewed via phone using a semi-structured interview guide. All interviews were recorded and transcribed verbatim. Data were analyzed through phenomenological reduction, with data coded for common themes and subthemes. Trustworthiness was established via peer review and member checks. **Results:** Three themes emerged: initial orientation, needed resources, and continued onboarding. For initial orientation, participants desired a formal orientation to review organizational values and policies and practice hands-on skills, such as review and initiation of the emergency action plan. Reviewing expectations regarding their role as an AT, especially in the secondary school setting, is desired and should include introductions to coaches, review of protocols, and setting-specific information about operating the Athletic Training Facility at their institution. Participants also felt a gradual immersion into their role

through shadowing another AT for a few days and then being observed with feedback would enhance their transition. Participants felt many resources were needed such as policies and procedures manuals, detailed protocols (e.g., concussion, return to play), information specific to role (e.g., contact information for coaches and physicians), and an assigned mentor. Participants desired a mentor who was not their supervisor so they could seek advice and ask questions in a low-pressure environment. For continued onboarding, participants wanted ongoing meetings with supervisors to discuss issues and ask questions, meetings with other ATs to discuss cases or get advice, feedback from supervisors and coaches, and supervisor site visits so they can observe the new AT and provide feedback for improvement. Additionally, periodic skills review with feedback would also help new ATs. **Conclusions:** New ATs desire a formal review of policies and procedures and expectations specific to their setting, but also desire ongoing meetings and discussions related to their job duties. Gradual immersion, practicing skills, and reviewing competencies, especially related to emergency care, would enhance orientation and onboarding. Supervisors should meet with new ATs regularly and perform site visits to provide feedback and ensure new ATs are adapting to their role.

Onboarding Provided for Newly Credentialed Athletic Trainers' During the Transition to Practice
Walker SE, Thrasher AB: Ball State University, Muncie, IN; Western Carolina University, Cullowhee, NC

Context: During transition to practice, newly credentialed athletic trainers (ATs) often face nervousness, stress, role ambiguity, and fear of failing. Onboarding, a formal process to provide support and integrate new employees into an organization and help them understand roles, positively impacts transition to practice. There is limited research examining onboarding for new ATs. The purpose of this study was to examine the onboarding provided to newly credentialed ATs during the transition to practice. **Methods:** In this phenomenological qualitative study, seventeen newly credentialed ATs who graduated from professional masters' programs and were in their first three months of employment participated (11 female, 6 male; 25.6 ± 2.2 years; work settings included college, secondary school, and clinic). Data saturation guided the number of participants. Participants were recruited via purposive sampling and were interviewed via phone using a semi-structured interview guide. All interviews were recorded and transcribed verbatim. Data were analyzed through phenomenological reduction, with data coded for common themes and subthemes. Trustworthiness was established via peer review and member checks. **Results:** Three themes emerged: initial orientation, continued development, and understanding role. Initial orientation included meetings with supervisors to formally review policies, procedures, and expectations, facilities tours, and meetings with coaches and physicians. Orientation initially for some participants included hands-on learning such as simulating protocols and actively reviewing the medical documentation system, all of which facilitated the transition. Continued development consisted of meetings with supervisors to discuss

procedures or answer questions, site visits where supervisors could provide advice (e.g., how to organize their athletic training facility) and feedback on skills, mentoring with supervisors or local ATs, and meetings with other ATs discuss challenges and receive advice. A supportive supervisor and network of ATs to provide help, advice, and discuss complex patient cases facilitated the transition by increasing confidence, providing validation, and helping them adapt to their role. Participants felt they understood their role as an AT, but their role in procedural tasks, such as physician referrals or specific communication procedures, were not clear. Over time and with support from supervisors and peers, new ATs better understood their role and developed as members within their organization. Resources, such as policy and procedures manual and clear expectations, provided a better understanding of their role and aided in their transition. **Conclusions:** Onboarding is a vital aspect in the transition to practice for new ATs, as it develops them as professionals by providing support and facilitating role understanding. Onboarding should go beyond initial orientation and include regular meetings with supervisors, meetings with other ATs, and site visits to provide feedback and ensure new ATs are adapting to their role. New ATs should seek support from supervisors and local ATs to continue their development and help better understand their role.

Professional Program Preparation, Orientation, and Mentoring Tactics Used in Developing Professional Responsibility in Early-Career Athletic Trainers

Szabo AL, Neil ER, Walker SE, Thrasher AB, Eberman LE: Indiana State University, Terre Haute IN; Ball State University, Muncie, IN; Western Carolina University, Cullowhee, NC

Context: Transition to practice is a pivotal period in an athletic trainer's (AT) career that includes higher than average job related stress due to the multitude of changes. Challenges faced during the transition include making decisions, developing confidence, understanding the role, and communicating with stakeholders. The purpose of this study was to assess professional master's athletic training program (PMATP) preparation (formal coursework and clinical experiences), orientation, and mentorship and explore how these tactics influenced the development of professional responsibility in the transition to practice in early career ATs. **Methods:** A cross-sectional design was used. Participants who graduated from a PMATP and board certified from 2015 to 2018 were recruited via email. This 58-item web-based survey was developed through previous literature and an expert panel. Content validity was established through expert review. The survey asked respondents to select which transition to practice tactics were used (formal coursework, clinical experiences, orientation, mentorship), if they were helpful, and how they were helpful. Data were analyzed using frequencies and modes. **Results:** Emails were sent to 889 potential participants; 154 participants responded (access rate=17.3%) with 126 participants completing the tool (completion rate=85.7%). The majority of participants were female (n=109/147, 74.1%), graduated in 2018 (n=88/147, 59.9%), worked in the college/university setting (n=54, 36.7%), and most often worked with three or more healthcare providers (n = 63/147, 42.9%).

Overall, 79.1% (n = 110/139) of participants perceived their PMATP prepared them to transition to practice. Regarding formal coursework, the majority of participants indicated they discussed professional behaviors (n = 107/147, 72.7%), which they found to be very helpful (n = 45/107, 42.1%) in developing professional communication in practice (n = 89/107, 83.2%). The most frequent tactics used in clinical experiences during professional preparation included being encouraged to make patient care decisions (n = 107/147, 72.7%; extremely helpful = 79/107, 73.8%) and being provided feedback about performance (n = 107/147, 72.7%; extremely helpful = 68/107, 63.6%), which were both were helpful in developing confidence (n = 97/107, 90.7%; n = 95/107, 88.8%, respectively). Only about a quarter of participants (n = 37/147, 25.1%) indicated they were exposed to formal orientation through human resources that accounted for both organizational policies and workplace benefits. Almost half reported having information orientation to their position by learning on the job (n = 63/147, 42.9%). Few participants were assigned a mentor (n = 33/147, 22.4%); however, those who were indicated the mentor was very helpful (n = 12/33, 36.4%) at understanding the workplace role. More often, respondents indicated they had an external mentorship relationship (n = 63/147, 42.9%) that was extremely helpful (n = 40/63, 63.5%) at developing confidence (n = 51/63, 81.0%). **Conclusions:** Early-career athletic trainers perceived their PMATP informal orientation, and unassigned mentors were helpful in developing professional responsibility. Often these tactics were effective at developing confidence, but other tactics may be necessary to assist with understanding role, managing patient load and administrative duties, and resolving conflicts.

Free Communications, Rapid Fire Oral Presentations: Gait Neuromechanics in Those With Chronic Ankle Instability

Thursday, June 27, 2019, 10:45AM-11:45AM, Mandalay Bay D; Moderator: Luke Donovan, PhD, ATC

The Foot and Ankle Ability Measure-Sport is Related to Spatiotemporal Gait Measures in Individuals With Chronic Ankle Instability

Allison RL, Kosik KB, Hartzel JD, Gribble PA, Hoch MC, Hoch J: University of Kentucky, Lexington, KY

Context: Individuals with chronic ankle instability (CAI) have demonstrated deficits in self-reported function and alterations in gait. While diminished self-reported function is related to a number of the common impairments associated with CAI, this relationship has not been examined with gait. Understanding the relationship between self-reported function and gait is important because walking is a critical activity for participation in many activities of daily living, recreation, and sport. Therefore, the purpose of this study was to determine the relationship between the FAAM-Sport and spatiotemporal measures of walking gait in individuals with CAI. It was hypothesized that CAI patients who reported lower FAAM-Sport scores would exhibit greater deviations in walking gait. **Methods:** Fifteen participants with CAI (3 males, 12 females, age: 23.00 ± 3.72 years, height: 168.51 ± 10.65 cm, mass: 71.51 ± 13.73 kg, BMI: 25.22 ± 4.51) participated in this case-control study. Participants reported ≥ 1 previous ankle sprain, ≥ 2 episodes of “giving way” in the previous 3 months and scored ≥ 5 on Ankle Instability Instrument and ≥ 11 on Identification of Functional Ankle Instability. Participants reported to the laboratory for a single data collection session and completed the FAAM-Sport and a series of walking trials on an instrumented walkway embedded with sensors. The FAAM-Sport is a validated 8-item patient-reported outcome instrument that captures self-perceived difficulty during sport-related tasks. Lower scores (%)

indicated lower self-perceived function. Participants performed 5 gait trials at a comfortable self-selected walking speed. During each trial, the participant was asked to take at least two steps before and after walking on the walkway and remain within a 5 cm/s velocity across 5 trials. The dependent variables provided by the instrumented walkway included velocity (cm/s), cadence (steps/min), stride length (cm), step length (cm), single limb support time (sec), double limb support time (sec), stance time (sec), swing time (sec), and step time (sec). Pearson correlations examined the relationship between each gait variable and the FAAM-Sport. Significance was set at $p \leq 0.05$. **Results:** The FAAM-Sport ($71.0 \pm 14.7\%$) was significantly related to cadence (113.38 ± 6.28 steps/min; $r = -0.78$, $p = 0.001$), step time (0.53 ± 0.03 sec; $r = 0.80$, $p = 0.000$), single leg support time (0.40 ± 0.03 sec; $r = 0.72$, $p = 0.003$), swing time (0.40 ± 0.03 sec; $r = 0.69$, $p = 0.005$), and stance time (0.66 ± 0.05 sec; $r = 0.55$, $p = 0.033$). No other gait measurements were significantly correlated to FAAM-Sport scores ($p \geq 0.05$). **Conclusions:** Individuals with CAI who expressed lower scores on the FAAM-Sport demonstrated increased cadence and less stance time, swing time, and single-limb support time during gait. These findings indicate lower self-reported function is associated with a shortened gait cycle which requires an increased step rate. These alterations in gait may be related to local impairments in ankle function or may represent a protective strategy to prevent future ankle sprains. Continued research should explore the long-term consequences of these gait alterations in individuals with CAI.

Sagittal Plane Ankle Kinematics and Variability During Walking and Running in Individuals With and Without Chronic Ankle Instability

Sugimoto YA, Rhea CK, Ross SE: The University of North Carolina Greensboro, Greensboro, NC

Context: Chronic ankle instability (CAI) individuals can have sensorimotor deficits that lead to altered joint mechanics. Research indicates that CAI individuals have less variability in dorsiflexion at initial contact during drop-jump landings and have less dorsiflexion in the initial phase of running. These altered mechanics may increase the risk of recurrent sprains. Thus, our objectives were to identify sagittal plane ankle motion differences between individuals with and without CAI during the entire gait cycle for walking and running on a treadmill. We hypothesized that CAI individuals would have less dorsiflexion and variation of motion in sagittal plane motion than healthy controls. **Methods:** Twenty-six physically active individuals with (21.77 ± 2.31 yr, 168.05 ± 8.65 cm, 72.45 ± 11.73 kg; 10 females, 3 males; $N = 13$) and without (22.23 ± 3.79 yr, 166.54 ± 6.09 cm, 68.48 ± 9.96 kg; 12 females, 1 male; $N = 13$) CAI were recruited to participate in this case-control study by attending a single session in a research laboratory. Participants were assigned an affected limb (AL) and unaffected limb (UL). The AL for CAI was identified as the limb with a history of ankle sprains, and the healthy participants were assigned an AL that was matched by dominance to the AL of the CAI participants. The unaffected limb (UL) was contralateral limb. Participants completed 12-minute walking and 6-minute running protocols at self-selected speeds on a treadmill. Kinematic data were recorded at 240 Hz utilizing a 3D motion capture system. Sagittal plane ankle motion (dorsiflexion, plantar flexion) in degrees was calculated between the markers representing

the lateral femoral condyle, lateral malleolus, and base of 5th metatarsal using Qualysis software. Plantar flexion was defined as values approaching 140 degrees and dorsiflexion was defined as values approaching 90 degrees. Trials with less than 4% missing values were processed to eliminate zero points in the data. The average sagittal plane motion and variability of motion (coefficient of variation=CV) were computed for data analysis. Two-tailed independent t-tests ($\alpha=0.05$) compared differences between ankle groups. **Results:** The CAI group had a significant decrease in average sagittal plane motion during walking (AL: CAI = $108.16^\circ \pm 2.70^\circ$, Heathy = $116.89^\circ \pm 5.72^\circ$, $p < .001$; UL: CAI = $110.57^\circ \pm 6.81^\circ$, Healthy = $115.59^\circ \pm 4.15^\circ$, $p = .032$) and running (AL: CAI = $110.45^\circ \pm 3.22^\circ$, Heathy = $120.04^\circ \pm 6.22^\circ$, $p < .001$; UL: CAI = $109.45^\circ \pm 5.70^\circ$; Healthy = $119.42^\circ \pm 4.91^\circ$, $p < .001$). Also, the CAI group had a significantly greater CV during walking only in the AL (AL: CAI = $8.84\% \pm 0.92\%$, Healthy = $7.20\% \pm 1.17\%$, $p = .001$; UL: CAI = $8.25\% \pm 1.50\%$, Healthy = $7.35\% \pm 1.11\%$, $p = .097$) and during running in both limbs (AL: CAI = $13.23\% \pm 1.44\%$, Healthy = $10.63\% \pm 1.47\%$, $p < .001$; UL: CAI = $12.95\% \pm 1.53\%$, Healthy = $11.36\% \pm 1.32\%$, $p = .009$). **Conclusions:** CAI individuals demonstrated increased dorsiflexion and had greater variability in motion throughout the gait cycles compared to healthy participants. Increased dorsiflexion in CAI may allow a closed-packed position to stabilize the ankle joint during gait. Moreover, increased variability indicates that random fluctuations of motion occurs throughout the gait cycles. Clinically, susceptibility to ankle sprains may increase if individuals with CAI fluctuate excessively out of stable positions.

Chronic Ankle Instability Effects Sural Nerve Reflexes in the Gastrocnemius During the Early Stance Phase of the Gait Cycle

Madsen LP, Katano K, Koceja DM, Zehr EP, Docherty CL: Indiana University, Bloomington, IN; University of Victoria, Victoria, BC, Canada

Context: In neurologically intact adults, non-noxious electrical stimulation of the sural nerve during walking produces reflexes that are phase dependent. The purpose of this study was to determine if subjects with chronic ankle instability (CAI) exhibit altered reflex modulation patterns throughout the gait cycle. **Methods:** This was a descriptive laboratory study and all data was collected in a controlled laboratory environment. Eleven uninjured, neurologically intact adults (4 male, 7 female, 21.2 ± 1.5 years, 167.7 ± 9.7 cm, 67.1 ± 12.2 kg) and 11 adults with unilateral CAI (4 male, 7 female, 21.0 ± 3.6 years, 168.9 ± 9.8 cm, 67.4 ± 15.7 kg) volunteered. Subjects walked on a treadmill at 4 km/h. Electromyographic (EMG) data were collected on the test limb

for the tibialis anterior (TA), peroneus longus (PL), medial gastrocnemius (MG), and lateral gastrocnemius (LG). The test limb for CAI subjects was the involved limb. The test limb for control subjects was matched so that the same number of dominant (N=7) and non-dominant (N=4) limbs were measured in each group. A DS7A constant current stimulator presented random trains of non-noxious electrical stimulation (5 pulses at 200 Hz, pulse width of 1.0 ms) to the ipsilateral sural nerve until 10 stimulations were elicited at eight different phases of the gait cycle. EMG data were used to calculate the magnitude of the middle latency reflex (80-120 ms post stimulation) for each muscle at each phase. The mean EMG activity of the unstimulated gait cycles was subtracted from the corresponding values obtained from the eight phases of the stimulated step cycles, with a negative number indicating muscle inhibition and a positive number indicating facilitation. Net EMG responses for each phase were analyzed for both groups using one-sample t-tests. Any values statistically different from zero represented a significant net reflex

effect. **Results:** Figure 1 shows group reflex amplitudes for each muscle throughout the gait cycle. Significant net reflex effects were similar between groups from the late stance phase to the late swing phase for all four muscles. In the early stance phase, control subjects showed significant reflex inhibition in the MG and LG muscles during phases 2 through 4 ($p < .05$). However, CAI subjects only showed significant inhibition in both the LG ($t(10) = -4.193$, $p = .002$) and MG ($t(10) = -3.088$, $p = .011$) at phase 4. The largest discrepancy in reflex responses occurred at phase 3 where the CAI and control groups had an average LG suppression of $-3.6 \pm 16.84\%$ and $-18.6 \pm 11.49\%$, respectively. **Conclusions:** CAI subjects' delayed protective unloading response in the triceps surae following non-noxious sural nerve stimulation during the early stance phase of walking may be linked to instability symptoms and recurrent ankle sprains. Evaluating cutaneous reflex modulations may help to identify neural alterations in the reflex pathways that contribute to functional deficits in those with CAI.

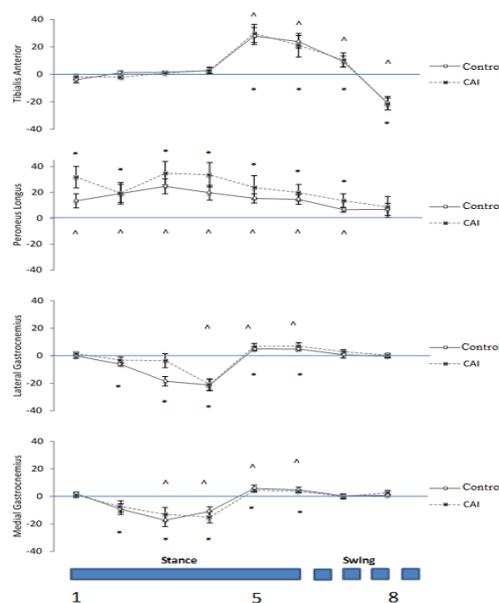


Figure 1: Modulation of net cutaneous reflex responses between 80 and 120 ms post stimulation for both groups. Error bars represent standard error of the mean. Significant reflex responses from zero at $P < 0.05$ are labeled with * for control subjects and ^ for CAI subjects.

Sudden Ankle Inversion Perturbation During Walking Alters Gait Kinematics in Chronic Ankle Instability Patients

Han S, Son SJ, Kim H, Lee H, Jeong H, Bruening DA, Seeley MK, Hopkins JT: Brigham Young University, Provo, UT; CHA University, Seongnam, South Korea; West Chester University, West Chester, PA

Context: Alterations in gait kinematics and kinetics after injury may contribute to recurrent ankle injury. Individuals with chronic ankle instability (CAI) have demonstrated altered joint kinematics in the ankle, knee, and hip during walking. However, little is known about the effect of sudden ankle inversion perturbation during walking on lower extremity gait kinematics in subjects with CAI. The purpose of this study was to examine feedback control of gait kinematics following repeated sudden ankle inversion perturbation during walking in CAI patients relative to matched controls. **Methods:** This study design was a single cohort and controlled laboratory trial.

Twenty-one CAI patients (M = 9, F = 12; 22±2 yrs, 175±10 cm, 81±20 kg, 83±7% FAAM ADL, 62±13% FAAM Sports, 3.7±0.9 MAII, 7±4.3 sprains), 21 matched controls (M = 10, F = 11; 22±2 yrs, 175±10 cm, 73±19 kg, 100% FAAM ADL, 100% FAAM Sports, 0 MAII, 0 sprains) participated. Subjects performed 5 walking trials at a preferred speed both before and after 10 sudden ankle inversion perturbations during walking while 3D joint kinematic data were collected using high-speed video (250Hz) and inground force plate (1000Hz). Main outcome measures were ankle angles (sagittal and frontal planes), knee angle (sagittal plane), and hip angles (sagittal and frontal planes), which were measured from heel-strike (1%) to toe-off (100%). Spatial trajectories of 44 markers were smoothed using a digital filter (10Hz). Functional analysis ($\alpha = 0.05$) were used to detect mean differences. If 95% confidence intervals did not overlap zero, significant differences existed. **Results:** Figure 1 shows that the CAI group demonstrated up to (i) 4.8 deg less ankle dorsiflexion during 38-90% of stance, (ii) 2.1 deg more ankle eversion during 31-90% of stance, (iii) 3.8

deg less knee flexion during 19-93% of stance, (iv) 2.7 deg less hip flexion during 19-66% of stance, and (v) 2.8 deg more adduction during 0-69% of stance, compared to the control group. The 10 sudden ankle inversion perturbations resulted in up to 1.6 deg more ankle dorsiflexion during 51-89% of stance only in the CAI group. However, both the CAI and control groups demonstrated no differences in frontal ankle, sagittal knee and sagittal and frontal hip kinematics between pre- and post-intervention measurements. **Conclusions:** Present data suggest that sudden ankle inversion perturbations did not affect gait kinematics in both CAI and control groups except sagittal ankle kinematics in the CAI group. However, CAI patients displayed altered gait kinematics at the ankle, knee, and hip relative to the control group. Moreover, increased ankle dorsiflexion after inversion perturbation in the CAI group may be the result of a change in motor control to avoid self-perceived vulnerable positions of the foot during walking.

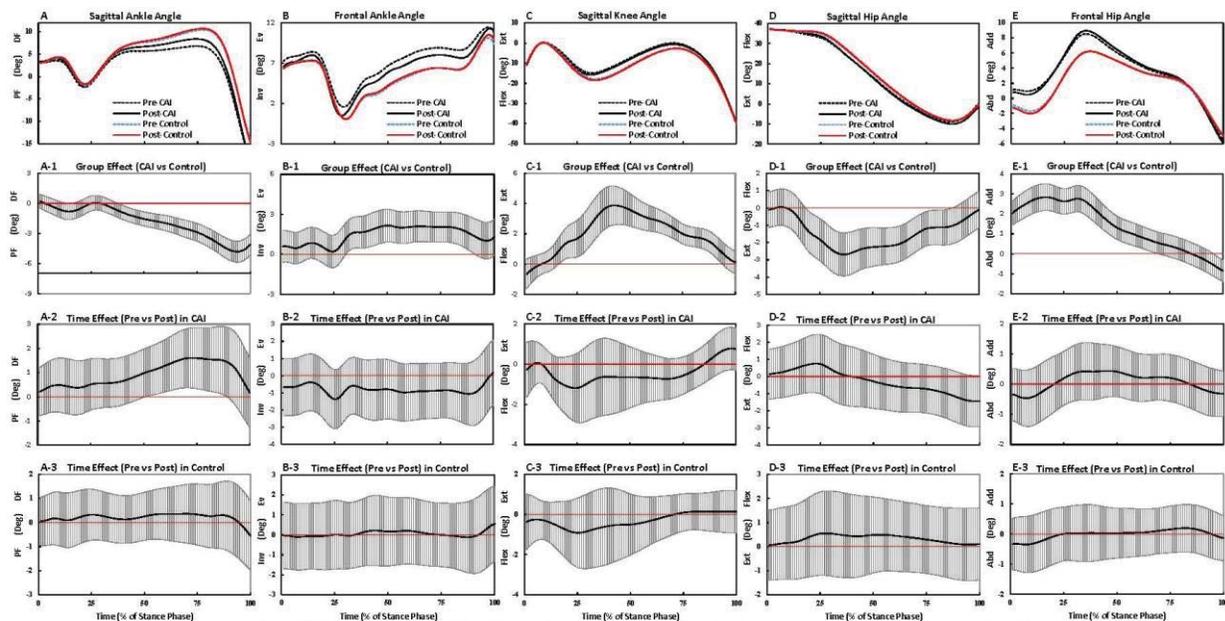


Figure 1. Lower-extremity kinematic angles of Sagittal Ankle (A), Frontal Ankle (B), Sagittal Knee (C), Sagittal Hip (D), and Frontal Hip (E) in each group's pre- and post-interventions during walking. A-1, B-1, C-1, D-1, and E-1 represent between-subjects (group) main effect in each angle. A-2, B-2, C-2, D-2, and E-2 represent time effects within a CAI group. A-3, B-3, C-3, D-3, and E-3 represent time effects within a control group. Mean differences (bold-black solid curve) and corresponding 95% CI (shaded area) are plotted as a function of time. When the shaded area does not overlap with the zero line (red horizontal line), a significant difference ($p < 0.05$) is indicated between groups or times.

How Patients With Chronic Ankle Instability React After Ankle Inversion Perturbation During Walking

Jeong H, Son SJ, Kim H, Lee H, Han S, Bruening DA, Seeley MK, Hopkins JT: Brigham Young University, Provo, UT; CHA University, Seongnam, South Korea; West Chester University, West Chester, PA

Context: Patients with chronic ankle instability (CAI) demonstrate high recurrence of ankle sprain. Many previous studies have shown altered lower extremity gait mechanics in CAI patients. However, little is known about the immediate effects of an ankle sprain on gait mechanics. The purpose of this study was to investigate changes in gait kinetics in both healthy controls and CAI patients following an ankle inversion intervention. We hypothesized that CAI patients would react differently to the simulated ankle sprain, employing altered gait kinetic strategies to maintain balance. This investigation may help better understand the mechanism of recurrent ankle injuries in CAI

patients. **Methods:** This study was designed as a single cohort and controlled laboratory trial. 21 CAI patients (M = 9, F = 12; 22 ± 2 yrs, 175 ± 10 cm, 81 ± 20 kg, $83 \pm 7\%$ FAAM ADL, $62 \pm 13\%$ FAAM Sports, 3.7 ± 0.9 MAII, 7 ± 4.3 sprains) and 21 matched controls (M = 10, F = 11; 22 ± 2 yrs, 175 ± 10 cm, 73 ± 19 kg, 100% FAAM ADL, 100% FAAM Sports, 0MAII, 0sprains) participated. Ankle joint kinetic data were collected while subjects performed 5 walking trials at preferred speeds both before and after a perturbation intervention. Motion data was recorded from a 12-camera motion capture system (250Hz) while force data were recorded using two in-ground force plates (1000Hz). The intervention involved walking ten times across an 8.5 m long custom-built walkway containing multiple trapdoors. The trapdoors were opened unpredictably, causing 30° of ankle inversion. Visual 3D was used to calculate sagittal plane ankle, knee, and hip moments. Functional data analyses ($\alpha = 0.05$) were used to detect mean group differences across stance phase. **Results:** The CAI patients had different moments from the control group. In sagittal ankle plane, the CAI patients

indicated decreased dorsi flexion (A-3) at mid-stance and decreased plantar flexion (A-3) at toe-off. In the frontal ankle plane, the CAI patients indicated increased inversion (B-3) from mid-stance to toe-off. In the sagittal knee plane, the CAI patients indicated increased knee flexion (C-3) from initial-contact to mid-stance and decreased knee extension (C-3) at toe-off. In the sagittal hip plane, the CAI patients indicated increased hip extension (D-3) at initial-contact and toe-off and increased hip flexion (D-3) at mid-stance and at terminal-stance. However, there were no different moments in pre-post intervention comparison in either the CAI or control groups (A up to D-2) (Refer to Figure 1). **Conclusions:** The CAI patients demonstrated altered gait kinetic patterns at the ankle, knee, and hip joints respectively as compared to the control group. However, these alterations were not affected by the ankle inversion perturbation. This suggests that the altered gait kinetic patterns of the low extremity in the CAI patients might be the results of compensation mechanisms for altered proprioceptive sensitivity, with the goal of maintaining postural stability.

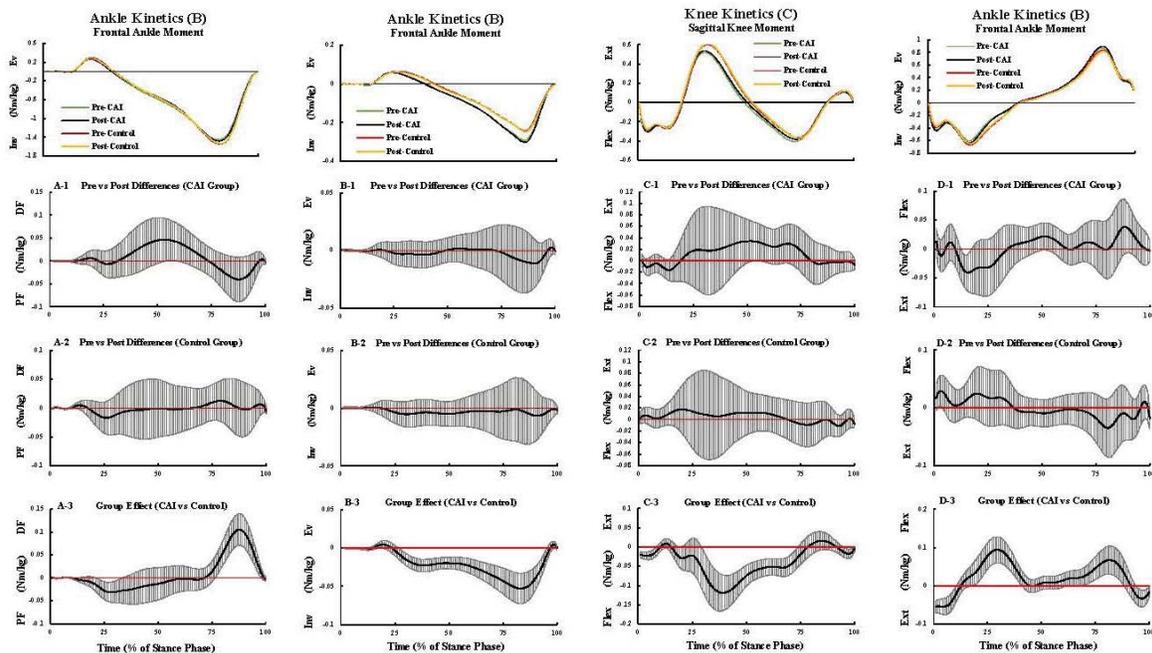


Figure 1. Lower extremity gait kinetics of Sagittal ankle (A), Frontal ankle (B), Sagittal knee (C), and Sagittal Hip (D) in each group's pre-post interventions. A-1, B-1, C-1, and D-1 represent pre-post main influence of the CAI group in each joint. A-2, B-2, C-2, and D-2 represent pre-post main influence of the control group in each joint. A-3, B-3, C-3, and D-3 represent group difference between the CAI and control groups in each joint. Mean differences (bold black solid curve) and corresponding 95% CI (shaded area) are plotted as a function of time. When the shaded area does not overlap with the zero line (bold horizontal red dotted line), a significant difference ($p < 0.05$) is indicated between groups or times.

Altered Muscle Activation Patterns During Walking Following Sudden Inversion Perturbation in Patients With Chronic Ankle Instability

Kim H, Son SJ, Han S, Lee H, Jeong H, Bruening DA, Seeley MK, Hopkins JT: West Chester University; West Chester, PA; CHA University; Seongnam, South Korea; Brigham Young University; Provo, UT

Context: Sensorimotor deficits due to lateral ankle sprains have been reported in patients with chronic ankle instability (CAI), leading to alterations in motor control strategies. However, little is known about the effect of sudden inversion perturbation on feedback motor control during walking. The purpose of this study was to investigate the effect of sudden inversion stress on lower-extremity muscle activity during walking in patients with CAI. **Methods:** This study design was a single cohort and controlled laboratory trial. Twenty-one CAI patients (M = 9, F = 12; 22±2 yrs, 175±10 cm, 81±20 kg, 83±7% FAAM ADL, 62±13% FAAM Sports, 3.7±0.9 MAII, 7±4.3 sprains), 21 matched

controls (M = 10, F = 11; 22±2 yrs, 175±10 cm, 73±19 kg, 100% FAAM ADL, 100% FAAM Sports, 0 MAII, 0 sprains) participated. Subjects performed 5 walking trials at a preferred speed both before and after 10 random sudden ankle inversion perturbations during walking while EMG activation in five lower extremity muscles were collected using wireless surface electrodes (1000 Hz, Delsys, Boston, MA). A custom-built 8.5-m runway consisting of seven 1.22-m segments was used to induce sudden ankle inversion perturbation during walking. EMG data of peroneus longus (PL), tibialis anterior (TA), vastus lateralis (VL), gluteus medius (Gmed), and gluteus maximus (Gmax) were collected from heel-strike (1%) to toe-off (100%). EMG data were smoothed using a root mean square algorithm (125 ms window). The smoothed EMG data were normalized to the smoothed reference EMG data. Functional analyses of variance ($\alpha = 0.05$) and 95% confidence intervals were used to evaluate between-subjects (CAI vs control groups) and within-subjects (pre- vs post-interventions) effects. **Results:** Figure 1 shows that the main group effect significantly influenced to lower-extremity

EMG activation. Relative to the control group, the CAI group demonstrated less PL, TA, VL, Gmed, and Gmax EMG activation during 48-95%, 16-32%, 52-59%, 0-15% and 22-96%, and 25-31% of stance, respectively. The CAI group showed more VL EMG activation during 38-48% of stance. There were significant time main effects in PL and Gmed EMG activation. Compared to the pre-intervention, PL and Gmed EMG activation were decreased during 72-80% and 16-25% of stance after sudden inversion perturbation, respectively. Within the CAI group, PL EMG activation was decreased during 60-65% and 72-78%, and VL EMG was increased during 31-49%, and Gmed EMG was decreased during 17-20% of stance after sudden inversion perturbation. **Conclusions:** Following sudden inversion perturbation, CAI patients demonstrated decreased muscle activation of frontal plane muscles. Ankle inversion perturbation may prevent these important ankle and hip muscles from maintaining “safe” positions of the foot and center of mass during movement in CAI patients, potentially leading to an increased risk of recurrent lateral ankle sprains.

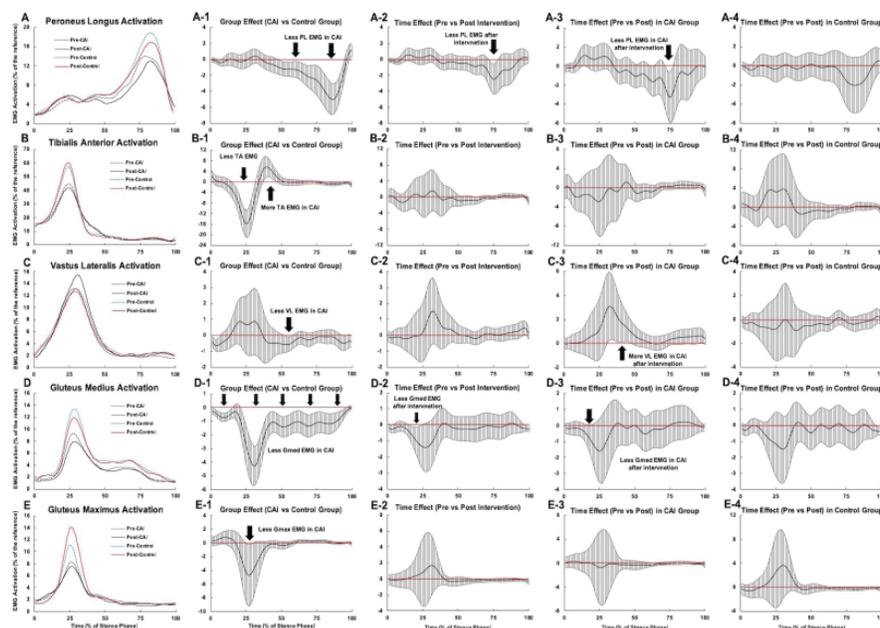


Figure 1. Lower-extremity EMG activation patterns of PL (A), TA (B), VL (C), Gmed (D), and Gmax (E) in each group's pre- and post-interventions during walking. A-1, B-1, C-1, D-1, and E-1 represent between-subjects (group) main effect in each muscle. A-2, B-2, C-2, D-2, and E-2 represent within-subjects (time) main effects in each muscle. A-3, B-3, C-3, D-3, and E-3 represent time effects within a CAI group. A-4, B-4, C-4, D-4, and E-4 represent time effects within a control group. Mean differences (bold black solid curve) and corresponding 95% CI (shaded area) are plotted as a function of time. When the shaded area does not overlap with the zero line (bold horizontal red dotted line), a significant difference ($p < 0.05$) is indicated between groups or times.

Differences in the Shank-Rearfoot Joint Coupling, Kinematics, and Kinetics Among Subject With Chronic Ankle Instability, Coper, and Controls During Jogging

Lee IJ, Lee SY: Yonsei University, Seoul, South Korea

Context: It is important to thoroughly investigate ankle and knee joint motion to determine the association among chronic ankle instability (CAI), coper, and normal population. However, there is no study comparing these variables among the three groups. Therefore this study aimed to examine differences in the shank-rearfoot joint coupling, kinematics, and kinetics of the ankle and knee joint among CAI, coper, and controls during jogging. **Methods:** Study design of this study is a case-control study. A total of 54 subjects were recruited. Demographic characteristics for three groups are as follows: CAI (n = 18, age = 24.61 ± 2.75 years, height = 172.98 ± 7.95 cm, mass = 67.82 ± 14.64 kg), coper (n = 18, age = 26.00 ± 4.56 years, height = 173.36 ± 7.45 cm, mass = 66.87 ± 10.34 kg), and controls (n = 18, age = 26.17 ± 2.33 years, height = 172.19 ± 8.22 cm, mass = 63.30 ± 11.15 kg). The modified Plug-in-gait model was used to collect spatial trajectory data at 200 Hz of the sampling rate. The force plate data was recorded at 1000 Hz. Subjects were instructed to jog at the speed of 2.68 m/s along the force plate embedded 8-m run-way in shod condition. Three valid trial data was collected. The continuous relative phase (CRP) angle for the shank-rearfoot joint coupling was computed using custom-written algorithms in MatLab (Mathworks Inc., Natick, MA). 3D joint angle for full gait cycle and joint moment for stance phase were calculated using Visual 3D (C-Motion Inc., Germantown, MD). Kinematic and kinetic data were low-pass filtered at 23 Hz using a 4th-order Butterworth filter. One-dimensional statistical parametric mapping was used to conduct curve analysis for time series data. An alpha

level was set a prior to 0.05. **Results:** There was no significant difference in the CRP angle among three groups. For joint angle, CAI showed significantly less dorsiflexion than coper (2-4%, 20-27%) and controls (1-5%, 21-26%, 90-92%). In addition, CAI demonstrated greater inversion than coper (2-3%, 35-37%, 45-50%) and controls (2-3%). For joint moment, coper showed greater knee internal rotation moment than controls although it was not significantly different. Furthermore, coper generated significantly greater knee internal rotation moment than CAI (31-35%, 45-47%). **Conclusions:** CAI showed altered ankle kinematics and knee kinetics during jogging as compared to coper and controls. It is crucial to optimally activate peroneals in order to prevent inversion sprain. However, as CAI may not use peroneal properly, utilizing knee joint motion (increased internal rotation and moment) done by coper in this study is needed to compensate inversion of the ankle. Therefore, controlling the knee joint during jogging has to be included in the gait training.

Free Communications, Oral Presentations: Professional Issues Facing Collegiate Athletic Trainers

Thursday, June 27, 2019, 12:00PM-1:00PM, Mandalay Bay D; Moderator: Randy Cohen, DPT, ATC

Work-Family Guilt in Collegiate Athletic Trainers

Rynkiewicz KM, Eason CM, Mazerolle SM: University of Connecticut, Storrs, CT; Lasell College, Newton, MA

Context: Guilt is an interpersonal, self-evaluative emotion stemming from a person feeling they violated some standard. Work-family guilt is used to assess both guilt related to work interference with family and family interference with work. It is reasonable to expect that experiences of work-family conflict may lead to feelings of work-family guilt in an individual. While work-family conflict has been studied extensively in the athletic trainer (AT) population, work-family guilt has not. The purpose of this study was to gather descriptive data on work-family guilt in collegiate ATs and determine if group differences exist. It was hypothesized that work-family conflict would be predictive of work-family guilt among this population. **Methods:** This study was a cross-sectional design utilizing an online survey. Inclusion criteria included fulltime employment in the collegiate clinical setting. The survey consisted of demographic questions, work-family guilt scale, and work-family conflict scale. A total of 257 ATs completed the survey. Scores were summed for total scales and subscales. Spearman's correlations determined relationships among work-family guilt, work-family conflict, age, years of experience, years of BOC certification, years in current position, and average hours worked per week. Mann-Whitney U tests determined differences in scores based on sex or family status. Kruskal-Wallis tests identified differences between scores based on race/ethnicity, highest level of education, current position title, length of contract, organizational reporting structure, marital status, and NCAA Division of employment. A simple linear regression

was run with work-family guilt total score as the dependent variable and work-family conflict total score as the predictor. **Results:** Reliability tests revealed good internal consistency for the work-family guilt ($\alpha=.83$) and work-family conflict scales ($\alpha=.85$). There were significant positive associations between work-family guilt total score and in-season hours, off-season hours, and work-family conflict scores as well as between work-family conflict total score and years in current position, in-season hours, and off-season hours. The Mann-Whitney U test revealed ATs with children had significantly higher scores on all summed scores except for work causing family conflict. The Kruskal-Wallis test revealed a significant difference among marital status for family causing work conflict; post hoc testing indicated a significant difference between married and single groups. No additional between group significant differences were found, including sex. A significant regression equation was found ($F_{(1, 238)}=398.1, p<.001$), with an $R^2=.626$ where participants' work-family guilt was predicted by work-family conflict. **Conclusions:** In our sample, work-family guilt and work-family conflict were universally experienced and work-family conflict was predictive of work-family guilt. Results indicate that higher levels of work-family guilt and work-family conflict are associated with a greater number of hours worked. Because guilt can negatively impact physical, emotional, and psychological health, steps should be taken to mitigate work-family conflict and work-family guilt in the AT population.

The Work Life Balance: A Perspective of the Athletic Trainer's Spouse

Mazerolle SM, Mensch JM: University of Connecticut, Storrs, CT; University of South Carolina, Columbia, SC

Context: Athletic trainers who work in the National Collegiate Athletic Association (NCAA) Division I college setting often struggle to create work-life balance (WLB) due to a myriad of reasons. Informal support systems, such as spouses, friends, and family members have been identified as possible facilitators to achieving WLB. Little however is known about the spouse and their experiences facilitating WLB, thus goal was to gain insights into WLB for spouses of NCAA Division I athletic trainers. **Methods:** Seventeen spouses (11 females, 6 males) of full time athletic trainers employed in the NCAA Division I setting completed our phenomenological study. We conducted online interviews where participants journaled their responses to 14 open-ended questions that pertained to WLB. The interview protocol was piloted prior to data collection, to ensure the questions accurately represented our phenomenon of study. Data were analyzed following a general inductive approach, and saturation was met at 17 spouses. Credibility was confirmed through peer review and researcher triangulation. **Results:** The spouses were on average 36 ± 6 years of age and married for an average of 9 ± 7 years. All participants were employed working an average of 39 ± 6 hours per week. All but 1 participant had 1 or more children and the majority of families required childcare from an outside source. Three major themes emerged as challenges that spouse's face. Living in a time-block refers to the spouses expressing the reality that during their spouse's time in-season there was no sense of WLB whereas out of season there was abundance.

Frequent schedule changes were seen by a lack of autonomy over ones work schedule that in return caused a majority of the WLB issues in their home. The assumption of many roles was present in all participants as they felt they had to fulfill many of the duties in the family construct in light of their spouse's absence due to work. Three strategies utilized by the spouses to find and support WLB for the family materialized. Time management and planning refers to the intentional efforts that spouses made in order to attempt to have WLB. Spouses also described the acceptance of their current lifestyle, with a spouse that works long hours and finding WLB can be challenging. Lastly, workplace integration was described as a strategy when spouses talked about the benefits of being able to integrate their family life into the ATs work environment; this was done by attending home/away games or assimilating into some part of the workday. **Conclusions:** Although athletic trainer's spouses face many WLB challenges, they acknowledge their supportiveness towards their spouses work life balance. Spouses reported overall satisfaction with current WLB but identified many ways it could be improved.

Leadership, Job Satisfaction, and Intent to Leave in NCAA Division I Athletic Trainers
Schroeder LH: University of North Carolina, Wilmington, NC

Context: Context: Attrition is a significant concern in the athletic training profession. Career advancement opportunities, particularly leadership roles could play a role in retention however; it has yet to be evaluated. **Objective:** Investigate if there is a relationship between perception of leadership opportunities for athletic trainers (ATs), job satisfaction, and intent to leave the profession. **Methods: Design:** Cross-sectional design **Setting:** NCAA Collegiate setting **Patients or Other Participants:** 162 ATs completed the survey (102 females; 60 males). The majority of the participants (70.4%) have been National Athletic Trainers' Association (NATA) Board of Certification (BOC) certified less than 10 years. 47.5% of the participants were in NCAA DI FBS, 20.4% in NCAA DI FCS, and 32.1% were in NCAA DI non-football institutions. **Interventions:** The demographic section collected information on gender, race, NCAA Division, NATA district, years NATA BOC certified, and primary employment classification. The Perceived Leadership Opportunities Survey (PLOS) was developed for this study and consisted of six quantitative items scored on a 5-point Likert scale. The survey was scored with positive terms ("excellent", "very satisfied", and "agree") worth 5 points ranging all the way to the negative terms ("none", "very dissatisfied", and "disagree") as 1 point. A panel of experts (n=3), in the field of athletic training, job satisfaction, and retention, established face and content validity. Cronbach's alpha for the PLOS was 0.727. The Intention to Leave Survey (ITLS) and the Job Satisfaction Survey (JSS) has been validated previously. **Main Outcome Measures:** The data were analyzed using IBM SPSS Statistics 22. Descriptive statistics of central tendency and frequency distribution were performed on demographic data. Pearson correlations were used to

evaluate the strength of the relationship between total PLOS, total ITLS, and JSS scores. Results were arranged from strongest to weakest while also noting gender. **Results:** All ATs working in NCAA Division I institutions were emailed the survey (n=2,405). This resulted in a 6.7% response rate (n=162). JSS scores found ambivalence in both male (M=137.25) and female ATs (M=135.93). Ambivalence was also found in male (M=21.57) and female ATs (M=20.47) with PLOS scores. Female ATs had the strongest ITLS score (M=11.59, SE=4.28) when compared to their male counterpart (M=10.13, SE=3.70). A strong predictor for job satisfaction amongst athletic trainers was found to be the perception of leadership opportunities ($r = 0.547, p < .001$). The strongest correlation between job satisfaction and the perception of leadership opportunities was found in female athletic trainers ($r = 0.587, p < .001$) with the weakest correlation found amongst male athletic trainers ($r = 0.464, p < .001$). **Conclusions:** Increasing leadership opportunities for ATs may improve retention rates. Women perceived opportunity to assume a leadership role is limited, suggesting this may be another reason they leave the profession.

The Relationship Between Burnout and Substance Use in Collegiate Athletic Trainers

Oglesby LW, Gallucci AR, Wynveen CJ, Ylitalo KR: The University of Southern Mississippi, Hattiesburg, MS; Baylor University, Waco, TX

Context: Burnout is a psychological syndrome that includes emotional exhaustion, a decreased perception of personal accomplishment, and depersonalization. Among healthcare professionals, burnout and substance abuse are well-documented. For example, increases in self-reported burnout symptoms are associated with increases in heavy episodic drinking among physicians, medical students and psychiatrists. Similarly, increases in tobacco use have also been associated with high levels of burnout among nurses. Smith's Cognitive-Affective Model of Athletic Burnout suggests that athletic trainers (ATs) suffering from burnout may engage in substance use as a coping behavior; however, this relationship has not been examined thoroughly. The purpose of this study was to examine burnout and its relationship with substance use in collegiate athletic trainers.

Methods: A web-based, cross-sectional study design via the National Athletic Trainers' Association (NATA) membership directory email broadcast service was utilized to sample ATs working full time in the college/university setting. Graduate assistants, interns, and other part-time employees were excluded. Participants (n=783; 57.9% female) were 36.4 ± 11.1 years old (range 22-79 years). The questionnaire consisted of survey items from previously used scales, including the Maslach Burnout Inventory (MBI) and substance use questions from the Monitoring the Future study. The survey took approximately 15 minutes to complete. Path analyses were used to analyze survey data. All independent (MBI subscales) and dependent variables (e.g. alcohol consumption, tobacco use and marijuana use) were mapped onto Smith's Cognitive-Affective Model of Athletic

Burnout to determine which dimensions of burnout alter the odds of self-reported substance use. **Results:** Almost half (46.3%) of the participants indicated that they had engaged in at least one episode of heavy episodic drinking (5 or more drinks in a row for males, 4 or more for females) in the previous month and nearly one quarter (22.9%) consumed at least one energy drink in the same time frame. However, the use of cigarettes (1.4%), smokeless tobacco (5.2%), and marijuana (3.5%) during the last month was less common in the sample. Emotional exhaustion ($B = .008$, $p = .023$; 95% CI = 0.001, 0.015) and decreased personal accomplishment ($B = -.016$, $p = .02$; 95% CI = -0.029, -0.003) were associated with binge drinking. Emotional exhaustion ($\text{Exp}[B] = 1.017$, $p < .001$; 95% CI = 1.009, 1.026) was also positively correlated with energy drink consumption.

Conclusions: Many collegiate ATs engage in heavy episodic drinking. Subscales of burnout (i.e. emotional exhaustion and a decreased sense of personal accomplishment) are significantly correlated with this behavior. Emotional exhaustion is also positively correlated with energy drink use in collegiate ATs. Because substance use/abuse may affect work performance and therefore affect patient outcomes, further examination of these relationships in collegiate ATs as well as ATs in other work settings is warranted.

Free Communications, Rapid Fire Oral Presentations: The Burden of Injury in the Performing Arts

Thursday, June 27, 2019, 1:15PM-2:15PM, Mandalay Bay D;

Moderator: Jatin Ambegaonkar, PhD, OT, ATC, CSCS

Posterior Tibial Nerve Entrapment in a Classical Ballet Dancer

Deleget LA: Harkness Center for Dance Injuries, New York University, New York, NY

Background: The patient is a 23 year old professional ballet dancer who complains of left medial arch pain and neurological symptoms of insidious onset. Her chief complaint is shooting pain, numbness and tingling of the medial arch and great toe. Aggravating activities include articulating through the foot, toe off phase of gait and during functional weight bearing activity, such as jumps. She qualifies her pain as achy ranging from 3-8/10 during activity and 8/10 after activity. She states once the pain and neurological symptoms are aggravated, they linger throughout the day. The patient has continued to dance despite her pain and neurological symptoms. Previous self-management consisted of wearing hard soled shoes and utilizing cryotherapy, neither of which provided relief to symptoms. The mechanism of injury was mechanical compression secondary to choreographic demands and dancer-specific pointe shoe modifications. Upon evaluation, visual inspection of the foot revealed a cavus foot type and minimal swelling surrounding the navicular region - from the medial malleolus through the medial longitudinal arch. Pain and neurological symptoms were reproduced with palpation of the navicular and surrounding musculature. Additionally, palpation and motion testing revealed tight gastroc-soleus complex, and rigid midfoot, decreased subtalar joint eversion and decreased posterior talar glide. Strength testing revealed moderate deficit of great toe plantar flexion. Positive special tests include tinels sign and slump. Neurological exam reveals decreased L5 dermatome and myotome. **Differential Diagnosis:** Plantar fasciitis; midfoot sprain; L5 nerve root compression; flexor hallucis longus

tendinopathy; posterior tibialis tendinopathy; abductor hallucis tendinopathy; posterior tibial nerve entrapment. Physician referral and diagnostic testing confirmed schwannoma causing entrapment at the medial plantar branch of the posterior tibial nerve. **Treatment:** Initial treatment consisted of manual therapy including soft tissue mobilization (STM); tool assisted STM; joint mobilizations; taping to facilitate subtalar joint eversion and navicular pronation; activity modifications sub-threshold to symptoms; and a home exercise program consisting of neural flossing and lower extremity stretching and strengthening. Surgical excision of the schwannoma was advised after 6 months of conservative management failed to resolve symptoms. **Uniqueness:** Schwannomas are one of the most common soft tissue tumors, but are a rare finding in adults overall. Incidence in the lower extremity makes up a small portion of these findings. No documentation of this injury in ballet dancers has been reported. **Conclusions:** It is important for Athletic Trainers to understand the functional anatomy of the foot in order to correctly diagnose and treat patients with neuropraxia or nerve entrapments. Standard plan of care includes referral back to physician if resolution of symptoms is not reached with 6 months of conservative care. This patient completed post-operative rehabilitation, has full sensation recovery and has returned to full dance activities.

Concussion Recovery in Two Dancers: A Case Study

McIntyre LM: Harkness Center for Dance Injuries, New York University, New York, NY

Background: Research has shown that delayed concussion reporting is associated with more symptoms, higher symptom severity scores, and significantly longer recovery time among athletes when compared with counterparts who were removed immediately from activity (Asken et al, 2018) Little is known about concussion in dancers, but a 2016 survey conducted with professional and collegiate dance cohorts suggests that delayed reporting may be prevalent (McIntyre & Liederbach, 2016). The purpose of this case study is to present the difference in recovery duration between two similar collegiate dancers who suffered simultaneously concussions, but whose removal from activity was handled differently. **Patient:** Two female, junior-year conservatory dancers hit each other's heads during rehearsal. Both dancers had matched symptom scores on baseline testing 2 years prior and no concussion history. Dancer 1 was 22 years old with current anxiety and depression but no other medical history. Dancer 2 was 20 years old with no medical history. Both dancers completed 4 hours of dance activity prior to injury. Dancer 1 was immediately removed from rehearsal and instructed to see the athletic trainer. Dancer 2 finished rehearsal, took a 2 hour dance class the next day, and was summoned by the athletic trainer the next day after obtaining the history of mechanism from Dancer 1. Both dancers were referred to the campus physician to confirm concussion diagnosis. Dancer 1 presented with the following SCAT5 (Sport Concussion Assessment Tool 5th Edition): 13 symptoms and a severity of 42, 19 out of 30 points for SAC (Standardized Assessment of Concussion), 0 errors on the mBESS (Modified Balance Error Scoring System), and delayed recall score of 3. Dancer 2 presented with the following SCAT5: 18 symptoms and a severity of 76, 27 out of

30 points for SAC, abnormal tandem gait, 3 errors during the mBESS, and delayed recall score of 4. Both dancers consented to have their de-identified information used for research. **Intervention or Treatment:** Active rehabilitation was used for both dancers, per the 2017 Concussion in Sport Group Consensus Guidelines (McCroory, 2017). Dancer 1 was treated with suboccipital release, cervical spine range of motion and stabilization, as well as eye-tracking exercises. Dancer 2 was treated with over the counter pain relievers for headache, suboccipital release, proprioceptive exercises, and sub-symptom threshold exercise on a stationary bike. Dancer 2 discontinued headache medication 6 days after onset and began progressive return to exercise. Dancer 2 was discharged from concussion treatment protocol in 13 days. Both dancers were educated about future concussion risk and proper care-seeking behaviors. **Outcomes or Other Comparisons:** Dancer 1 was discharged from concussion treatment protocol in 8 days after progressive return to aerobic and dance-specific exercise beginning 5 days after onset. Dancer 2 discontinued headache medication 6 days after onset and began a progressive return to exercise. Dancer 2 was discharged from concussion treatment protocol in 13 days. Both dancers were educated about future concussion risk and proper care-seeking behaviors. **Conclusions:** Since both dancers were female, similar in age and training level, and had matched baseline symptom scores, this case study emphasizes the importance of prompt removal from activity when concussion is suspected. Dancer 1 discontinued activity immediately and returned to dance in 8 days after injury, whereas dancer 2 had a 24 hour delay in reporting the concussion and returned to dance in 13 days after injury. This 5 day difference in recovery follows trends shown in the literature about extended return to sport outcomes following delayed reporting. **Clinical Bottom Line:** Similar to the findings in sports literature, this dual-case description of dance-related concussion suggests that delayed reporting is paired with an increased recovery time outcome.

Epidemiology of Injury and Illness in a Mid-Atlantic WGI Independent World Indoor Drumline

DiSanto GD, Merritt NC: University of Virginia, Charlottesville, VA; Furman University, Greenville, SC

Context: With the recent development of athletic training in emerging settings, it is important to examine the rate of injury occurrence within these settings. Currently, there is a dearth of information regarding epidemiology of injury and illness in Winter Guard International (WGI) Indoor Drumline patients. The purpose of this study is to describe the epidemiology of injuries among participants in a WGI Independent World Indoor Drumline.

Methods: The design of the study was an epidemiological practice based study and was conducted in college and high school facilities. Forty indoor drumline members from an Independent World indoor drumline group that practices and competes seasonally on the weekends in the Mid-Atlantic region (Male=31, Female=9, Age=20.38±1.31yrs) were monitored over the six month season for the rate of injury incidence. Injury and athlete exposure (AE) data were collected from an electronic medical record system that was used to keep track of injury incidence throughout the season, totaling approximately 495 hours of activity. A transient injury (TR) was classified as an injury occurring during a WGI-sanctioned practice or competition that required medical attention. An injury resulting in time loss (LT) was classified as an injury that caused removal from participation for one practice block (3 hours). Members were instructed to self-report any type of injury that occurred. The collected data were coded and analyzed for LT, TR, and injuries per section. The injury counts, along with total practices and members per section, were used to calculate time loss injury rates per 1,000AE. Proportions of injuries/illness by body part and specific diagnosis were calculated. **Results:** Among the

injured (n=32) and uninjured members (n=8), there were a total of 40 injuries (LT=7, TR=33) reported in 440 practice hours and 55 competition hours. Seven and-a-half percent of participating members sustained more than one injury. All accounted injuries occurred during practice hours. The overall injury rate was 90.91 injuries per 1,000AEs. The LT rate was 15.91 injuries per 1,000AEs and females accounted for 57.14% of LT injuries. **Conclusions:** These findings demonstrate that WGI Indoor Drumline is a strenuous activity and deserves to be considered an area of emerging practice for athletic trainers and other health care professionals. Athletic Trainers and other health care professionals can apply this information to demonstrate to stakeholders the necessary integration of athletic trainers into the realm of WGI.

Incidence of Musculoskeletal Injuries in a World-Class Drum Corps

Dangel ZR, McPherson AM,
Docherty CL: Indiana University,
Bloomington, IN

Context: The risk of sustaining an injury while participating in traditional sports has been well documented, however, the performing arts have only recently been considered as an activity which might put performers at an increased risk of injury. The marching arts is a subset of this group that have received limited attention. To date, studies have collected only member self-reported data and have generally ignored the elite, highly-athletic touring marching band units known formally as drum and bugle corps (more commonly referred to as “drum corps”.) Therefore, the objective of this study was to determine the incidence, prevalence, and descriptive characteristics of musculoskeletal (MSK) injury observed in a single drum corps population over the course of one season. **Methods:** This cohort study observed injury occurrence in all members of a single, World-Class drum corps. One-hundred and forty-eight members (male: n=100, female: n=48, age=19.3 ± 1.4yrs, height=1.75 ± 0.10m, weight=72.06 ± 13.66kg, drum corps experience [World-Class]=1.35 ± 1.30yrs) were observed for injury occurrence over the 3-month season. All potential injuries were evaluated by the corps’ full-time certified athletic trainers. Diagnosis and other relevant injury characteristics (side, body part, mechanism, etc) were gathered and documented using an electronic medical record systems (Athletic Trainer System®, Grove City, PA). An injury was defined as the diagnosis of an injury by a corps athletic trainer or a referred healthcare provider, according to their standard clinical practice. General member demographics (sex, years’ experience, role in corps) and participation exposure were collected in standard fashion. Data were analyzed for frequencies, descriptive statistics, and incidence and prevalence rates. **Results:** Of the 148

members, 31 members sustained one injury, 10 sustained two injuries, and 1 sustained three injuries over the course of the season. In total, 54 injuries were recorded. Both risk of MSK injury and period prevalence were 28.38%. 54,784 rehearsal-exposures (equivalent unit to traditional athlete-exposure) and 99,409.58 hours of exposure were recorded. The injury incidence rate was 0.36 injuries per member-season, 0.001 injuries per rehearsal-exposure, and 0.54 injuries per 1,000 member-hours. The majority of injuries occurred to the lower extremity (79.63%), with muscle strain being the most common diagnosis category (27.78%). **Conclusions:** MSK injuries occurring during and/or consequent to drum corps activity is an existing issue and warrants further investigation. Injuries were most likely to be chronic, lower extremity, and muscular in nature, and to affect females, brass members, and those less-experienced in drum corps. Despite a lower injury incidence rate compared to traditional sports settings, our study demonstrates a considerably higher exposure rate. These data further support the need for athletic healthcare within this unique setting, and can be used to inform current and future healthcare providers on potential prevention foci.

Injury Incidence and Exposure in Collegiate Dancers - A 2-Year Prospective Study

Fauntroy V, Hansen-Honeycutt JA, Nolton EC, Cortes N, Caswell SV, Ambegaonkar JP: George Mason University, Fairfax, VA

Context: Dancing is physically demanding. Approximately, 85% of professional dancers suffer a dance related injury annually. Dance exposure reportedly affects professional dancers' injury risk. However, how exposures and injury rates may change across academic years in collegiate dancers is limited. Therefore, medical teams working with collegiate dancers often rely on exposure and injury rates derived from professional dancers to make clinical decisions. Thus, our objectives were to: 1) compare dance exposure hours (DEhr), and 2) examine injury rates in one cohort of collegiate dancers during two consecutive academic years.

Methods: Data were collected on 20 freshman university dancers (18.3±0.7 years, 170.7±7.7 cm, 70.2±18.9 kg) over 2 academic years (30 weeks/year, total=60 weeks; during the 2016-17 and 2017-18 academic years). Injuries, defined as any medical condition where

the dancer sought medical attention, were collected by an in-house medical team. Dance exposure hours (i.e. class, rehearsal, performance) were recorded; a DEhr was defined as one dancer participating in one hour of class, rehearsal, or performance. Class was defined as the dancers' regular modern and/or ballet technique class. Rehearsal was non-class time devoted to a later performance (i.e. residency, student pieces, etc.). Performance was defined as the participation in choreographed pieces over one or multiple days. A paired t-test compared total DEhr between year 1 and year 2 (p<.05). Injuries were classified as non-time loss (<24 hours dance participation restriction) or time loss (>24 hours participation restriction). We also calculated injury frequencies and rates (IR) for both years. **Results:** Dancers' weekly exposure hours remained similar across both years [year 1=23.5 DEhrs, year 2=23.3 DEhrs, t(18)=.61, p = .55] (Table 1). Overall, in year 1, 80% of dancers were injured (total 33 injuries, injury rate (IR)=2.3/1000 DEhr; 95% CI: 1.5-3.1) and in year 2, 100% dancers were injured (total 51 injuries, IR=3.8/1000 DEhr; 95% CI: 2.8-4.9). However, only 18%(n=6) and 25%(n=13) of the

injuries for year 1 and 2 respectively were time-loss injuries. **Conclusions:** Dancers' exposure hours remained similar across both years (~23 hours/week). Similar to prior observations in professional dancers, most dancers suffered some dance-related injury. However, the majority of these injuries were non-time loss injuries. The dance exposure (~23 hours/week) and injury incidence numbers (2.3-3.8/1000 DEhr) described are consistent with prior reports in professional dancers (range:25-28 hours/week and range: 4.5-4.8 injuries/1000 DEhr). These findings are encouraging and suggest that having an in-house medical team may allow dancers to be forthcoming with their health concerns and seek medical attention. Overall, our findings support the notions that dancing is physically demanding, and that dancers need in-house healthcare support to care for their medical concerns.

Table 1. Dance Exposure Hours (DEhr) over 2 Consecutive Years for the Same Cohort of Collegiate Dancers

Class	Fall Semester	Spring Semester	Total Year	# of Dancers	DEhr/Dancer	DEhr/Week
2016-2017	6482.4	7617.5	14099.9	20	705	23.5
2017-2018	6480	6827.9	13307.9	19	700.4	23.3

Dancers' Perceptions and Utilization of Strength Training and Conditioning: A Qualitative Approach

Rosenthal ME, McPherson AM, Docherty CL, Klossner J: Indiana University, Bloomington, IN; University of Maryland, College Park, MD

Context: Research demonstrates dancers benefit from reduced injury time and improved health by engaging in strength training and conditioning (STC). However, in the discipline of dance there is a long-standing stigma that a dancer's aesthetic appearance is impacted and undermined by engaging in STC. The purpose of this study was to explore dancers' perceptions and utilization of STC. **Methods:** Using criterion sampling methods we recruited female dancers, of any age-level or years of dance experience, from undergraduate contemporary and ballet major programs at a single midwestern university. We recruited from each program until we reached data saturation. Ultimately, a total of twenty-three participants volunteered including thirteen contemporary dancers and ten ballet dancers (age: $19.95 \pm .97$ years; years of dance experience: 15.70 ± 1.66 years). Utilizing a general inductive approach to qualitative research, each participant participated in face-to-face semi-structured interviews that lasted approximately 30 minutes each. Interviews were recorded and transcribed verbatim. We established trustworthiness through initial and interpretive member checks, peer debriefing, and reflective journaling. **Results:** Three major themes were identified, (1) evolving aesthetic image, (2) motivation, and (3) education. Aesthetic image was a key component of why dancers participated in STC. Furthermore, intrinsic and extrinsic factors motivated dancers to achieve their optimum physical fitness levels to better succeed in dance. Strength training and conditioning education

or lack of education did not contribute significantly to the utilization of STC practice among dancers. **Conclusions:** Collegiate dancers utilize STC as a means of complementing their dance training and improving their optimum fitness as well as honing their aesthetic image. The information from this study suggests STC education should be initiated and promoted in the discipline of dance for its importance in physical fitness and general well-being.

Evaluating Movement Dysfunctions in Performing Artists Using the Selective Functional Movement Assessment

Hansen-Honeycutt JA, Ambegaonkar JP, Nolton EC: George Mason University, Fairfax, VA

Context: Dancers are performing artists who have unique physical demands. Previous literature reports 85% of dancers sustain an injury annually. Thus, identifying and managing movement dysfunctions and asymmetries that may contribute to pain and/or injury in performing artists is essential for Athletic Trainers (ATs) working with them. ATs often use screenings in the form of pre-participation examinations and/or functional assessments. The Selective Functional Movement Assessment (SFMA) is one assessment option that can be used for performing artists. As dancers are at increased risk of overuse

injuries versus acute injuries, a systematic screen of global movement patterns may aid in identifying causes of chronic pain. Therefore, our purpose was to use the SFMA to examine the prevalence of movement dysfunctions in freshman university dance students. **Methods:** 40 university freshman dance students (male=6, female=34, age 18.1±0.8 years) participated in SFMA screens over two years. Each dancer participated in a 30-minute assessment completed by the same investigator trained in administering the SFMA. If the investigator noted a movement dysfunction, the breakout was completed (i.e. analyzed for causes using SFMA tests). The top tier movements were categorized by denoting if the movement is functional non-painful(FNP), functional painful(FP), dysfunctional painful(DP), and dysfunctional non-painful(DNP). The top-tier has 10 movements, 5 are assessed bilaterally, creating 15 categories of global movements that can be categorized. **Results:** 67.5 % (n=27) of dancers presented with >11 of 15 DNP

movements. Only 32.5%(n=13) dancers presented with ≤10 DNP movements. Two dancers presented with FNP or DP movements, stemming from a previous orthopedic injury. The major DNP patterns present were cervical flexion (90%, n=36), multisegmental extension (92.5%, n=37), multisegmental rotation (97.5%, n=39), and overhead squat (92.5%, n=37)(Table 1). **Conclusions:** Despite all the freshmen dancers being apparently healthy and actively taking part in dance when they were assessed, most dancers (67.5%) presented with greater than 11 DNP global movement patterns. Prior researchers note that the prevalence of movement dysfunctions may contribute to increasing injury risk in this population. Thus, using the SFMA may allow ATs to identify movement dysfunctions and asymmetries that could predispose dancers to injury. ATs can also use the SFMA to design tailored interventions to decrease injury risk and enhance performance in dancers and athletes.

Global Movement	Functional Non-Painful	Functional Painful	Dysfunctional Painful	Dysfunctional Non-Painful
Cervical Flexion	3	0	1	36
Cervical Extension	6	0	1	33
Cervical Rotation R	4	0	0	36
Cervical Rotation L	2	0	0	38
Upper Extremity Under R	13	0	0	27
Upper Extremity Under L	15	0	0	25
Upper Extremity Over R	12	0	0	28
Upper Extremity Over L	16	0	0	24
Multisegmental Flexion	10	1	0	29
Multisegmental Extension	3	0	0	37
Multisegmental Rotation R	1	0	0	39
Multisegmental Rotation L	0	0	0	40
Single Leg Stance R	27	0	0	13
Single Leg Stance L	27	0	0	16
Overhead Squat	3	0	0	37

Table 1. Selective Functional Movement Assessment top tier global movements classified by function or dysfunction in university of dancers

Do FMS Scores Predict Injury Risk in Collegiate Dancers - A Prospective Analysis

Coogan SM, Schock C, Hansen-Honeycutt J, Caswell SV, Ponder J, Cortes N, Ambegaonkar JP: George Mason University, Fairfax, VA

Context: Dance is a physically demanding activity, with 85% of dancers suffering injury during a single performance season, the majority of which occur in the lower extremity (LE) and are classified as chronic injury. These overuse injuries arise when causal factors are not identified and addressed. Movement screens such as the Functional Movement Screen (FMS) have gained popularity for their potential to detect and quantify kinetic chain dysfunction, stratifying those at increased injury risk to allow for targeted interventions that might reduce injury occurrence. Whether the FMS has predictive ability to identify individuals at risk of injury remains unclear. Thus our objective was to examine whether FMS scores predicted injury in collegiate dancers.

Methods: In order to examine whether the FMS could predict overall and LE injury risk in this prospective study, we scored 43 dancers (18.3±0.7 yrs; 163.9±7.3 cm; 60.8±8.1 kg) on the seven FMS movements: Deep Squat, Hurdle Step, In-Line Lunge, Active Straight Leg Raise, Rotary Stability, Shoulder Mobility, and Trunk Stability Push-Up. Bilateral Yocum's tests, spinal flexion and spinal extension clearing tests were also conducted to assess for pain indicative of pathology. Positive clearing tests override FMS scores for their associated movement tasks, as a score of 0 is given if pain is indicated. Each movement was scored on a 0-3 scale, where 3=movement completed as requested without compensation, 2=movement completed, but with compensation(s), 1=unable to complete movement as requested, 0=experienced pain during movement or clearing test, for a total composite score of up to 21. We documented participants'

overall (N=21) and LE injuries (N=20) over an academic year and examined whether FMS scores predicted injury status using separate receiver operator characteristic (ROC) curve analyses. **Results:** 20 dancers were injured, whereas 23 remained injury-free. Injured dancers had 55 overall (1.28 injuries/dancer) and 44 LE injuries (1.02 LE injuries/dancer). FMS Scores were (16.2±1.7, range=11-19). FMS score did not predict overall (AUC=.28, SE=.08, p=.02, 95%CI=.13-.43) or LE injury risk (AUC=.38, SE=.1, p=.21, 95%CI=.21-.56). **Conclusions:** FMS scores did not predict overall or LE injuries in our dancers. Dancers face unique physical demands intrinsic to their craft which distinguishes them from traditional athletes. For example, greater ranges of movement are often necessary to perform. However, the FMS does not distinguish 'appropriate' from 'excessive' mobility which is important to identify in this population. Thus, the FMS may not be sensitive enough to adequately identify dysfunctional movement in dancers. Overall, despite prior suggestions that the FMS may identify movement dysfunction, our results suggest that clinicians should use caution before using it as a measure to identify dancers at increased injury risk.

Free Communications, Oral Presentations: Experiences of Athletic Trainers Providing Medical Care to Elite Athletes

Thursday, June 27, 2019, 2:30PM-3:30PM, Mandalay Bay D; Moderator: Barnett Frank, PhD, ATC

Experiences of Athletic Trainers Working in the Professional Setting

Zweigle KZ, Neil ER, Spangler NJ, Eberman LE: Indiana State University, Terre Haute, IN

Context: Professional sport setting athletic trainers (AT) are highly visible to the public and may serve as an inspiration to join the profession; however, very few ATs serve patients in this setting. Previous literature has reported that ATs in the professional setting experience role strain from extreme organizational expectations and demands, resulting in perceived limitations in patient care and work-life imbalance. **Methods:** This qualitative study was guided by questioning the workplace experiences of ATs in the professional setting. We recruited ATs currently practicing in professional sports settings through word of mouth, social media, and snowball sampling; 18 participants (males=15, female=3; age=38±8y; years certified=14±7y; years in professional sports=11±9y) from various professional sports participated in the study. Participants completed a semi-structured one-on-one interview, which were audio-recorded (Zoom, San Jose, CA) and transcribed verbatim (Temi, San Francisco, CA). A 3-person data analysis team used a multi-phase process to identify emerging domains and core ideas, ultimately developing a consensus codebook. Trustworthiness was established with member checking, multiple researcher triangulation, and an external audit. **Results:** The experiences of ATs in the professional setting have four emergent domains: 1) job attractors, 2) feeling valued, 3) characteristics of the workplace environment, and 4) making sacrifices. Participants reported being attracted to their jobs to work with elite athletes, having supportive coworker relationships, having a network of ATs and mentors from the professional

sport setting community, and having increased access to resources and education due to their position. ATs reported feeling valued by employers through increasing professional responsibilities within their current position and increasing compensation or recognition. They also discussed having trusting relationships with their patients that made them feel valued by their respective organizations. When describing the workplace environment, the participants demonstrated a mutual loyalty between the organization and employee. They also described situations where inappropriate behaviors had been exhibited (e.g. patients in the athletic training facility in a towel or naked, offensive language) and a sub-culture of acceptance for behaviors that would otherwise be unacceptable (e.g. job duties outside the realm of healthcare, banter that could subjectively cross a line). Similar to most workplaces, participants detailed common coworker tensions related to miscommunications and coworker conflict. Participants also described challenges related to providing care to non-native language speakers. Although participants were positive about their workplace's experiences, they stated they made sacrifices to acquire and retain their current positions, including a high time commitment to the job and regular travel expectations, family compromises, fewer opportunities for promotion, and a long period to progress to their current position. **Conclusions:** Professional sport setting ATs feel valued for their work despite the long hours and promotional sacrifices. Positive coworker environments and access to resources continue to attract ATs to this setting.

Professional Quality of Life and Workplace Satisfaction of Athletic Trainers Working in the Professional Sport Setting

Spangler NJ, Neil ER, Zweigle KA, Eberman LE: Indiana State University, Terre Haute, IN

Context: Despite females comprising over half of National Athletic Trainers' Association (NATA) membership, they remain underrepresented in professional sport settings. The purpose of this project was to compare the experiences of male and female athletic trainers working in professional sports and to identify barriers and resistance females experience working in the professional sports setting. **Methods:** The design of this study was an exploratory cross-sectional survey. Potential participants were recruited through the NATA membership database. All professional sport NATA categorized members were sent a recruitment email. The workplace experiences survey was modified from two previously validated instruments that measured work-life balance and overall experiences working in professional sports. The final survey was pilot tested by a sample of credentialed athletic trainers to establish internal consistency and feasibility. We identified excellent internal consistency for the overall tool (Cronbach's $\alpha=0.876$). Survey data were analyzed using Mann-Whitney U test and Kruskal-Wallis tests to identify the differences between genders, overall work experiences, and job satisfaction measures. Significance was set at $p<.05$ a priori. **Results:** Invitation emails were sent to 757 potential respondents. A total of 94 participants began the survey (access rate=12.4%), 92 participants were eligible (response rate=12.2%) with 81 participants completing the survey in its entirety (completion rate=88.0%). Participants were predominantly white (71/81, 87.7%) males (73/81, 90.1%). There were no significant differences between female

and male responses on any of the subscales of the Professional Quality of Life Scale. Participants reported high compassion satisfaction (42.57 ± 5.09), low burnout (33.63 ± 3.67), and low secondary traumatic stress (23.58 ± 3.43). Results also indicated that a majority of participants were satisfied with several aspects of their job including health and safety practices (91.4%), their amount of control and involvement (85.2%), and growth and development opportunities (72.8%). Only one item showed a significant difference between males and females. Females reported that they did not regularly participate in programs or utilize policies that allowed them to be flexible in where, when, or how much they worked compared to males ($p=.047$). We did not find any other significant differences between gender. **Conclusions:** The results of this survey indicated that the majority of athletic trainers working in the professional setting experience high levels of job satisfaction, and positive work experiences regardless of gender. Previous literature indicated that roughly half of athletic trainers in this setting experienced role strain. Role strain has been associated with a decrease in job satisfaction, so participants displaying high satisfaction scores was not expected. The survey also indicated that men and women share similar experiences related to professional quality of life and other parameters of their work. This would indicate that the underrepresentation of females in the professional setting is not due to differences in workplace experiences.

Collegiate Athletic Trainers' Experiences With External Pressures Faced During Medical Care Decision-Making

Pike AM, Mazerolle SM, Bowman TG: University of Connecticut, Storrs, CT; University of Lynchburg, Lynchburg, VA

Context: Reports in the media have highlighted conflicts between sports medicine professionals and coaching staffs regarding return to play decisions for athletes following injury, specifically in the National Collegiate Athletic Association (NCAA) Division I (D1) setting. The first-hand experience of athletic trainers (ATs) regarding such conflict has not been fully investigated. Therefore, the purpose of this study was to explore the relationship between organizational conflict and ethical decision-making of ATs regarding patient care and return-to-play following injury in the NCAA D1 Football Bowl Subdivision (FBS) setting. Furthermore, we aimed to better understand outside pressures ATs faced when making medical decisions. **Methods:** Our purpose was achieved through a qualitative study design grounded in phenomenology. We recruited ATs working in the D1 FBS setting to complete semi-structured one-on-one telephone interviews, which were recorded and transcribed verbatim. Participant recruitment was accomplished through purposeful and snowball sampling, and was guided by data saturation. A total of 10 NCAA D1 FBS ATs (4 males, 6 females; age: 31 ± 8 years (range = 24-48)) completed our study. They were certified for 9 ± 8 years, and worked at their respective universities for 6 ± 7 years (median = 3) at the time of the study. Thematic analysis was completed through a phenomenological approach, allowing the true experiences of our participants to naturally emerge. We utilized researcher triangulation, peer review, and member checks to establish trustworthiness in our findings. **Results:** Participants reported facing pressure from coaches, athletes, and/or administration regarding return to

play and other medical decisions in their role as collegiate ATs, but clarified that pressures received were rooted in eagerness to return an athlete to play, rather than questioning the skillsets and abilities of the ATs. Perceived pressure was heightened when working with revenue-driven sports such as football. Two major themes emerged from the qualitative analysis: (1) pressure is an expected component of the collegiate AT role, and (2) strategies can be implemented to mitigate the negative impacts of pressure. Three subthemes support the second major theme: (1) establishing positive relationships with coaches, athletes, and/or administration, (2) ensuring ongoing and frequent communication with stakeholders related to an injured athlete's status, as well as anticipated timelines for return-to-play, and (3) providing rationale to coaches/administration for why specific medical decisions are being made to foster understanding. **Conclusions:** External pressure regarding medical decisions was an anticipated occurrence for our sample. Such pressure was described as a natural part of the position, not negative, but rather a product of the culture and environment of the D1 FBS setting. ATs who frequently face pressure from coaches and administration should utilize the aforementioned strategies to improve workplace dynamic and allow for an environment that focuses on patient-centered care.

Identification of Professional Values for the Athletic Training Profession: A Pilot Study

Baker CS, Colson MA, Wilson ET, Nutt AK, Schlabach GA: University of Tennessee at Chattanooga, Chattanooga, TN; Northern Illinois University, DeKalb, IL

Context: Currently, athletic training's professional organization, the National Athletic Trainers' Association (NATA), has yet to explicitly articulate a set of professional values (PVs) for the profession. PVs shared congruently among members of a professional group are meant to promote consistent quality practices and behaviors of that group. The purpose of this study was to identify shared PVs for the profession of athletic training. Specifically, the PVs identified from this study will not only represent those of the members of the NATA, but will also represent those of all organizations within the Athletic Training Strategic Alliance, which includes the NATA, Committee on Accreditation of Athletic Training Education, Board of Certification, and the Research and Education Foundation. **Methods:** Survey items were developed and responses were summarized by descriptive statistics. A literature review was conducted to identify articles relating to PVs within health profession journals. The search identified 45 articles, which contained 234 potential PV terms. PVs that appeared in <4 articles were eliminated (192), terms that did not meet the definition of PV were removed (24), and relative terms were combined to form a single professional value for the similar terms (7), resulting in 16 PVs. An "attentional variable" of self-interest was added, resulting in a total of 17 items. The survey was administered electronically to 95 members of the Athletic Training Strategic Alliance. Participants were asked to: 1) indicate relative importance of each PV ("very important"=6 to "unfamiliar"=0; 2) rank the three most important PVs; 3) identify the importance of PV articulation; and 4) identify importance of PV

articulation to the professional body. Internal consistency was analyzed using Cronbach's alpha. **Results:** 64% (61/95) of potential participants responded; 69% (n=42) male and 31% (n=19) female. Integrity, Truth/Honesty, Trust, Responsibility, Accountability, Competence, Respect, Excellence, and Safety had a median of 6 (very important) and a mean >5.4. Integrity ranked most important (males 57%, females 74%), followed by Competence and Responsibility. Overall, Competence was considered important (ranked 2nd), but rankings differed on the basis of sex. Identification of PVs reported as "very important" (66%) or "important" (34%) personally and to the profession. Cronbach's alpha demonstrated internal consistency of 0.847. **Conclusions:** The majority of PVs identified as important were consistent with the ethical values implied by the NATA Code of Ethics. Overall, Athletic Training Strategic Alliance leadership believes PV identification is important. PVs shared by members of a professional group can influence individual motivations and practice behaviors, and may attract individuals to the profession who embrace such principles. Survey of the entire NATA membership is the next phase of this research, to establish a set of clear and concise terms that will collectively represent guiding principles for athletic training practice.

Free Communications, Poster Presentations: Anterior Cruciate Ligament and Meniscal Injury

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;
Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Brain Activation During Anterior Knee Joint Loading

Park-Braswell K, Jung Y, Schmitz RJ: University of North Carolina at Greensboro, Greensboro, NC; Wake Forest University, Winston-Salem, NC

Context: Greater anterior knee laxity is known as a significant independent risk factor of anterior cruciate ligament (ACL) injury. Beyond mechanical restraint properties, the ACL also has an important role in the sensory system. Mechanoreceptors, located in the ACL, transmit the sensory signals to the central nervous system which influences the motor system to assist in stabilizing the knee joint. However, it is largely unknown where the brain processes sensory information from the ACL mechanoreceptors. The objective of this study is to identify brain activation during anterior knee joint loading designed to strain the ACL. We hypothesized that the brain regions related to receiving somatosensory signals will be activated during anterior knee joint loading.

Methods: Six healthy female college

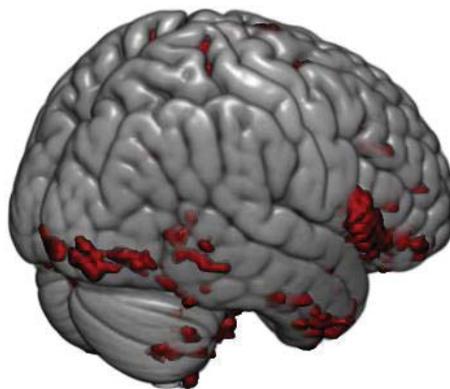
students (aged 26.8 ± 5 years, range 20-35) who are right-handed/footed without a history of current or severe lower leg injury or any neurologic disorders participated in this cohort study conducted at a university imaging center. While in a 3T magnetic resonance (MR) scanner, participants experienced anterior knee joint loading through a custom MR safe joint loading device, which was designed to simulate a Lachman's Test. Neuroimaging occurred during a block design that involved four 30s intermittent joint loading phases interleaved with five 30s rest phases. Functional magnetic resonance imaging (fMRI) of the blood oxygen level dependent (BOLD) signals representing 90 whole-brain volumes were obtained during the joint loading-rest phases. FSL software package processed fMRI data including alignment, normalization, filtering, and smoothing. First level individual analyses contrasted the BOLD signals of anterior joint loading phases with the rest phases. Second level group analysis assessed the average group effect. Significant clusters were identified a priori as $z > 2.3$.

Results: Absolute head motion during

the test was 0.36 ± 0.1 mm. Significantly activated brain regions included the inferior temporal gyrus ($Z_{max}=4.04$, cluster size=36153, voxels, $p<.001$), subcallosal cortex ($Z_{max}=3.69$, cluster size=533 voxels, $p<.001$), and visual cortex ($Z_{max}=3.12$, cluster size=394 voxels, $p<.001$) during joint loading phases compared to the rest phases. In Figure 1, the highlighted areas represent significant regions of brain activation.

Conclusions: This study demonstrated that experiencing anterior translation knee joint loading in a novel joint loading device resulted in increases in brain activation in areas associated with visual processing. Activation of visual processing regions during joint loading can be interpreted as an increase in the need for motion visualization when ACL is stressed. Understanding brain activation patterns during stressing ACL in a healthy population may serve as the foundation for future studies that aim to understand limitations in neural function in individuals with levels of knee laxity considered to be at greater risk of ACL injury. This knowledge may eventually lead to "brain-based" prevention programs.

Figure 1



Clinical Evaluation of Sport-Related Meniscal Pathologies: A Report From the Athletic Training Practice-Based Research Network

Jones KC, Marshall AN, Lam KC:
A.T. Still University, Mesa, AZ

Context: Little is known of the clinical presentation of meniscal pathologies during athletic training clinical practice or whether athletic trainers (ATs) are using best available evidence to facilitate the evaluation and diagnostic process. The objective of this study was to describe the clinical findings reported by ATs related to meniscal injuries and determine if ATs are using provocative tests best supported by current evidence. **Methods:** We retrospectively analyzed electronic patient records created by ATs between October 2009-October 2018 from 53 athletic training facilities (high school = 42, college = 8, clinic = 3) across 14 states. The participants were 137 ATs (female = 91, age = 29.4 ± 7.5 years, years certified = 4.8 ± 6.0 , years employed at site = 2.0 ± 4.2) within the Athletic Training Practice-Based Research Network. Initial evaluation forms from patient records were identified using ICD-9 diagnostic codes for meniscal pathologies (836, 836.1, 836.2 = medial, lateral, and unspecified acute meniscal tear, respectively; 717, 717.41 = medial and lateral old meniscal tear, respectively) and reviewed. Summary statistics (percentages, frequencies) were calculated to describe evaluation findings, including sex, sport, mechanisms of injury (MOI), active (AROM) and passive (PROM) range of motion, manual muscle test (MMT), and special tests. We also reported the percentage of patient cases with documented components of clinical clusters associated with meniscal pathologies (ie, history of catching/locking, joint line tenderness, pain with forced hyperextension, pain with maximal passive knee flexion, pain/audible click with McMurray's maneuver;

specificity=.90-.99, positive likelihood ratio=3.15-11.45, positive predictive value=76.7-92.3). **Results:** During the study period, 253 patients (male=167, age= 17.0 ± 2.3 years) were diagnosed with a meniscal pathology (acute meniscal tear=181, old meniscal tear=72). Patients were typically football (30.0%, n=76), soccer (15.0%, n=38), and basketball (11.9%, n=30) athletes who reported non-contact (30.0%, n=76), twisting (23.7%, n=60), and contact (21.7%, n=55) MOIs. Most patients were full-weight bearing (74.3%, n=188) and presented with joint line tenderness (76.4%, n=207), effusion (57.3%, n=145), and pain greater than 5 on the Numeric Pain Rating Scale (62.5%, n=158; mean= 4.9 ± 2.3). AROM and PROM were within normal limits for 48.0% (n=130) and 51.3% (n=139) of patients, respectively. Strength deficits (MMT $\leq 4/5$) were most commonly identified in the hamstrings (41.2%, n=61/148), quadriceps (38.2%, n=58/152), and adductors (29.6%, n=8/27). ATs frequently used McMurray's maneuver (positive=72.8%, n=139/193), Apley compression (positive=69.7%, n=69/99), Thessaly (positive=79.7%, n=55/69), and Apley distraction (positive=53.0%, n=35/66) tests. Only 7.1% (n=18/253) of patient cases had at least 3 out of 5 components of the clinical cluster associated with meniscal pathologies. **Conclusions:** These findings describe the clinical presentation of meniscal injuries during routine athletic training clinical practice. ATs appear to use special tests that are supported by evidence but do not use reported clinical clusters to aid the evaluation process of meniscal pathologies. The use and components of clinical clusters should be emphasized in educational efforts to improve efficiency and effectiveness of clinical evaluations.

Effects of Knee Injury History on Femoral Articular Cartilage Response Following a Competitive Rugby Season: A Prospective Observational Study

Hori M, Terada M, Suga T, Isaka T: Ritsumeikan University, Shiga, Japan

Context: Knee joint injuries have a significant impact on rugby players' performance and long-term joint health. Altered knee joint loading due to a knee joint injury are hypothesized to associate with deleterious changes in the macrostructure and cartilage composition of the femoral cartilage, potentially developing early onset of degenerative disease of the femoral cartilage. While previous studies showed that the femoral cartilage had response to change their structures after physical activity, it is unknown if knee injuries accelerate exercise-related deformation in the femoral cartilage. Understanding associations between knee injury and response of the femoral cartilage to sport will direct clinicians and researchers to determine optimal exercise-related strategies to mediate the risk of knee osteoarthritis. Therefore, the purpose of this study was to determine differences in femoral cartilage response following a competitive athletic season between collegiate rugby players with and without a history of knee joint injury. **Methods:** Using a prospective observational design, fifty-three male collegiate rugby players with a previous history of knee injury (age: 19.8 ± 1.4 , height: 173.9 ± 5.4 cm, body weight: 82.8 ± 12.2 kg) and fifty-five those without knee injury history (age: 19.7 ± 1.0 , height: 174.4 ± 6.9 cm, weight: 85.5 ± 11.5 kg) participated in this study. All athletes were cleared for full participation. A femoral cartilage ultrasonography assessment was performed before (pre-season) and following (post-season) the athletic season. The knee with a previous history was examined in the knee injury group, while a dominant limb was used for the control group. ImageJ software was used to assess femoral cartilage

thickness, cross-sectional area, and echo intensity. Femoral cartilage thickness was measured at the intercondylar notch and 1cm apart in the medial and lateral directions that were used as an estimate of the medial and lateral condyle cartilage thickness. The cross-sectional area was calculated as an area of cartilage between lateral and medial points where femoral cartilage thickness was measured. Echo intensity was evaluated the average gray-scale value across all pixels in the selected area on scale from 0 to 255. Absolute change scores of each ultrasonography cartilage outcomes were used to compare between pre- and post-season outcomes. Mann-Whitney tests were used to compare femoral articular cartilage response after the competitive season between collegiate rugby players with and without knee injury history. **Results:** The knee injury history group had smaller absolute changes in the lateral cartilage thickness ($0.23 \pm 0.48\text{mm}$) and cross-sectional area ($1.97 \pm 6.73\text{mm}^2$) compared to the control group (thickness= $0.42 \pm 0.50\text{mm}$, area= $4.33 \pm 7.01\text{mm}^2$) (thickness:p=0.020, area:p=0.019). There were no significant results for other ultrasonography outcomes ($p > 0.05$). **Conclusions:** We observed the knee injury history group had less deformation of the femoral cartilage compared to the control group. The results from this study indicate that there may be no additive influence of a previous history of knee joint injuries on exercise-related changes in the femoral cartilage.

Assessment of the Foundational Evidence Supporting the Efficacy of ACL IPPs: A Systematic Review

Huang YL, Mulligan CMS, Jung JH, Oh JK, Norcross MF: Oregon State University, Corvallis, OR; Korea National Sport University, Seoul, Korea

Context: A recent meta-analysis of meta-analyses (MAofMAs) concluded that ACL injury prevention programs (IPPs) reduce the risk of ACL injury by 50%. However, questions surround the validity of this risk reduction estimate given that the analysis did not exclude pooled data from studies using lower quality research designs- despite evidence that analyses limited to higher quality designs such as randomized controlled trials (RCTs) are associated with more conservative effect estimates. In addition, it is unknown whether the interventions evaluated in the original studies meet current best-practice IPP recommendations. Therefore, the purpose of this systematic review was to evaluate and quantify whether the original studies included in the MAofMAs

employed high-quality research designs and interventions that meet best-practice recommendations. **Methods:** The original interventional studies included in the MAofMAs were identified and full-text versions obtained. For each study, the first and second authors- blinded to author/journal- independently assessed: 1) the study design, and 2) whether the intervention used met best-practice recommendations of the NATA position statement on IPPs. **Results:** After removing duplicates, 15 original interventional studies included in at least 1 of the 8 meta-analysis reviews used in the MAofMAs were identified. One study not written English was excluded because it could not be assessed by the authors. Of these 14 original studies, only 43% (n=6) used Level 1 research designs (cluster- or true- RCTs). Only 57% (n=8) of the studies used interventions that met minimal NATA recommendations (Table 1). Most low-quality studies were published earlier and included in >6 meta-analyses. Plyometric (86%) and agility (79%) exercises were used most frequently in interventions, and 50% (n=7) of study interventions incorporated more than 3 exercise components. **Conclusions:** Though a recent

MAofMAs reported that ACL IPPs demonstrate a 50% reduction in injury risk, the current results raise concerns about the accuracy of the reported effect estimate. Given that: 1) 57% of the original studies included in the meta-analyses used in the MAofMAs were non-RCTs, and 2) the likelihood that these lower quality studies are over-represented in the MAofMAs analysis due to their inclusion in more of the 8 meta-analysis reviews used in the MAofMAs; the reported efficacy estimate could be overestimated. However, we also identified that just 57% of the original studies used interventions that meet the current NATA IPP recommendations. The inclusion of these interventions- that do not meet best-practice recommendations and therefore may not be as efficacious- into the analysis suggests that the reported efficacy estimate could be underestimated. A future meta-analysis that is limited to original studies with high-quality designs and interventions that meet best-practice recommendations is needed to address these concerns and improve confidence in the estimated magnitude of the preventative effect of IPPs for reducing ACL injury risk.

Table 1: Multi-Component Breakdown of ACL Injury Prevention Programs

Author	# of MAs ^b included in	Strength	Plyometrics	Agility	Balance	Flexibility	Feedback Provided	Meets NATA ^c
Caraffa (1996)	1/8	Yes	No	No	Yes	No	No	No
Hewett (1999)	8/8	Yes	Yes	Yes	No	Yes	Yes	Yes
Heidt (2000)	7/8	No	Yes	Yes	No	No	Unclear	No
Soderman (2000) ^a	6/8	No	No	No	Yes	No	No	No
Myklebust (2003)	7/8	No	Yes	Yes	Yes	No	Yes	Yes
Petersen (2005)	8/8	No	Yes	No	Yes	No	Yes	No
Mandelbaum (2005)	7/8	Yes	Yes	Yes	No	Yes	No	No
Olsen (2005) ^a	5/8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pfeiffer (2006)	6/8	No	Yes	Yes	No	No	Unclear	No
Gilchrist (2008) ^a	5/8	Yes	Yes	Yes	No	Yes	Yes	Yes
Steffen (2008) ^a	4/8	Yes	Yes	Yes	Yes	No	Yes	Yes
Pasanen (2008)	2/8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LaBella (2011) ^a	4/8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Walden (2012) ^a	3/8	Yes	Yes	Yes	Yes	No	Yes	Yes
Total # of studies: 14		9/14 (64%)	12/14 (86%)	11/14 (79%)	9/14 (64%)	6/14 (43%)	9/14 (64%)	8/14 (53%)

^a Studies are either cluster- or true- randomized control trials; ^b MA: meta-analysis used in meta-analysis of meta-analyses; ^c Meets NATA Position Statement on Prevention of ACL Injury minimum recommendations by including technical feedback and exercises from at least 3 of the following exercise categories: strength, plyometrics, agility, balance, and flexibility.

Effect of Delayed Anterior Cruciate Ligament Reconstruction on the Medial Meniscus: A Critically Appraised Topic

Lounsbury H, Durnin E, Scibek J, McGovern R, Beidler E: Duquesne University, Pittsburgh, PA

Context: To limit secondary injuries for ACL-deficient patients, optimal timing for anterior cruciate ligament reconstruction (ACLR) should be defined. The purpose of this critically appraised topic was to answer the question: Is there an increased risk of medial meniscal injuries associated with delayed ACLR as compared to early reconstruction in ACL deficient patients?

Methods: The PICO for this project was Patient: Active persons with ACL deficiency, Intervention: Early ACLR, Comparison: Delayed ACLR, and Outcomes: Risk of meniscal injury. Using the phrase “ACL reconstruction AND meniscal tears”, PubMed, CINAHL, Medline, Cochrane Library, and SPORTDiscus were searched. Hand searches were also conducted. Article inclusion criteria included articles written in English and published after 2007 in peer-reviewed journals, articles noting outcome measures associated with meniscal injury risk, and anterior cruciate ligament reconstruction studied at 3 months and later. Exclusion criteria included meta-analyses, systematic reviews, delayed reconstruction time frames longer than 2 years, subjects deciding to avoid repairing their ACL (copers), and subjects who had multi-ligamentous knee injuries. All articles selected included data that evaluated meniscal injury rates in relation to ACLR, while also meeting the inclusion criteria. Summary measures identified in the selected articles included odds ratios (OR), P-values, and confidence intervals (CI), which allowed for the comparison between the effects of early and delayed ACLR on medial meniscal injury rates. To appraise the evidence each article was scored using the PEDro scale and was evaluated based

upon the Centre for Evidence-Based Medicine (CEBM) evidence hierarchy. The search yielded 467 articles; three articles were selected based on the selection criteria. **Results:** Anderson & Anderson found a statistically significant relationship between time-to-surgery and medial meniscal tears ($P = .007$), as well as an increased odds estimate in the delayed surgery group ($OR = 3.51$; 95% CI, 0.79-15.6). Chhadia et al. also noted a relationship between time-to-surgery and medial meniscal injury, ($OR = 1.81$, 95% CI, 1.29-2.54, $P = .001$). Michalitsis et al. identified a 6% increase in medial meniscal injury every year post-injury ($OR = 1.06$, 95% CI, 1-1.13, $P < .05$), as well as a 9% increase in meniscal tears between the early and delayed reconstruction groups. An assessment of article quality revealed two articles having a CEBM level of 3 and one article being rated as level 2. PEDro scores ranged from 4-5 for each article. **Conclusions:** Delaying ACLR surgery, 3-months post-injury or longer, greatly increased the risk for medial meniscal injury in ACL deficient patients. Therefore, it is recommended that ACL deficient patients undergo ACLR within 3-months of injury. While research should continue to examine the relationship between time-to-surgery and medial meniscal injury, additional efforts should examine pre-surgery ACL rehabilitation programs that limit medial meniscus stress and meniscal injury risk.

Patient Reported Outcomes for Use of Platelet Rich Plasma in the Treatment of Post Surgical Pain

Miller MM, Baria MR: The Ohio State University, Columbus, OH

Context: Platelet rich plasma (PRP) injection is a safe orthobiologic treatment used to stimulate a controlled inflammatory response in injured tissue with the goal of healthy tissue regeneration and is available to patients in most sports medicine clinic settings. It is sometimes the case that despite regaining full strength and range of motion after successful rehabilitation athletes may still wrestle with residual pain that is difficult to control. The purpose of this abstract was to examine clinical cases in which platelet rich plasma was used to treat continued post-injury pain in elite level athletes using validated patient reported outcomes (PRO) questionnaires

Methods: Five NCAA Division 1 collegiate athletes were referred to the clinic seeking treatment for continued pain after injury rehabilitation and symptoms were monitored for response to PRP injection. As all patients within the clinic receiving PRP injections, the 5 athletes were given an extremity appropriate PRO questionnaires the day of injection for a baseline reading and again at their 1 and 3 month follow-up visits. The International Knee Documentation Committee (IKDC) questionnaire was used for 3 of the 5 athletes seeking treatment for knee pain, the Victorian Institute of Sport Assessment - Achilles (VISA-A) was used for 1 athlete seeking treatment for insertional tendonitis, and the QuickDASH was used for one athlete seeking treatment for acute onset ulnar collateral ligament sprain. Data were collected in the clinical setting as part of standard treatment practices and analyzed as individual case reports.

Results: Four of the five athletes fully returned to self-reported pre-injury performance level. The same four of five athletes reported a decrease in pain and demonstrated PRO questionnaire improvement: IKDC scores 64 -> 79.3 and

73.6 -> 89.3; VISA-A score of 20 -> 77, and QuickDASH score of 31.8 -> 6.8. The fifth athlete saw IKDC score improvement of 57.5 -> 74.7 and reported a reduction in pain, however was unable to return to previous performance level due to post-surgical knee effusion that proved difficult to manage. None of the athletes reported adverse events during or following their PRP injection. **Conclusions:** When working with elite level athletes post-injury, it can be disheartening to wrestle with continued pain despite successful rehabilitation resulting in full strength, range of motion, and agility. Platelet-rich plasma injection therapy is a safe and potentially effective treatment option for such situations.

Cognitive Training Improves Joint Stiffness Regulation and Knee Function in ACLR Patients

An YW, DiTrani Lobacz A, Baumeister J, Rosen J, Swanik CB: New Mexico State University, Las Cruces, NM; Neumann University, Aston, PA; University of Paderborn, Paderborn, Germany; University of Delaware, Newark, DE

Context: Growing evidence has suggested that functional joint instability following an anterior cruciate ligament reconstruction (ACLR) may be associated with cognition and emotional regulation. Cognitive training is employed for emotional regulatory interventions, but may also improve executive functions necessary for preparatory and reactive dynamic restraint mechanisms during high velocity athletic maneuvers. However, the influence of cognitive training on joint stiffness regulation and knee function outcomes in ACLR patients has not been tested. **Objective:** To examine the effects of cognitive training on joint stiffness regulation in response to negative visual stimuli and knee function in ACLR patients compared to healthy controls. **Methods:** **Design:** Pretest-posttest study. **Setting:** Neuromechanics laboratory. **Patients or Other Participants:** Sixteen unilateral ACLR patients (22.2 ± 3.9 yrs, 74.4 ± 27.5 kg, 166.2 ± 10.8 cm) and 17 healthy Controls (24.5 ± 5.0 yrs, 62.5 ± 12.6 kg, 166.0 ± 8.8 cm) with no history of knee injury volunteered. **Interventions:** All participants received four weeks of online cognitive training. Joint stiffness during emotionally evocative visual stimuli (neutral, fearful, knee injury-related pictures) and a single-legged hop task were compared before and after the intervention. For the joint stiffness task, participants were instructed to relax and immediately resist to a sudden knee flexion perturbation (30° to 70°) and an acoustic startle (100dB, 10ms duration, 1000Hz) was applied 100ms prior to the perturbation to replicate an unanticipated event.

Main Outcome Measures: Mid-range (0-20°) normalized knee joint stiffness (Nm/°/kg) was compared across picture types (NEU, FEAR, INJ) and time (PRE, POST) within each group. The single-legged hop for distance (percent of healthy limbs) was compared across time (PRE, POST) and groups (ACLR, CONT). **Results:** A significant time by picture type interaction effect for mid-range stiffness was observed in the ACLR (F[1.415,16.986]=4.908, p=0.030), but not in the CONT (F[1.477,16.243]=0.114, p=0.833). The ACLR produced greater stiffness in response to FEAR (p=0.024, 0.028±0.021) and INJ (p=0.017, 0.031±0.025) than NEU pictures (0.016±0.013) before the cognitive training, while there were no post-intervention stiffness differences within emotion types (p=0.584, NEU:0.018±0.016, FEAR:0.022±0.013, INJ:0.017±0.011). A significant time by group interaction effect for the single-legged hop for distance (F[1,27]=4.319, p=0.047) revealed that the ACLR group improved the single-legged hop for distance after cognitive training (p=0.024, PRE: 93.15±9.07, POST: 96.66±6.14), while the healthy group had no improvement (p=0.161, PRE: 100.58±5.57, POST: 88.60±33.41). **Conclusions:** Because enhanced executive function may facilitate neural processing necessary for both emotional regulation and neuromuscular control, cognitive training may help reduce joint stiffness dysregulation associated with emotionally arousing images and unanticipated events, thereby improving knee function in ACLR patients.

Relationship Between Quadriceps Corticomotor and Neuromechanical Function After ACL Reconstruction

Scheurer SA, Glaviano NR, Ingersoll CD, Norte GE: The University of Toledo, Toledo, OH

Context: Impaired corticomotor function has been observed following ACL reconstruction (ACLR), and is theorized to perpetuate long-term muscular dysfunction. Understanding the relationship between centrally-driven neurological adaptations and unique neuromechanical characteristics will provide insight about the functional implications of impaired corticomotor function. Our objective was to compare quadriceps corticomotor and neuromechanical function between patients after ACLR and healthy controls, and assess the relationship between corticomotor and neuromechanical function.

Methods: This cross-sectional study was performed in a university laboratory. 15 patients with a history of primary, unilateral ACLR (7 female, age: 20.2 ± 1.7 years, height: 174.8 ± 9.4 cm, mass: 79.6 ± 19.6 kg, time from surgery: 35.1 ± 26.6 months) and 15 healthy individuals (7 female, age: 20.9 ± 1.7 years, height: 175.3 ± 7.5 cm, mass: 76.4 ± 9.4

kg) participated. Independent variables included group (ACLR, healthy) and limb (ACLR, contralateral). Knee extension maximal voluntary isometric contractions (MVIC) were performed bilaterally on a stationary dynamometer at 90° knee flexion. Participants were instructed to kick out as hard and fast as possible, and performed the task with visual feedback and verbal encouragement. Surface EMG recorded motor evoked potentials in the vastus medialis elicited by transcranial magnetic stimulation delivered over the motor cortex contralateral to the ACLR (or matched healthy) limbs. Corticomotor function was quantified by the active motor threshold (AMT, %) for the ACLR and matched control limbs. Neuromechanical function was quantified by the electromechanical delay (EMD, milliseconds), early (RTD0-100ms, Nm/kg/s) and late (RTD100-200ms, Nm/kg/s) rate of torque development, torque coefficient of variation (CV, %), and MVIC torque (Nm/kg). Between- and within-group comparisons were performed using independent and dependent t-tests, respectively. Cohen's d effect sizes were calculated to assess the magnitude of differences observed. Pearson's r correlations were used to assess the relationship between AMT and each

measure of neuromechanical function ($\alpha = 0.05$, $1 - \beta = 0.80$). **Results:** AMT was higher in ACLR limbs compared to matched control limbs (ACLR: $45.3 \pm 8.5\%$ vs. healthy: $29.3 \pm 8.0\%$, $P < .001$, $d = 1.7$ [0.8, 2.6]), indicating lower corticomotor excitability. Late RTD100-200ms (ACLR: 0.007 ± 0.002 Nm/kg/s vs. contralateral: 0.008 ± 0.002 Nm/kg/s, $P = 0.005$, $d = 0.6$ [0.1, 1.3]) and MVIC torque (ACLR: 2.4 ± 0.5 Nm/kg vs. contralateral: 2.8 ± 0.6 Nm/kg, $P = 0.005$, $d = 0.7$ [0.0, 1.5]) were lower in ACLR limbs compared to contralateral limbs. Higher AMT was associated with lower early RTD0-100ms in the ACLR group ($r = -0.457$, $P = 0.043$) (Figure 1). **Conclusions:** Lower corticomotor excitability is related to a slower rate of torque development during the early phase of force generation in patients with a history of primary, unilateral ACLR. Early RTD is governed by neural factors, such as motor unit recruitment and discharge rate, which may explain its relationship with corticomotor excitability. The ability to rapidly generate quadriceps torque is important to resist perturbation, produce dynamic stability, and attenuate joint forces during early loading, when the potential for ACL strain is greatest.

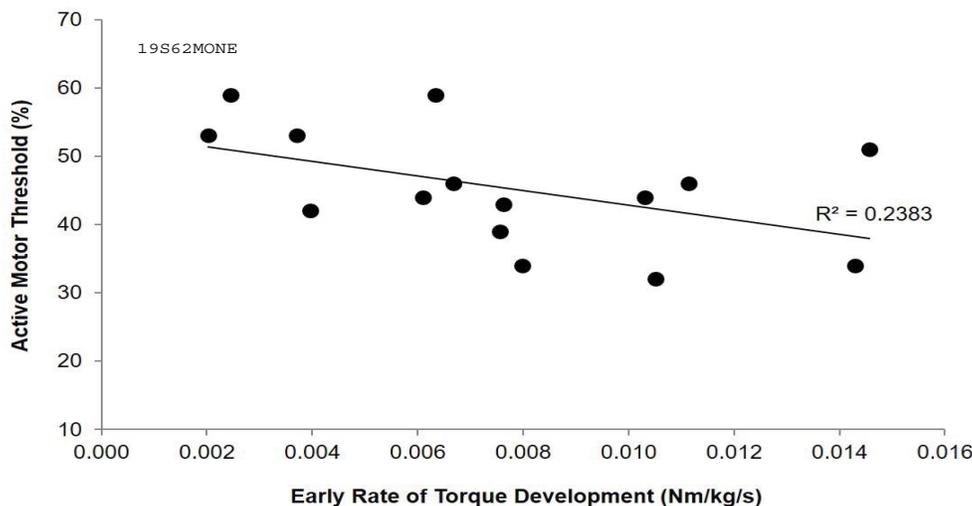


Figure 1. Correlation between vastus medialis active motor threshold (corticomotor excitability) and early rate of torque development during the first 100 milliseconds of a knee extension maximal voluntary isometric contraction (ACLR limb only).

Free Communications, Poster Presentations: Acute Upper Extremity Case Studies

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;
Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Posterior Shoulder Instability in a Professional Basketball Player: A Level 3 CASE Report

Anumba MC, Citriniti A, Decker-Hamm M: The University of Texas at Arlington, Arlington, TX; Baylor Scott & White Sports Performance Center, Frisco, TX

Background: Posterior shoulder instability accounts for about 5% of all shoulder instability. Imaging has confirmed that 86% of cases are found to have a Reverse Hill-Sachs lesion accompanying posterior instability. Course of treatment, either surgical or conservative, depends on the size of the bony lesion; however, surgery is most often recommended as the first treatment option. Conservative treatment has been used with a stable glenohumeral joint and a defect of less than 25% of the articular surface. Conservative treatment can have positive results, as seen in this Level 3 CASE Study, but 65% to 80% of cases show recurrent posterior dislocation. **Patient:** A 26-year-old professional, right hand dominant male basketball player, with a previous history of two left shoulder subluxations, presents with left shoulder pain during a basketball game. The injury occurred as the athlete reached for a loose ball and collided into another player, resulting in a pop sensation in his shoulder. The athlete was evaluated by the team athletic trainer (ATC) and team physician. Common findings from both evaluations were painful and decreased external and internal rotation strength and decreased range of motion (ROM) with abduction and flexion of the left shoulder. The following special tests provided a positive response: Kim test, Jerk test, and Sulcus sign. After the exam, the physician requested an X-ray and MRI with contrast. The results revealed a left posterior shoulder subluxation, Reverse Hill-Sachs lesion, and humeral avulsion of the posterior band of the inferior glenohumeral ligament.

The team surgeon recommended surgery, however the athlete decided to obtain two other opinions, of which one recommended surgery and the other recommended conservative treatment. **Intervention or Treatment:** The athlete decided to rehabilitate his shoulder in an effort to return with enough time to complete the season. The athlete was immobilized for one week post-injury and rehabilitation in the following weeks focused on ROM, strengthening of shoulder stabilizers, and cardiovascular conditioning. During week 4, the athlete began non-contact practice, followed by a week of light contact practice. Full contact practice began at week 6 and the athlete returned to play at week 7. According to the literature, rehabilitation should focus on restoration of scapulothoracic and glenohumeral kinematics, control, and function. The athlete's rehabilitation was in line with the recommendations for conservative treatment of posterior shoulder instability, which is to restore shoulder stability. **Outcomes or Other Comparisons:** There lacks evidence about the most appropriate conservative treatment for posterior shoulder instability. The general consensus from the literature states that 6 months of rehabilitation can be beneficial; however, the athlete in this case safely returned after 7 weeks of intensive rehabilitation. **Conclusions:** Posterior shoulder instability is rare in the athletic population, other than in football players during blocking, and the most common treatment is surgical intervention. According to the literature and the shoulder specialist, the desired course of treatment should have been an open repair in order to visualize the full extent of shoulder damage. This case report presents a professional basketball player with posterior shoulder instability who chose conservative rehabilitation in order to complete his basketball season. **Clinical Bottom Line:** From a rehabilitation perspective, the consensus for success with conservative

treatment is based on size of bony lesion and overall ability to maintain shoulder stability. However, other than those recommendations, there is no clear protocol for conservative management of posterior shoulder instability. This case highlights the possibility of such non-surgical management based off impairments and presentation. Further investigation into the most effective conservative approach and time to return to play is needed.

Acute Subluxation and Multi-Directional Instability in a Male, Collegiate Basketball Patient: A Level 3 Exploration Case Study

Burton CA, Rivera MJ, Powden CJ: Indiana State University, Terre Haute, IN

Background: This level 3 exploration case study describes a patient with multi-directional instability and acute subluxation. The patient previously experienced five subluxations over a six-year period. No activity limitations or healthcare intervention was sought, although literature indicates rehabilitation or surgical intervention in similar cases. **Patient:** A 19-year-old male basketball patient presented with right shoulder pain. The patient stated that the pain progressively worsened over the previous week with no history of injury. Initial evaluation noted anterior shoulder pain increasing after upper extremity activity, point tenderness in the upper trapezius and bicipital groove, AROM equal bilaterally, manual muscle testing (MMT) of rotator cuff (RC) musculature=4/5, positive External Rotation Lag Sign, positive Internal Rotation (IR) Lag Sign, negative Biceps Load, and negative Piano Key. The patient was educated on risk of further injury and activity modifications but still requested to practice that day. Shortly into practice the patient requested to be removed from activity due to increased pain. Patient was re-evaluated, which noted considerable disability assessed via Disability of the Arm, Shoulder and Hand-Quick (QuickDASH) and

QuickDASH-Sport (Table 1). The patient also demonstrated decreased shoulder AROM, scapular dyskinesis during pain-free AROM, RC weakness, positive Load and Shift, negative Apprehension Test, and positive Sulcus Sign with the patient reporting subluxation during test (Table 1). Following physical examination conclusion, guided questioning revealed non-disclosed episodes of five subluxations over a six-year period, the most recent occurring four days ago. No previous episode resulted in time loss from activities. Initially, RC tendinopathy was suspected due to no mechanism reported. Upon re-evaluation, clinical diagnosis changed to multi-directional instability with possible capsular strain and RC tendinopathy. **Intervention or Treatment:** Following re-evaluation, the patient was removed from activity and began conservative intervention of passive-assisted ROM, isometric strengthening, grade I Maitland mobilizations, and ice for pain control. Radiographic imaging demonstrated a healthy glenohumeral joint. Objective ligamentous laxity was noted by an orthopedic physician who diagnosed the patient with multi-directional instability. The patient was prescribed conservative intervention and a Sully® brace at the patient’s request. Patient progressed through ROM, strengthening, and functional rehabilitation without complication. At four days post-evaluation the patient presented with improved outcomes (Table 1) and completed functional progression. The patient refused to use the Sully® brace due to discomfort and neurological impairment to the Ulnar Nerve distribution. Patient continued activity restriction

and conservative rehabilitation for four more days before fully returning to activity. After consultation with another athletic trainer, a regional interdependence (RI) evaluation was utilized. Muscle energy techniques (MET) and mobilizations were rendered to the sacroiliac joint (SIJ) and cervical spine. MET for the SIJ addressed innominate up slips, down slips, and anterior rotations dependent on daily clinical presentation, while mobilization techniques addressed posteriorly positioned femur in the acetabulum and “locked SIJ” limiting lateral glide of the hips. An atlanto-occipital joint release was performed using cervical spine MET. After three RI interventions, further improvement of clinical outcomes were noted (Table 1). **Outcomes or Other Comparisons:** The patient and clinician-rated outcomes used assessed similar levels of disability compared to previous literature utilizing conservative treatments for multidirectional instability (Table 1). **Conclusions:** Further evaluation led to appropriate diagnosis and thorough plan of care. The patient completed conservative care and returned to full activity with no setbacks. Systematic evaluation and interventions applied at non-pathological sites aided in improving patient end-stage function. **Clinical Bottom Line:** Thorough history with clinician-guided questions improves quality of care. Conservative intervention for multi-directional instability is favorable for patients who quickly recover from subluxation episodes. With difficult patient cases, evaluation and intervention with an RI model may enhance quality of care.

Table 1. Main Outcome Measures Assessed Throughout the Treatment Plan.

	Day 1	Day 4	Day 14	Day 16
AROM	Flexion=85°, Abduction=80°, Internal rotation=45°, external rotation=85°	Full ROM, discomfort at end-range	Full ROM, discomfort at end-range	Full ROM, pain-free
MMT	RC musculature=3/5	RC musculature=5/5	RC musculature=5/5	RC musculature=5/5
QDASH	50.00	20.45	27.27	4.55
QDASH Sport	75.00	18.75	31.25	6.25
Lift Off	-	-	1cm	6cm
Apley Scratch (IR)	-	-	T7	T3

Abbreviations: QDASH: Disability of the Shoulder, Arm, and Hand Quick Version; RC, rotator cuff; IR internal rotation; Lift Off, Gerber’s lift off test.

Acromioclavicular Joint Sprain in a College Football Athlete

Fouda R, Craddock J: Florida Gulf Coast University, Fort Myers, FL

Background: This is a level 3 validation clinical case study of an athlete who sustained a grade III acromioclavicular joint sprain. In this case, the athlete sustained the injury by getting hit on the lateral part of his shoulder and arm while his arm was at his side. The initial treatment was putting the athlete in a sling for three days, then going the nonoperative route by starting a progressive rehabilitation which consisted of range of motion exercises, strengthening exercises, and sport-specific activities. This case is unique because it is a grade III sprain that had no damage to any other structures. Another interesting aspect of the case is that this athlete had full strength as well as range of motion and was able to return to play after three weeks of rehabilitation. It was also interesting that he did not need any operative treatment to repair the acromioclavicular ligament. **Patient:** The athlete is an 18-year-old male college football athlete who was diagnosed with a grade III acromioclavicular joint sprain. He has no prior medical history of any shoulder issues. The athlete complained that he hurt his shoulder after he got hit during a play. During the observation portion of the initial evaluation, there was an obvious deformity at the acromioclavicular joint. Athlete was point tender and did not have full active range of motion or full strength. Strength showed to be a 2/5 in all directions. Differential diagnosis includes acromioclavicular joint sprain, clavicle fracture, clavicular contusion. acromioclavicular joint Shear test (+), acromioclavicular joint distraction test (+), acromioclavicular joint Piano Key test (+), and palpation revealed no signs of a fracture. **Intervention or Treatment:** The athlete was removed from competition and put in a sling for three days. After this initial immobilization of the affected arm, the athlete completed a rehabilitation program over the next

three weeks which followed a progression of basic range of motion exercises with the goal of increasing range of motion before moving on to the next part of rehabilitation. During this phase of the rehabilitation program, the athlete used ice and electrical stimulation that was on the premod setting to treat pain. Next was the strengthening exercises, which the athlete did until he was ready to be tested for his performance during sport specific activities. After this progression through rehabilitation, he was able to return to play with no issues. **Outcomes or Other Comparisons:** The athlete had great success following this method of rehabilitation which focused first on immobilization, basic range of motion exercises, strengthening and testing how well the athlete can perform sport specific exercises before returning to play. At the end of the rehabilitation, the athlete had full active range of motion, full strength and reported no pain. **Conclusions:** This clinical case highlights the non-operative process this athlete followed for the diagnosis, to the initial treatment, rehabilitation exercise progression, and return to play of an athlete with a grade III acromioclavicular joint sprain, which took three weeks. The athlete in this case did not take much time to recover from this injury. **Clinical Bottom Line:** The athlete in this case study presented with a grade III acromioclavicular joint sprain, whose progression through a rehabilitation protocol that was faster than expected but saw great success through a non-operative method of treatment and rehabilitation.

Bilateral Sternoclavicular Joint Reconstruction in a Collegiate Swimmer With Chronic Sternoclavicular Joint Instability

Mundy HM, Fernandes O, Martin BM, Millett PJ: The Steadman Clinic, Vail, CO; Steadman Philippon Research Institute, Vail, CO

Background: Chronic sternoclavicular(SC) joint instability can lead to pain and functional limitations in the athletic population. Treatment for SC joint injuries varies, and adequate management is important for long-term outcomes. Conservative management is recommended prior to surgical intervention. This level 3 CASE study addresses a collegiate upper extremity athlete diagnosed with bilateral SC joint instability, with failed conservative treatment for 4+ months. **Patient:** 19 year-old female, collegiate-level, freestyle swimmer experienced pain, popping, and instability with swimming and weight lifting. Initial symptoms began after front squatting, with popping near her collar bone. The right-side had greater a pain than the left. Conservative treatment included 4 months resting from swimming and weight training, focusing on rehabilitation. After returning to sport, her symptoms continued. Physical exam by the athletic trainer revealed no gross deformity of SC joints. Right SC joint had palpable instability with elevation and adduction of the upper extremity and mild TTP over the joint. Left SC joint had less instability compared to the right, but mildly increased TTP. Patient had full, pain free glenohumeral ROM and strength bilaterally. Radiographs revealed no SC joint arthritis or dislocation. MRI revealed no evidence of SC joint dislocation or arthritic changes, possible tearing of the sternoclavicular disk on the right side, and limited evidence of disk tearing on the left side with mild sclerosis, osseous ridging and possible slight bone signal about bilateral SC joints. CT Angiogram was obtained to examine surrounding vasculature. **Intervention or Treatment:** Initially, conservative treatment included ice, decreased activity, bracing, anti-inflammatories, PT, chiropractic care, acupuncture, and PRP injections over 4 months. Treatments were ineffective, therefore the

patient sought another opinion and opted for surgical intervention. Right SC joint reconstruction with Gracilis autograft, and left SC joint PRP injection was first performed. No improvement in symptoms of the left SC joint led to left SC joint reconstruction with Gracilis autograft, performed 3 months later.

Outcomes or Other Comparisons:

Following surgery of the right SC joint, the patient was placed in a sling for 6 weeks, with unrestricted hand/wrist/elbow ROM. The patient was able to begin PROM of the shoulder at 6 weeks, and AROM without limitations at 6-8 weeks with no excessive protraction or retraction of the shoulder girdle. At 8 weeks post-operative, the patient reported significant progress with PT and satisfaction with the results, yet was having persistent symptoms on the left SC joint, limiting her PT. Left SC joint reconstruction was then performed. Following surgery of the left SC joint, the patient was assigned the same sling and motion restrictions. At 8 weeks, the patient was cleared to begin kicking in the pool, with intention of full return to swimming at 16 weeks. At 4 months follow-up for the left SC joint, the patient reported no complaints and felt stable with full ROM. The patient was cleared to begin a return to swim protocol. At 8 months post-operative left-side, the patient was progressing well with return to swim.

Conclusions: SC joint instability can present acutely or chronically. Chronic instability can be managed with rehabilitation; surgical intervention is also an option especially for upper extremity athletes. It is important to assess SC joint stability in athletes experiencing pain on or near the collar bone/sternum. Chronic SC joint instability may be overlooked by an athletic trainer that is not aware of the condition. Surgical outcomes for chronic incidences have shown success in returning an athlete back to a high level of upper extremity sport. **Clinical Bottom**

Line: Athletic trainers should recognize that SC joint instability should first be addressed with conservative treatment, however if this fails, surgical intervention is an option.

**Outpatient Clinic Setting:
Thoracic Pain in a Recreational
Weightlifter**

McClelland JM, Zaremski JL:
University of Florida, Gainesville,
FL

Background: Patient is a 25-year-old male with three-year history of right sided thoracic pain in area of trapezius and rhomboids. Initial injury occurred in 2015 while completing an upper body work out including weighted pull-ups and rows. He began experiencing pain along medial border of right scapula. He was evaluated and treated for a right trapezius strain with physical therapy and rest. Over the course of three years symptoms would temporarily improve with rest and manual therapy, but symptoms would return following upper body training such as rows and pull downs. In 2018 patient presented to the outpatient orthopaedic clinic where he was evaluated by the athletic trainer. No signs of atrophy or abnormalities to posterior scapulothoracic region were noted on visual inspection. Patient was tender to palpation along the medial border of the right scapula without erythema or swelling. No scapular dyskinesis was observed on the right and symmetric to the left. Active range of motion and strength were full and symmetric throughout bilateral upper extremities. Symptoms were exacerbated with scapular retraction based activities such as rows and pull downs. Based on the examination and history, a MRI of thoracic spine and scapula was recommended to rule out a posterior right rib and/or scapular bony abnormality. **Differential Diagnosis:** Thoracic spine stress reaction/fracture, rhomboid strain, scapulothoracic bursitis, stress reaction of posterior right rib(s), and stress fracture of scapula. **Treatment:** Physician concurred with initial assessment and MRI of thoracic spine and scapula was ordered. MRI revealed marrow edema along the medial border of the scapula reflecting stress reaction with no clear fracture line. Initial treatment included strict rest. Patient was

instructed to refrain from any upper body lifting for 4-6 weeks, specifically no retraction to minimize activation of the rhomboids. Symptoms improved at 6 follow up visit and patient was referred for a biomechanical assessment and physical therapy focusing on retraction exercises. Recommendations included low weight lifting regimen and resistance band exercises for 6 weeks. While patient's symptoms improved with three months of rest and physical therapy, he continued to experience pain at inferior angle of the scapula. Patient was referred at this time for CT guided scapulothoracic bursa injection for diagnostic purposes and continuation of physical therapy. Patient felt symptoms were improving enough that he declined to complete the injection. Physical therapy recommendations were to start at 25% of previous weight lifting regimen before injury and progress 25% every 2 weeks as symptoms allowed. Patient was able to progress back into normal daily exercise routine with treatment plan and no further symptoms.

Uniqueness: Scapular stress fractures are extremely rare.^{1,2} This pathology has been reported in overhead athletes participating sports requiring repetitive upper extremity stress such as golf, tennis, baseball, and rowing. Scapular stress reactions involving the acromion, coracoid, scapular spine, body of the scapula, and lateral border of the scapula are more commonly reported. This specific case is unique given this patient was not an overhead athlete, and stress reaction at the medial border of the scapula is extremely rare. **Conclusions:** Our patient's symptoms were misdiagnosed for three years due to rarity and presentation of symptoms. History of repetitive load to the shoulder and posterior chain, while rare, scapular stress reactions should be considered as a differential diagnosis. With a proper diagnosis and appropriate progressive management, our patient was able to return to exercise with little to no symptoms.

The Evaluation and Treatment of Scapular Body and Coracoid Process Fractures in a High School Football Athlete: Level 4 CASE Study

Harpestad AL, Hall EA, Tritsch AJ:
University of South Florida, Tampa, FL

Background: This case involves an 18-year-old male high school football player who presented with left shoulder pain after attempting to tackle an opponent during a varsity football game. He immediately complained of pain following direct contact with his shoulder against the opponent's chest. On-field examination by the athletic trainer revealed no obvious deformity of the shoulder and ROM was limited due to pain. Team physician performed a more thorough exam and found that the athlete was tender over the posterior glenoid and the acromioclavicular (AC) joint, no swelling or ecchymosis was present. He had pain in all planes of motion, external rotation and flexion being most intense, but had normal strength in all planes. AC compression test was negative but anterior and posterior load and shift test was positive for pain. These were the only tests performed due to athlete's pain level. Athlete was placed in a sling and referred to the emergency department for imaging. **Differential Diagnosis:** Shoulder subluxation, labral tear, humeral head fracture, AC ligament sprain. **Treatment:** Immediate referral for an X-ray to rule out a fracture was recommended by the physician the night the athlete was injured. X-ray confirmed a nondisplaced fracture of the scapular body. Follow-up imaging of a CT scan further confirmed a hairline fracture in the scapular body, and a comminuted fracture of the coracoid process, resulting in an 8mm displacement. Due to the nondisplaced scapular fracture, a conservative route of treatment was taken. Athlete was directed to remain in the sling for 6-8 weeks and was restricted in all shoulder motions but was permitted to elbow and wrist motions. About 3.5 weeks

post-injury, a Disabilities of the Arm, Shoulder, and Hand (DASH) score was completed and scored at 53.3/100. At the 4 week post-injury follow-up, the physician took new images, declared that the bones were healing well, and allowed the athlete to begin working on ROM exercises. By week 5 post-injury, the athlete had full, pain-free ROM and began strengthening exercises for the rotator cuff muscles and deltoid. Agility and cardio drills relevant to his position were added to the treatment plan at 7 weeks post-injury. Athlete's final DASH score at 9 weeks post-injury was 2.5/100. Final X-ray at 9 weeks post-injury confirmed that the scapular body fracture was completely healed but the coracoid process fracture still had a 2mm dissociation. After discussing the risks of participating with a fracture, physician gave the athlete clearance to participate in full-contact practice for two weeks and, if no complications occur, participate in a game. Unfortunately, the athlete reinjured himself unrelated to this case 3 days prior to the game and was unable to participate. **Uniqueness:** A fracture to the scapula is a rare occurrence due to the high amount of force needed, which is commonly seen in motor vehicle accidents or high falls. Fractures to the scapula only represent 1% of all skeletal fractures, while coracoid process fractures represent 2% to 13% of all scapular fractures. Not only is the injury itself unique, but the mechanism of injury did not raise any suspicion to this diagnosis. **Conclusions:** Despite the rareness or prevalence of any injury, athletic trainers should consider all diagnoses as a possibility. Perhaps a clinical prediction rule, similar to the Ottawa Ankle Rules, could be created to determine the need for diagnostic imaging at the shoulder complex. If the CT scan was not performed, the coracoid process fracture may have been overlooked which could have led to complications during the treatment plan.

Biceps Tendon Pathology in a Minor League Baseball Athlete Smith LJ, Craddock JC: Florida Gulf Coast University, Fort Myers, FL

Background: Athlete is a 24 year-old (180.3 cm and 99 kg) male minor league baseball pitcher. Athlete's previous medical history includes a right knee ACL, medial and lateral meniscus tear that was surgically repaired and right shoulder pain that was treated conservatively. The athlete's chief complaint was right anterior and lateral shoulder pain over the biceps tendon similar to the pain he experienced previously. Athlete stated that his pain is a 10/10 while he is warming up and in the late cocking to acceleration phases of throwing. The athlete reported decreased symptoms after warming up however, it has been taking him longer to warm up. Athlete later disclosed that his initial pain never went away as he reported it did after completing rehabilitation for his shoulder pain. The athlete disclosed that his pain remained a 7/10 over the course of the season following his initial assessment. Athlete reports having no symptoms with non-baseball activity with no neurological symptoms noted. The athlete's shoulder ROM was normal other than shoulder flexion which was greater than 180 on both arms. Bilateral MMT equal but right shoulder symptoms increased with shoulder internal and external rotation. All special tests on the left shoulder were negative, however on the right shoulder there was a (+ for pain) O'briens Test, (+ for pain) Hawkins Kennedy Test, (+ for pain) Neers Test, and (+ for superior/posterior click that was pain free) Clunk Test. The athlete was then referred to a physician for an MRI. The evaluation from the orthopedic surgeon revealed all negative tests and the athlete was cleared to begin rehabilitation exercises and return to throwing. As the athlete began to throw again, he began experiencing similar symptoms and was shut down from throwing any further but continued rehabilitative exercises.

Physician evaluation revealed lesions of the long head of the biceps tendon. A biceps tendon transfer to the conjoint tendon was recommended to increase pain free function. **Differential Diagnosis:** Biceps Tendonitis, SLAP labral tear, Lesions of Long Head of Biceps Tendon. **Treatment:** The athlete received a biceps tendon transfer to the conjoint tendon as recommended. The procedure used an arthroscopic approach via the sub-deltoid space which allows for better access to the anterior shoulder. Athlete is currently going through the post-operation rehabilitation process. **Uniqueness:** Shoulder pain is a common complaint found in both minor league and major league baseball players. Evidence has indicated that pathology of the biceps tendon is often a factor to consider when a baseball athlete is experiencing shoulder pain. However, treatment of biceps tendon pathology still remains controversial. Conservative treatment and management of a biceps tendon pathology includes activity modification, rehabilitation exercises, local steroid injections and oral anti-inflammatory medications. If conservative management and treatment fails to relieve shoulder symptoms, surgical intervention options should be considered. Surgical interventions include a biceps tenotomy, biceps tenodesis and a biceps tendon transfer to the conjoint tendon. This case is unique because the athlete chose to proceed with the more recent surgical intervention of a biceps tendon transfer to the conjoint tendon. **Conclusions:** This case highlighted the unique surgical procedure of an all-arthroscopic biceps tendon transfer to the conjoint tendon in a minor league baseball pitcher. This case provides as an instance of failure of conservative treatment for a biceps tendon pathology and elaborates on the possible surgical interventions. This case further illustrates the surgical procedure itself and the complexities of rehabilitation following the procedure in a minor league baseball pitcher.

Distal Triceps Brachii Tendon Rupture and Ulnar Collateral Ligament Sprain in a Collegiate Basketball Player

Gildard M, Marinelli A, Henry K:
Marist College; Poughkeepsie, NY

Background: A healthy, 20-year-old male collegiate basketball fell to the court while attempting to gather a rebound during a game. The athletic trainer witnessed the patient fall onto his outstretched arm and then observed his elbow flex beneath his body weight as he collapsed to the court. The patient reported an audible crack as his elbow hit the floor, and reported to the athletic trainer complaining of significant pain and visible swelling across the posterior elbow. Upon evaluation, he was removed from the game and referred to the local emergency room for radiology to rule-out a fracture or humerolunar dislocation. **Differential Diagnosis:** Humerolunar Dislocation, Monteggia Fracture, Supracondylar Fracture, Ulnar Collateral Ligament Sprain, Biceps Brachii Tendon Rupture, Triceps Brachii Tendon Rupture **Treatment:** Lateral radiographs were negative for fracture or other abnormality. In the subsequent days, the patient continued to experience pain with movement, a decrease in elbow extension motion, and decreased strength, prompting the team physician to order MRI of the elbow to rule out an ulnar collateral ligament sprain or other soft-tissue injury. MRI results revealed a partial tear of the distal triceps brachii tendon, along with a partial tear to the UCL. During surgery to repair the triceps tendon, it was discovered that the patient had actually suffered a complete rupture of the distal tendon and avulsion of the proximal olecranon process. The surgeon successfully anchored the distal tendon to the ulna, however elected to leave the UCL unrepaired to facilitate the rehabilitation process for the triceps brachii. Following four weeks of cast immobilization, the patient was able to commence range of motion and flexibility exercises, and was cleared to begin mild

resistance strengthening at two months post-operative. The patient was able to return to competitive basketball following his full course of rehabilitation, and has not had any recurrence of injury or complications to date. **Uniqueness:** Triceps tendon ruptures are relatively uncommon, accounting for less than 2% of all tendon injuries and the uniqueness only increases in the presence of a comorbid ulnar collateral ligament sprain. A systematic review of 262 patients that underwent surgery to repair a triceps tendon rupture represented a mean age of 45.6 years, which is significantly older than our patient. Further, only four of the cases reviewed (<0.1%) included an associated ulnar collateral ligament injury. Some additional medical comorbidities linked to these cases included renal disease (10%), anabolic steroid use (7%), and neuromuscular disease (3%) – none of which the patient identified. The athletic trainer was unable to accurately assess this patient for an UCL sprain due to his other pathology. The surgeon in our case elected to anchor the triceps tendon, whereas in the referenced systematic review only 17% of cases utilized an anchor procedure as the majority (81%) utilized a repair via suture fixation. This technique, however, likely shortened the recovery time for the patient. Finally, although our patient presented with the typical etiology for a triceps tendon rupture condition, the injury was initially unfounded due to the radiographic results. **Conclusions:** Athletic trainers should continue to rely on comprehensive injury evaluation measures, and pursue additional testing when the results are inconsistent with the patient presentation. Further, clinicians need to be cognizant of potential comorbidities associated with an injury, regardless of how prevalent they may be in the literature.

Acute First Rib Fracture in a Batting Athlete

Vitale D, Boland S, Ward K, Lynall RC: University of Georgia, Athens, GA

Background: During batting practice, a healthy 19-year-old male right-handed baseball player reported feeling a pop in his right shoulder during the follow-through portion of his swing after ball contact. The patient denied feeling any pain or symptoms prior to the injury. He reported 6/10 pain and paresthesia inferior and superior to his right clavicle. He also reported right upper back pain that radiated around to the right side of his chest at the nipple line. He had full passive and active shoulder range of motion, but any arm movement (especially abduction) increased pain to an 8/10. Cervical rotation and lateral flexion to both sides were painful. Palpation to the proximal 2/3 of the clavicle and in the space posterior and inferior to the proximal 2/3 of the clavicle were painful. **Differential Diagnosis:** Thoracic outlet syndrome, compressed long thoracic nerve, fractured rib **Treatment:** The patient was sent to see an orthopedic physician's assistant the next day. An x-ray revealed a right first rib fracture, a diagnosis that was confirmed with a CT scan. Prior to starting treatment, the patient underwent a DEXA scan that revealed a higher than average bone density. The patient was not put in a sling or swath, but all baseball activities and workouts were stopped immediately, and the patient was informed not to perform any activity that elicited pain or increased symptoms. Acute treatment with the athletic trainer mainly focused on analgesia and maintaining/building muscular strength of the whole body without involving the injured right arm. Initially the patient was only allowed to do lower body exercises, such as biking, with no arm movement. After 3 weeks, the patient was cleared for activities with more substantial arm

movement, such as running, but was not cleared for any weightlifting. At week 4, the patient was approved to start a weight training program with no restrictions. At this time, shoulder stabilization exercises were started in the athletic training room, mainly focusing on the rotator cuff. The patient began a throwing progression at week 6, followed by a hitting progression at week 12. Both programs were completed with the athletic trainer and without any complications. At 15 weeks the patient was fully cleared for competition. **Uniqueness:** Despite having an above average bone density the patient still sustained an unusual fracture. According to the literature, the most common mechanism for first rib fracture in baseball athletes is chronic stress from the anterior and middle scalene muscles and the serratus anterior due to repetitive throwing or pitching, resulting in a stress fracture. Here we have an acute fracture caused by a violent muscle pull of the same muscles in a baseball athlete from a swing, which has not yet been reported. **Conclusions:** Recognizing this injury is important for athletic trainers, as first rib fractures can have substantial negative consequences such as a compromised subclavian artery and/or vein, Horner's syndrome, or thoracic outlet syndrome if not identified and treated properly. Athletic trainers need to be aware of potential first rib fracture mechanisms beyond those commonly reported in the literature.

Free Communications, Poster Presentations: Adaptations in Those With Chronic Ankle Instability

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

The Relationship Between Mechanical Laxity and Perceived Instability Among High School Athletes With Chronic Ankle Instability

Imazaki Y, Burcal CJ, Grindstaff TL, Rosen AB: University of Nebraska at Omaha, Omaha, NE; Creighton University, Omaha, NE

Context: Chronic Ankle Instability (CAI) is intersecting paradigms of mechanical instability, perceived instability, and recurrent sprain. Although previous studies have reported the relationship between mechanical characteristics and subjective function in adult populations, no research has been conducted among high school population where the onset of CAI likely occurs. Therefore, our purpose was to investigate the relationship between the mechanical characteristics and subjective ankle function among high school athletes. **Methods:** We utilized a descriptive study design using high school athletes with CAI that were recruited from local high schools (n=11,

age: 16.0±1.1 years, height: 168.6±11.6 cm, mass: 68.5±14.6 kg). CAI was defined as having a history of at least one lateral ankle sprain and a Cumberland Ankle Instability Tool-Youth (CAIT-Youth) score <27. Subjective ankle function was assessed using the CAIT-Youth, Foot and Ankle Ability Measure Activities of Daily Living and Sports subscales (FAAM-ADL, FAAM-Sport). Mechanical laxity was measured during an inversion talar tilt test using an instrumented arthrometer. Outcomes included the inversion angle (degree), stiffness at 4dN-6dN range (dN/mm), and stiffness at 12.5dN-15dN range (dN/mm). The inversion test was conducted three times, and the average of the last two trials was used for the analysis. Non-parametric Spearman's rho (ρ) rank correlations were calculated to assess the relationship between mechanical outcomes and subjective ankle functional scores. **Results:** The mean values of the CAIT-Youth, FAAM-ADL, and FAAM-Sports were 21.5±2.4, 94.0±4.6%, and 87.0±11.6%, respectively. The talar tilt inversion angle (31.41±8.90°) showed

large negative relationships with the FAAM-ADL ($\rho = -0.576$, $p=0.041$). In addition, the stiffness at high-load range (0.70±0.20 dN/mm) displayed strong positive relationships with the FAAM-ADL ($\rho=0.685$, $p=0.014$) and FAAM-Sport ($\rho=0.669$, $p=0.017$) (Table 1). **Conclusions:** The talar tilt and stiffness at high-load range had significant correlations with self-reported ankle function in high school athletes with CAI. Those who had greater laxity demonstrated worse function. In addition, CAI patients with lower levels of stiffness reported more severe impairments in perceived function, which differs from previous work in adult populations. These preliminary results may demonstrate a unique age-related relationship between mechanical laxity and perceived function. Further research is necessary to determine the progression of this relationship across the lifespan to provide a deeper understanding of CAI pathogenesis. This could be a key to developing more effective treatment plans in adolescent populations.

Table 1 Spearman's rho (ρ) rank correlations between the mechanical characteristics and the subjective functional scores

	CAIT-Y	FAAM ADL	FAAM Sports
Talar tilt inversion	-0.440 ($p=0.10$)	-0.576 ($p=0.041$)	-0.497 ($p=0.072$)
Stiffness 40-60N	0.495 ($p=0.073$)	0.055 ($p=0.441$)	0.288 ($p=0.210$)
Stiffness 125-150N	0.471 ($p=0.085$)	0.685 ($P=0.014$)	0.669 ($p=0.017$)

Single-Leg Landing Energetics in Individuals With Chronic Ankle Instability

Brown CN, Norcross MF: Oregon State University, Corvallis, OR

Context: Joint energetics during landing may influence chronic injury occurrence, specifically through inadequate or altered dissipation strategies across joints of the lower extremity. Individuals with Chronic Ankle Instability (CAI) have demonstrated altered joint kinematics during single leg landing, but it is unclear if energy absorption (EA) is also altered. The objective was to determine if individuals with CAI exhibited altered EA patterns in the ankle, knee and hip compared to Controls (CON). We hypothesized the CAI group would exhibit increased EA in the ankle and decreased EA at the hip. **Methods:** This cross-sectional study was completed in a biomechanics laboratory. Volunteer recreationally active individuals were categorized into two groups. The CAI group (4 males, 11 females; age 20.4 ± 1.7 yr; height 172.2 ± 11.2 cm; mass 68.7 ± 12.2 kg) reported at least 1 moderate-severe ankle sprain at least one year ago, 2 episodes of “giving way” at the ankle, Cumberland Ankle Instability Tool (CAIT) score ≤ 24 indicating poor function, and no clinical evidence of mechanical laxity. The CON group (9 males, 5 females; age 20.4 ± 1.3 yr; height 173.3 ± 9.0 cm; mass 66.9 ± 10.3 kg) had no history of ankle injury and CAIT scores ≥ 29 indicating good function. Participants completed 5 successful trials of single leg landing, starting 70cm from the force platform (1200Hz) jumping to 50% of maximum vertical height and stabilizing. Lower extremity kinematics and kinetics were collected and filtered, and sagittal plane EA was calculated for the ankle, knee and hip during the following epochs: at Initial (0 to 100ms), Terminal (100 to 200ms), and Total (0ms to maximum knee flexion) after initial ground contact. These time periods were selected because they represent periods during landing when lateral ankle sprains are

thought to occur. EA was normalized to the product of body weight and height ($J \cdot [N \cdot m]^{-1}$) and individual joint EA was reported as a percentage of total EA across all joints (ankle + knee + hip) for each time period. Independent t-tests were used to determine group differences ($\alpha < 0.05$). **Results:** The CAI group demonstrated decreased EA at the hip as a percentage of overall EA compared to the CON group at Initial (4.0 ± 2.2 vs. $9.9 \pm 7.7\%$; $p = 0.02$; $d = 1.0$; $1 - \beta = 0.77$) and at Total (5.0 ± 2.8 vs. $10.1 \pm 7.0\%$; $p = 0.02$; $d = 0.7$; $1 - \beta = 0.95$). There were no other group differences by joint or time period ($p > 0.05$). **Conclusions:** The CAI group demonstrated less reliance on the hip to dissipate energy during initial landing and also across the entire landing period compared to the CON group. Lack of differences at the ankle may be due to constraints of the landing task. Inability to appropriately dissipate energy absorption to a proximal joint may perpetuate injury at a distal joint. Clinicians may need to focus restoring EA to the hip via strengthening or improved sagittal plane mechanics during landing.

The Effect of Progressive Visual Occlusion on Postural Control Response in Those With and Without Chronic Ankle Instability

VanDeMark LH, Vander Vegt CB, Ford CB, Wikstrom EA, Mihalik JP: The University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Chronic ankle instability (CAI) alters sensory organization strategies and increases reliance on visual information. Improving sensorimotor integration strategies is a primary clinical objective when managing CAI. This may be accomplished by administering a two-fold rehabilitation approach: 1) balance training exercises on unstable surfaces to promote the use of visual information, or 2) eyes-closed exercises to improve balance by enhancing the use of somatosensory information. Unfortunately, static eyes-closed exercises limit functionality during rehabilitation. Stroboscopic eyewear limiting some but not all visual information does not inhibit dynamic movement and may improve functional rehabilitation interventions. The influence of limited vision on postural control in those with CAI is not well understood. Therefore, the purpose of this study was to examine differences in how

those with and without CAI respond to increasing levels of visual occlusion during static stance. **Methods:** Forty-eight participants (15 Males (30.6%); age=21.1±2.0 years; mass=66.2±10.7 kg; height=1.7±0.1 m) provided written consent and were enrolled in a cross-sectional study conducted in a clinical research center. Those with CAI (n=32) met the International Ankle Consortium inclusion criteria recommendations. Healthy controls (n=16) had no history of ankle sprains. All participants completed postural control assessments including a 3-minute double-limb stance on a triaxial forceplate (AMTI, Watertown, MA) under the following four visual conditions: 1) eyes-open, 2) low-occlusion, 3) high-occlusion, and 4) eyes-closed. Low (level 2) and high (level 6) occlusion conditions were produced using stroboscopic eyewear (Senaptec, Beaverton, Oregon). Dependent variables included time-to-boundary minima means in the mediolateral (TTB-ML) and anteroposterior (TTB-AP) directions measured in milliseconds. Time-to-boundary estimates the time one has to make a postural correction to prevent balance loss. Two-way repeated measures ANOVAs were used to assess differences between groups and visual conditions. **Results:** Data were normally distributed with

one outlier within the CAI group which was discarded. We did not observe any Group x Condition interaction for TTB-AP ($F_{3,138}=0.61$; $p=0.61$) or TTB-ML ($F_{3,138}=2.50$; $p=0.076$). No group main effects were observed for TTB-AP ($F_{1,46}=0.109$; $p=0.743$) or TTB-ML ($F_{1,46}=0.63$; $p=0.431$). We did observe a condition main effect for both TTB-AP ($F_{3,138}=22.9$; $p<0.001$) and TTB-ML ($F_{3,138}=93.7$; $p<0.001$). Specifically, our observed main effects were driven by differences between the eyes-open condition and the subsequent limited-vision conditions for both outcomes ($p<0.001$). Additionally, significant differences in TTB-ML were found between eyes-closed and both low- ($p<0.001$) and high-occlusion ($p<0.001$). Table 1 presents all data related to these analyses. **Conclusions:** Those with and without CAI have decreased postural control under limited or no vision conditions. Low-occlusion and high-occlusion conditions produced similar postural control outcomes as eyes-closed, indicating a similar disruption to the sensorimotor system forcing participants to rely more on somatosensory information. Future research on implementing stroboscopic eyewear in functional rehabilitation for those with CAI is warranted.

Table 1. Descriptive data (mean ± standard deviation) for study outcome measures for both groups (healthy vs. CAI) across visual conditions.

Outcome measures	Visual conditions			
	Eyes-Open	Low-Occlusion	High-Occlusion	Eyes-Closed
TTB-AP minima mean (ms)				
Overall	66.7± 18.7 ^a	54.9 ± 19.2	56.8 ± 17.3	54.3 ± 16.6
Healthy	66.5 ± 23.3	57.6 ± 21.2	58.0 ± 18.3	55.2 ± 18.4
CAI	66.8 ± 16.4	53.6 ± 18.3	56.2 ± 17.0	53.8 ± 15.8
TTB-ML minima mean (ms)				
Overall	28.9 ± 5.5 ^a	21.9± 6.7	22.1 ± 6.4	19.8 ± 5.9 ^b
Healthy	28.9 ± 5.5	23.8 ± 6.0	23.4 ± 5.2	20.3 ± 5.7
CAI	29.2 ± 5.7	21.1 ± 7.0	21.6 ± 6.8	19.8 ± 6.1

^a Eyes-open significantly higher than low-occlusion, high-occlusion, and eyes-closed

^b Eyes-closed significantly worse than low-occlusion and high-occlusion

Differences in Sensory Organization Between Chronic Ankle Instability and Control Participants

Rosen AB, Henrickson J, Yentes JY, Mukherjee M: University of Nebraska at Omaha, Omaha, NE

Context: Ankle sprains, among the most common athletic injuries, often lead to a debilitating condition known as chronic ankle instability (CAI). CAI is characterized by “giving-way” and repetitive sprains, which leave the ankle susceptible to early onset osteoarthritis and decreased quality of life. Researchers theorize patients with CAI improperly interpret information regarding their surrounding environment, however, it is unclear how the different sensory systems contribute to postural control. Therefore, the purpose of this study was to assess the contributions of vestibular, visual and somatosensory systems to postural control between persons with CAI and healthy participants. **Methods:** A cross-sectional study was completed in a biomechanics research facility. Twenty-two healthy control (9/13 female/male, age=21.9 ± 2.2 years, mass=77.4 ± 13.2 kg, height=173.6 ± 8.1cm) and 29 people with CAI (14/13 female/male, age=22.0 ± 2.1 years, mass=75.3 ± 14.7kg, height=174.0 ± 9.4 cm) volunteered to participate in this study. Participants with CAI had a history of sprain with two or greater episodes of giving way and a Cumberland Ankle Instability Tool (CAIT) score of ≤24. Participants completed the sensory organization test (SOT) on a force platform. The SOT has six separate conditions; SOT1: stationary surface and stationary vision, SOT2: stationary surface and without vision, SOT3: stationary surface and sway-referenced vision, SOT4: sway-referenced surface and fixed vision, SOT5: sway-referenced surface and no vision, and SOT6: sway-referenced surface and sway-referenced vision. Visual (SOT4/SOT1), vestibular (SOT5/SOT1), somatosensory (SOT2/SOT1) and preference ((SOT3+SOT6)/

(SOT2+SOT5)) ratios were calculated across the conditions. Lower sensory ratios indicate a worse ability to use input from that sensory system to maintain postural control. Independent samples t-tests and Cohen’s d effect sizes were utilized to determine differences between control and CAI participants. The relationship to CAI severity was assessed via non-parametric Spearman’s rho correlations between sensory ratios and CAIT scores. **Results:** Participants with CAI demonstrated significantly lower visual ratios compared to controls (control= 0.82 ± 0.13, CAI= 0.72 ± 0.17, p=0.038, d=0.66). Visual ratios were also moderately, significantly correlated with CAIT scores ($\rho=0.40$, p=.002). **Conclusions:** Participants with CAI demonstrated an altered ability to integrate multisensory systems compared to healthy controls. Specifically, those with CAI had a worse ability to utilize somatosensory and vestibular sensory feedback in the presence of faulty visual information. In addition, individuals who displayed lower levels of self-reported function also had lower visual ratios. This indicates that visual information usage may play a role in influencing symptom severity. Individuals with CAI may be relying on faulty visual information, which may lead to repetitive sprain and episodes of “giving-way.” Future studies may want to identify the benefit of adding visual training protocols to rehabilitation programs aimed at improving long-term outcomes in individuals with CAI.

Sagittal Ankle ROM Gain During Squats Associated With Increased Frontal Hip and Transverse Knee ROM for Chronic Ankle Instability Individuals

Samson CO, Simpson KJ, Brown CN: Southern Utah University, Cedar City; University of Georgia, Athens, GA; Oregon State University, Corvallis, OR

Context: Limited closed-chain ankle dorsiflexion is common in those with Chronic Ankle Instability (CAI). The deficit may be addressed by elevating the heels on a board during squatting, as done in the Functional Movement Screen, but resulting changes in all movement planes of lower extremity joints after removing the ankle deficit with this modification remains unclear. We hypothesized increased sagittal ankle ROM would be associated with greater knee and hip ROM gains in CAI individuals compared to healthy controls. **Methods:** This cross-sectional study was conducted in a Biomechanics laboratory. Physically active individuals with CAI (determined as described by the International Ankle Consortium) and healthy matched controls participated (n=48; 24 CAI and 24 CON; 22 female and 26 male; height=172.1±8.4cm; mass=72.6±12.2kg; age=23.3±3.6yr). Closed-chain dorsiflexion was measured with the weight-bearing lunge test (WBLT) distance to confirm existing group differences in sagittal ankle ROM. Ankle, knee, and hip angular kinematic data were obtained from motion capture (240Hz) throughout two body weight squat conditions, normal (SN) and elevated rearfoot (SH). Participants performed 4 trials of 10 repetitions for each condition. ROM gain was calculated as the difference of angular displacement between the two conditions (ROMgain=SH-SN) with a positive difference indicating greater displacement for the SH condition. Independent samples t-tests were used to determine group differences for WBLT distance and sagittal ankle ROM

gain ($\alpha=.05$). Associations of sagittal ankle ROM gain with ROM gain at all lower extremity joints in all movement planes for each group (CAI, CON) were determined with Pearson's correlations ($\alpha=.05$). **Results:** CAI individuals were confirmed with significantly less closed-chain dorsiflexion than CON (CAI 9.9 ± 3.6 cm, CON 12.4 ± 3.6 cm; $p=.02$, Cohen's $d=0.68$, $(1-\beta)=0.65$), but there were no differences in the amount of sagittal ankle ROM gain (CAI $6.8\pm 4.4^\circ$, CON $5.2\pm 3.1^\circ$; $p>.05$, $d=0.42$, Power $(1-\beta)=0.42$) from SN to SH between groups. Sagittal ankle ROM gain was positively correlated with sagittal knee ROM gain for both groups (CAI: $r=0.84$, $p<.001$, $R^2=0.70$; CON: $r=0.79$, $p<.001$, $R^2=0.62$). Additionally, sagittal ankle ROM gain was associated with frontal hip ($r=0.58$, $p=.003$, $R^2=0.34$) and transverse knee ($r=0.62$, $p=.001$, $R^2=0.39$) ROM gain for CAI individuals and with transverse ankle ($r=0.68$, $p<.001$, $R^2=0.46$) and hip ($r=0.62$, $p=.001$, $R^2=0.39$) ROM gain for their healthy counterparts. **Conclusions:** Increasing sagittal ankle ROM with elevation of the rearfoot during squats was positively correlated with increased knee sagittal ROM for both groups as expected. Improved closed-chain dorsiflexion in those with CAI is associated with an increase in frontal hip (adduction) and transverse knee (internal rotation) ROM and differs from matched controls. This may suggest altered movement strategies of CAI individuals even after normal sagittal closed-chain ROM is achieved. Clinicians are encouraged to incorporate neuromuscular control exercises simultaneously when working to restore normal sagittal ankle ROM.

Spinal Reflexive Excitability of Lower Extremity Musculature in Individuals With and Without Chronic Ankle Instability: A Systematic Review and Meta-Analysis

McCann RS, Suttmitter AMB: Old Dominion University, Norfolk, VA

Context: Individuals with CAI exhibit a host of neuromuscular impairments thought to be mediated by the central nervous system. Inhibition within the spinal reflex loop, which can be measured through tests of spinal reflexive excitability, has been proposed as a potential contributor to these residual neuromuscular impairments. The objective of this study is to conduct a systematic review and meta-analysis of studies comparing spinal reflexive excitability of lower extremity musculature between individuals with and without CAI. **Methods:** A database search of PubMed, CINAHL, SPORTDiscus, and ERIC was conducted on September 10, 2018 using the following search terms: ("chronic ankle instability" OR "functional ankle instability" OR "mechanical ankle instability" OR "ankle sprain") AND ("spinal reflexive excitability" OR "neural excitability" OR "hoffman reflex" OR "h reflex" OR "h-reflex" OR "paired reflex depression" OR "recurrent inhibition"). Articles were included in the study if they evaluated spinal reflexive excitability of at least 1 lower extremity muscle in a cohort with CAI and another classified as healthy controls (CON) or ankle sprain copers (COP). Two investigators independently evaluated methodological quality of included studies with the modified Downs and Black scale. Discrepancies were resolved through discussion between the 2 investigators. Means, standard deviations, and sample sizes of spinal reflexive excitability measures were extracted from each article. Random effects meta-analysis modeling calculated pooled effect sizes (ES) and 95% confidence intervals for each between-groups comparison. **Results:** After screening 84 total articles, 13 were

included. The methodological quality scores ranged from 9 to 12. The studies varied in the lower extremity muscles tested, methods of measuring spinal reflexive excitability, and populations to which CAI groups were compared. Among all measures of lower extremity spinal reflexive excitability, CAI and CON groups' involved limbs did not differ (ES=-0.13[-0.27,0.01]; $P=0.07$). When further separated by muscle and method, the CAI group demonstrated a significantly lower soleus H:M in the involved limb compared to CON (ES = -0.19[-0.37,-0.02]; $P=0.03$), although the magnitude of the effect was negligible. The CAI (ES=-0.36[-0.64,-0.08]; $P=0.01$) and CON groups (ES=-0.49[-0.84,-0.15]; $P<0.01$) both had significantly lower involved limb soleus spinal reflexive excitability compared to COP. The CAI group had less H:M modulation than CON when progressing to more difficult balance conditions (ES=-0.83[-1.09,-0.56]; $P<0.01$). **Conclusions:** There is grade C evidence that individuals with CAI do not differ in spinal reflexive excitability of lower extremity musculature compared to healthy individuals. However, ankle sprain copers appear to have increased soleus spinal reflexive excitability compared to those with CAI and healthy individuals, which might represent an adaptive mechanism allowing them to avoid the onset of CAI. The impaired ability of individuals with CAI to modulate soleus spinal reflexive excitability when progressing to more challenging balance conditions might contribute to reduced balance performance.

Plantar Cutaneous Sensation Deficits in Those With Chronic Ankle Instability: A Systematic Review

Rivera MJ, Burcal CJ, Powden CJ: Indiana State University, Terre Haute, IN; University of Omaha Nebraska, Omaha, NE

Context: Sensorimotor deficits are common after ankle sprains and may contribute to the development of conditions such as chronic ankle instability (CAI) and the recurrent trauma that is associated with the condition. Plantar cutaneous sensation (PCS) is one of these sensorimotor factors that may play an important role in the cycle of trauma experienced by patients with CAI. To conduct a systematic review to synthesize the evidence describing PCS in participants with and without CAI. **Methods:** Electronic databases (PubMed, MEDLINE, and SportDiscus) were searched from inception through September, 2018. The search was completed using a combination of key words related to CAI, PCS and Semmes-Weinstein monofilaments (SWM). Search limits were full text

publications written in English. An additional hand search of references was completed. Inclusion criteria required that studies evaluated PCS using SWM, were peer reviewed, and included human participants with CAI with or without a control comparison. Articles were excluded if they did not evaluate PCS or used another method of assessing PCS. The modified Downs and Black checklist for non-randomized studies was used to determine the methodological quality of included studies by two independent reviewers. Medians and Interquartile ranges were extracted from the included studies for PCS and then organized by CAI status. **Results:** Eight studies met the inclusion criteria. The average methodological quality of the studies was 12.4/15 and ranged from 12 to 13. The items most commonly missed were representation of the entire population that subjects were recruited and a lack of blinding of the researchers measuring the outcomes from participant groups. The eight included studies produced four unique data sets that were included in the analysis. Additionally, data was included in the analysis regardless of SWM application location. Four data sets examined PSC

for participants with CAI (median=4.08 (range=3.22, 4.56)). Three data sets compared PCS of participants with CAI (median=4.08 (range=3.22, 4.56)) compared to a control groups (median=3.61 (range=3.22, 4.17)). One data set compared PCS in participants with CAI (median=3.61 (range=3.61, 4.08)), controls (median=3.22 (range=3.22, 3.61), and copers (median=3.61 (range=3.22, 3.61)). Individual study median and interquartile ranges by testing location are presented in Table 1. **Conclusions:** There is Grade B evidence that patients with CAI demonstrate deficits in PCS compared to controls. However, there is not enough data to draw conclusions regarding copers and PCS deficits. Reported SWM values indicated that those with CAI are classified as having diminished light touch at multiple points on the plantar aspect of the foot. Clinicians treating patients with CAI need to understand the sensorimotor deficits that patients may demonstrate, particularly in PCS. Future research is needed to indicate how PCS deficits contribute to the repetitive trauma and functional impairments, such as gait, experienced by patients with CAI.

Table 1. Median and Interquartile Ranges of Semmes Weinstien Thresholds by Testing Location

CAI	SMW Median (Q1, Q3)		
	5MT	1MT	CAL
Burcal & Wikstrom 2016	3.61 [3.61, 3.84]*	3.61 [3.22, 4.08]*	4.17 [3.61, 4.17]
Houston et al 2015	-	-	4.08 [3.61, 5.46]
Powell et al 2014	4.31 [4.08, 4.37]*	4.08 [3.96, 4.60]*	4.56 [4.27, 4.78]*
Song et al 2017	-	3.22 [NR]	-
Healthy			
Burcal & Wikstrom 2016	3.22 [2.83, 3.61]	3.22 [2.83, 3.61]†	3.61 [3.61, 4.17]
Powell et al 2015	3.61 [3.61, 4.08]	3.61 [3.41, 3.72]	4.17 [3.96, 4.31]
Song et al 2017	-	3.22 [NR]	-

Abbreviations: 5MT, head of the fifth metatarsal; 1MT, head of the first metatarsal; CAL, calcaneous

*Indicates significant difference from control group in respective study

†Indicates significant difference from CAI group

Corticomotor Excitability in the Lower Extremity Musculature in Individuals With Chronic Ankle Instability: A Systematic Review and Meta-Analysis

Suttmiller AMB, McCann RS: Old Dominion University, Norfolk, VA

Context: Individuals with CAI consistently display neuromuscular control deficits which have been attributed to central nervous system changes. Transcranial magnetic stimulation is a non-invasive method for measuring corticomotor excitability and could enhance our understanding of these central alterations. The objective of this study was to conduct a systematic review and meta-analysis of the current literature investigating corticomotor excitability in lower extremity musculature in individuals with and without CAI. **Methods:** An electronic database search of PubMed, CINAHL, SPORTDiscus, and ERIC was conducted on September 10, 2018 using the following search terms: (“chronic ankle instability” OR “functional ankle instability” OR “mechanical ankle instability” OR “ankle sprain”) AND (“neural excitability” OR “corticospinal excitability” OR “corticomotor excitability” OR “transcranial magnetic stimulation” OR “tms”). Inclusion criteria required that studies examined corticomotor excitability measures in a lower extremity muscle in individuals with CAI and controls (CON) and provided adequate data for the calculations of effect sizes and 95% confidence intervals. Methodological quality was evaluated independently by two investigators with the modified Downs and Black scale. If discrepancies existed, discussion between investigators occurred until consensus was reached. Sample sizes, means, and standard deviations of corticomotor excitability measures were extracted from each article. Random effects meta-analysis modeling calculated pooled effect sizes (ES) and 95% confidence intervals for between-groups comparisons of separate excitability outcomes. **Results:** Forty articles were

initially retrieved including 25 duplicated results. Based on the selection criteria, 5 articles were included for analyses. The methodological quality scores ranged from 10 to 12. Multiple measures of corticomotor excitability were used, and collectively, the studies examined four muscles of the lower extremity: vastus medialis, fibularis longus, soleus, and tibialis anterior. Across all lower extremity muscles of the involved limb, motor threshold measures for CAI and CON groups did not differ (ES = 0.06; 95% CI = -0.20,0.31; P = 0.67). Similarly, no group differences were found when comparing the motor evoked potentials (ES = -0.15; 95% CI = -0.34,0.04; P = 0.12). The included studies examined other corticomotor excitability variables beyond motor thresholds and motor evoked potential, but they were only examined in individual studies and could not be included in a meta-analysis. In particular, corticomotor mapping of the fibularis longus and cortical silent period of the soleus differed between groups. **Conclusions:** There is level C evidence that motor thresholds and motor evoked potential of the quadriceps and lower leg musculature are not different between individuals with CAI and healthy controls. The lack of available literature limited the meta-analyses to only two excitability measures, and prevents inclusion of other corticomotor alterations found to be significant between groups. Future studies should explore these outcomes further and examine corticomotor changes within other lower extremity musculature, such as the gluteals, in order to gain a deeper understanding of the central changes that may contribute to CAI.

Kinesiophobia Found to be Associated With Chronic Ankle Instability

Schimmel JR, Nolton EC, Ambegaonkar JP: George Mason University; Manassas, VA

Context: An estimated two million lateral ankle sprains (LAS) are reported each year. Of those, approximately 73% will develop chronic ankle instability (CAI). Previous literature notes many factors increase CAI risk, including recurrent ankle sprains, mechanical instability, and impaired proprioception. Greater fear-related beliefs following initial injury may result in guarding and unnatural functional movement which may increase risk of injury. Previous researchers have found kinesiophobia—a fear of movement—to be a factor in recurrent ACL injury despite a structurally healthy knee following previous injury. However, it is unclear if kinesiophobia is similarly associated with CAI. Thus, the purpose of our study was to compare kinesiophobia

scores between cases (individuals with CAI) and controls (individuals with previous LAS but no CAI). **Methods:** A web-based survey via Qualtrics was administered to adult volunteers. Participants completed the Foot and Ankle Ability Measure (FAAM; to determine CAI status) and the Tampa Scale for Kinesiophobia (TSK; 68 possible points) to measure a fear of movement. We excluded those who suffered a LAS within the last year to reduce the influence of acute symptoms and deficits. An independent samples t-test was conducted to compare group TSK score mean differences between CAI and non-CAI participants (α -level=.05). **Results:** 85 adult participants (female=49; male=36, age=37.5±14.5 years) with prior LAS ranging from 1-56 years ago (10.29±27.4 years). Of the 67 participants who could recall laterality, 74.6% reported injuring their right ankle during the initial incident and 55.2% from either side subsequently suffered a contralateral LAS. 72.9% of respondents suffered at least one recurrent ipsilateral LAS and 21.6% of

those who suffered recurrent ipsilateral LAS reported having greater than five incidents. Of the 84 participants who rated their current function, 70.6% stated they felt normal, 24.7% were nearly normal, 3.5% were abnormal, and none were severely abnormal. FAAM scores classified 21 participants as having CAI with TSK scores of 39.8±4.4 while the non-CAI group (n=64) had TSK scores of 34.0±5.2. There was a statistically significant difference in groups means between CAI and non-CAI participants ($t(83)=-4.549$, $p<.001$; see Figure 1). **Conclusions:** We found higher TSK scores (indicating greater fear-related beliefs) to be associated with CAI. Clinicians can administer the TSK to observe kinesiophobic tendencies and identify patients who may be at risk for subsequent and chronic sequelae. The high prevalence of LAS and propensity of developing CAI warrants further evidence that identify potential risk factors. Our findings will help contribute to the growing body of literature associating kinesiophobia with chronic injuries—now including CAI.

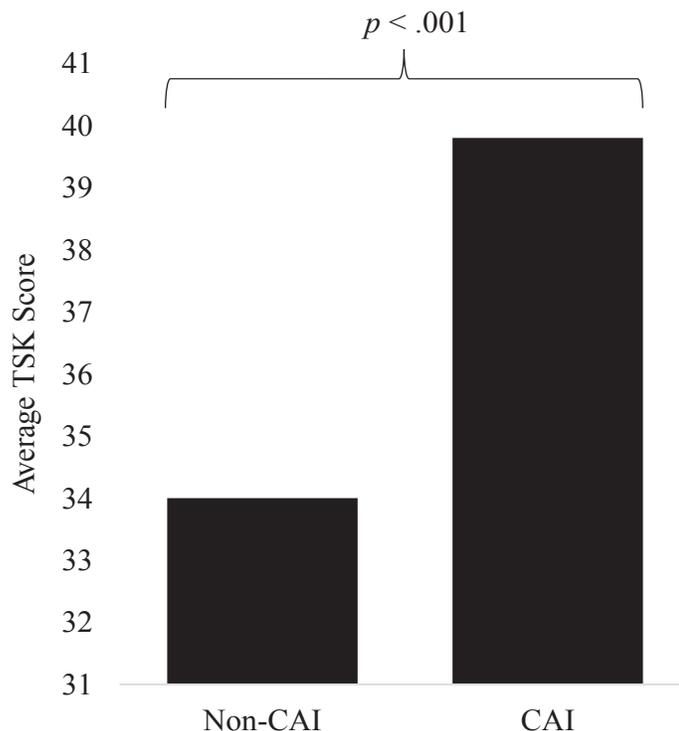


Figure 1. Bar graph of average TSK scores for non-CAI and CAI groups.

Predicting Movement Strategies in Chronic Ankle Instability

Hopkins JT, Son SJ, Kim H, Page G, Seeley MK: Brigham Young University, Provo, UT; CHA University, Seongnam, South Korea; West Chester University, West Chester, PA

Context: Five distinct movement strategies were previously identified in a large sample of subjects with chronic ankle instability (CAI). Each strategy presumably presents unique clinical deficiencies. Successful intervention relies on effective identification of the unique movement strategy or deficits. The purpose of this study was to evaluate the effectiveness of several clinical descriptors of CAI for prediction of the 5 movement strategies. **Methods:** The study design was descriptive laboratory study. 200 CAI subjects (104 male, 96

female, 22 ± 2.2 yrs, 174 ± 10 cm, 73 ± 14 kg) were selected according to inclusion criteria established by the International Ankle Consortium. Lower-extremity joint biomechanics, and ground reaction forces were collected during a maximum vertical jump landing, immediately followed by a side cut. Data were reduced to functions or curves, kinematic data from the frontal and sagittal planes were reduced to a single representative curve for each plane, and representative curves were clustered using a Bayesian clustering technique. Distributions for each predictor (BMI, FAAM ADL, FAAM Sport, MAII, Duration since last sprain, Number of previous sprains, Age) were then compared across clusters using a permutation test of equality ($P < 0.05$). Finally, Eigen decomposition analysis was performed to determine which combination of predictors impacted a specific cluster formation. **Results:** The distribution of

each predictor is represented in Figure 1. Generally, BMI ($p=0.001$), FAAM ADL ($p=0.014$), and FAAM Sport ($p=0.05$) presented differences between clusters. Eigen decomposition revealed that the combination of duration since last sprain, FAAM Sport, and FAAM ADL explained the greatest percent of variation in all of the clusters (0.82), however the combinations were not influential in distinguishing between clusters. **Conclusions:** The predictors used in this study were descriptive in nature and provided limited information about the cluster assignment of each subject. Similarly, the combinations of predictors provided little distinction between predictors. Descriptive data for CAI subjects does not appear to predict unique movement strategies. Future work should evaluate predictors that are part of a more detailed assessment of the patient.

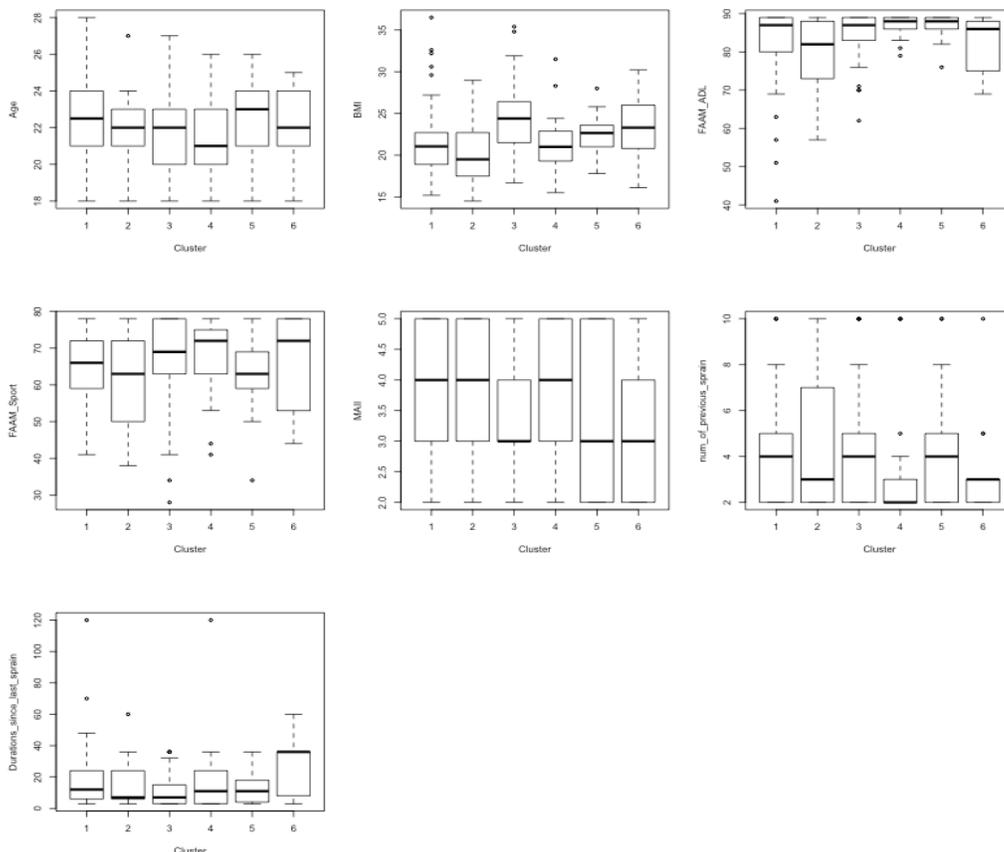


Figure 1. Distributions of each predictor into movement cluster.

Chronic Ankle Instability Impairs Submaximal Force Steadiness

Lee H, Son SJ, Kim HS, Han S, Jeong H, Seeley MK, Bruening DA, Hopkins JT: Brigham Young University, Provo, UT; CHA University, Seongnam, South Korea; West Chester University, West Chester, PA

Context: Patients with chronic ankle instability (CAI) have demonstrated deficits in balance, joint position sense, peroneal nerve function, strength, and muscle reaction time potentially due to impairments of mechanical and sensorimotor systems. The sensorimotor system plays an important role in steadily generating fine forces to control balance and functional movement. Submaximal force steadiness measures sensory, motor, and visual function via feedback mechanisms, which helps researchers and clinicians to comprehend sensorimotor deficits associated with CAI. This study aimed to identify the influence of CAI on submaximal force steadiness.

Methods: This study was designed as a single cohort in a laboratory setting. Twenty-one CAI patients (M=9, F=12; 22±2 yrs, 175±10 cm, 81±20 kg, 83±7% FAAM ADL, 62±13% FAAM Sports, 3.7±0.9 MAIL, 7±4.3 sprains) and 21 matched controls (M=10, F=11; 22±2 yrs, 175±10 cm, 73±19 kg, 100% FAAM ADL, 100% FAAM Sports, 0 MAIL, 0 sprains) participated in this study. Patients performed 3 trials of a maximal voluntary isometric contraction (MVIC) of hip abduction, eversion, and inversion using an isokinetic dynamometer (100Hz). After a 3-min break, subjects performed 2 practice followed by 3 testing trials of 10% and 30% of their MVIC as closely as possible for 15 seconds for submaximal force steadiness measures. The central 10-sec (20-80% of the total time) of 3 testing trials were analyzed. Main outcome measures were force steadiness which was one standard deviation (SD) across the 10-sec data, and force accuracy was a root mean square, which was calculated by subtracting the force

signal generated by the subject from the target/reference force. **Results:** CAI patients demonstrated less steadiness in 30% inversion MVIC compared with the control group (0.43±0.25 vs. 0.23±0.14, p=0.0027, Cohen's d: 1.36). Additionally, CAI patients had lower accuracy in 10% (0.60±0.67 vs. 0.29±0.14, p=0.043, Cohen's d: 0.65) and 30% eversion MVIC (0.97±0.96 vs. 0.49±0.33, p=0.034, Cohen's d: 0.68). CAI patients showed lower accuracy in 10% inversion MVIC (1.06±0.54 vs. 0.26±0.29, p<.0001, Cohen's d: 1.83) and 30% inversion MVIC (1.26±1.46 vs. 0.47±0.51, p=0.024, Cohen's d: 0.72). Across all conditions, higher target forces induced less steadiness in hip abduction (1.25±0.51 vs. 0.84±0.31, p<.0001, Cohen's d: 0.98) and eversion (0.33±0.23 vs. 0.16±0.12, p<.0001, Cohen's d: 0.92). In addition, higher target forces elicited lower accuracy in hip abduction (1.75±0.90 vs. 1.35±0.82, p=0.32, Cohen's d: 0.47) and inversion (0.73±0.75 vs. 0.45±0.50, p=0.45, Cohen's d: 0.44). **Conclusions:** CAI patients demonstrated less submaximal force steadiness and lower force accuracy in both evector and invertor muscles (10% and 30% of their MVIC) compared with matched controls. Inability to control fine force (10% and 30% of their MVIC) during an active test may suggest deficits in sensorimotor control in the CAI group.

Decreased Isometric Peak Torque at the Ankle and Hip in Young and Middle-Aged Adults With Chronic Ankle Instability

Bain KA, Gribble PA, Johnson N, Terada M, Thomas AC, Kosik KB: University of Kentucky, Lexington, KY; Ritusmeikan University, Kusatusu, Shiga-ken, Japan; University of North Carolina at Charlotte, Charlotte, NC

Context: After sustaining an ankle sprain, individuals may experience full recovery with no residual symptoms (Copers) or develop CAI. CAI is a clinical pathology characterized by recurrent ankle sprains and repeated episodes of 'giving way'. Previous research has focused on identifying various impairments and quality of life measures associated with CAI in young-adult populations. It is unknown whether common musculoskeletal impairments associated with CAI such as strength, continue to persist as individuals with CAI age. Identifying persistent strength deficits will aid in the development of appropriate future rehabilitation programs for both young and middle-aged adults.

Methods: A case-control design was used to compare isometric peak torque at the ankle, knee, and hip between younger and middle-aged adults with and without CAI in a research laboratory. Young-adults were assigned to a CAI (n = 35, 26.4 ± 6.6 years, 168.5 ± 10.4 cm, 75.3 ± 15.9 kg), Coper (n = 27, 25.0 ± 5.5 years, 168.1 ± 8.5 cm, 68.1 ± 13.5 kg), or healthy-control (HC) (n = 37, 26.2 ± 5.4 years, 169.81 ± 9.1 cm, 70.3 ± 14.4 kg) group. Middle-aged adults were assigned to the same respective groups of CAI (n = 16, 53.3 ± 9.5 years, 164.5 ± 10.6 cm, 78.4 ± 19.3 kg), Coper (n = 16, 53.3 ± 9.5 years, 170.3 ± 10.2 cm, 80.0 ± 15.5 kg) and HC (n = 25, 56.6 ± 9.8 years, 166.9 ± 12.6 cm, 73.2 ± 13.2 kg). Isometric strength was measured with a handheld dynamometer (HHD). Participants completed three, 5s isometric trials of dorsiflexion (DF), plantarflexion (PF), knee extension (KEXT), hip extension (HEXT), and hip abduction (HABD). CAI and Coper groups were tested on the involved limb and HC were

tested on a randomly selected limb. Peak torque, measured in Newtons (N), was averaged across three trials, multiplied by the moment arm length (m) and divided by body mass (kg) to obtain normalized torque (Nm/kg). To determine differences based on Injury Status and Age, two-way ANOVAs were used for each testing condition ($p < 0.05$). **Results:** A significant interaction between Age and Injury Status was observed for DF ($p = 0.033$). Tukey post hoc analysis indicated young-adults with CAI had decreased DF compared to the HC ($p < 0.001$) and Coper ($p < 0.001$) groups. Additionally, middle-aged participants in the Coper and HC group had decreased DF strength compared to younger-aged participants in each respective group. There was a significant Injury Status main effect for PF ($p = 0.009$) and HEXT ($p = 0.018$). Tukey post hoc comparisons indicated the CAI group had decreased PF ($0.55 \pm 0.16 \text{ Nm/kg}$ vs. $0.65 \pm 0.18 \text{ Nm/kg}$, $p = 0.004$) and HEXT ($1.55 \pm 0.53 \text{ Nm/kg}$ vs. $1.89 \pm 0.72 \text{ Nm/kg}$, $p = 0.010$) compared to the HC. There were significant Age main effects for all primary outcome measures ($p < 0.05$), indicating the middle-aged group had decreased strength compared to younger population for all measures. **Conclusions:** Individuals with CAI regardless of age, experienced diminished ankle and hip muscle strength compared to Coper and HC groups. These findings suggest strength deficits persist, especially for PF and HEXT, as individuals with CAI age. With this information, future research should identify the best intervention to improve lower extremity strength across both age groups and optimize treatment in young adults to minimize persistent deficits.

Abductor Hallucis Cross-Sectional Area and Activation in Individuals With Chronic Ankle Instability

Jones CL, Kosik KB, Hartzell JT, Allison RL, Hoch JM, Gribble PA, Hoch MC: University of Kentucky, Lexington, KY

Context: Impairments of the intrinsic foot musculature are hypothesized to contribute to sensorimotor deficits, such as poorer balance, in people with chronic ankle instability (CAI). This is supported by evidence of decreased intrinsic foot muscle volume in people with CAI when measured using MRI imaging. It is unknown if deficits in intrinsic foot muscle morphology or activation can be identified in people with CAI using more cost-effective techniques such as diagnostic ultrasound. Therefore, the purpose of this study was to compare differences in resting and activated measures of abductor hallucis (AH) cross-sectional area (CSA) in subjects with and without CAI. We hypothesized the CAI group would demonstrate smaller CSA and less activation of the AH compared to the healthy group. **Methods:** Fifteen participants with CAI (3 males, 12 females, age: 23.0 ± 3.85 years, height: 168.51 ± 10.65 cm, mass: 71.51 ± 13.73 kg, BMI: 25.22 ± 4.51) and 15 matched healthy participants (3 males, 12 females, age: 23.0 ± 2.32 years, height: 166.94 ± 7.61 cm, mass: 65.52 ± 9.55 kg, BMI: 23.47 ± 2.56) volunteered in this case-control study. The CAI group reported ≥ 1 previous ankle sprain, ≥ 2 episodes of giving way, ≥ 5 on the Ankle Instability Instrument and greater ≥ 11 on the Identification of Functional Ankle Instability. Participants completed one testing session in a laboratory which assessed AHCSA using diagnostic ultrasound with a 12 MHz linear array transducer. The transducer was positioned perpendicular to the long axis of the medial foot and anterior to the medial malleolus to measure CSA while the participant was seated (Resting-CSA). Measures were repeated with

the participant standing on the test limb to measure CSA while the AH was activated (Active-CSA). Images were exported and post-processed on a laptop computer. CSA was measured using a manual trace function and defined as the area (cm^2) within the fascial borders of the muscle. The ratio of Active-CSA to Rest-CSA was calculated to represent the activation ratio. All CSA measurements were normalized to BMI (cm^2/BMI). The average from two images were used for analysis. Mann-Whitney U tests examined differences in Resting-CSA, Active-CSA, and activation ratio between groups. Significance was set at $p \leq 0.05$. **Results:** No differences were identified in Resting-CSA ($p = 0.76$) between the CAI ($0.089 \pm 0.021 \text{ cm}^2/\text{BMI}$) and healthy ($0.089 \pm .023 \text{ cm}^2/\text{BMI}$) groups. Similarly, no difference ($p = 0.63$) was identified in Active-CSA between the CAI ($0.089 \pm 0.026 \text{ cm}^2/\text{BMI}$) and healthy ($0.096 \pm 0.031 \text{ cm}^2/\text{BMI}$) groups. However, greater activation ratios were identified ($p = 0.05$) in the healthy group (0.046 ± 0.007) compared to the CAI group (0.040 ± 0.010). **Conclusions:** AH CSA was comparable across groups. However, the CAI group demonstrated less AH activation based on changes in CSA from seated to standing positions. These findings suggest that diagnostic ultrasound may provide a method of identifying intrinsic foot muscle activation deficits associated with CAI. Future research should explore the relationship between AH activation and other sensorimotor deficits associated with CAI.

Towards a More Functional Test in Athletes With a History of Lateral Ankle Sprains

Coronel SC, Jaffri AH, Saliba SA, Hertel J: University of Virginia, Charlottesville, VA

Context: Lateral ankle sprains (LAS) are the most common injury in sports and recurrent injuries are common. Functional tests are used during the rehabilitation of athletes with LAS to clear them for return to play; however, most clinical functional tests do not incorporate game-like distractions. Perhaps a disconnect exists between traditional functional testing done in the athletic training clinic and actual game-like environments that athletes experience when they return to play. Traditional functional testing protocols may not adequately assess injured athletes for readiness to return to competitive play and may predispose them to the recurrent LAS. The purpose of the study was to compare the performance of athletes who have not previously sustained a LAS to athletes who have sustained at least one LAS within the past 12 months during a functional assessment that incorporated a more game-like environment. **Methods:** This was a case-control study in a field setting. Sixteen varsity intercollegiate athletes with a history of LAS (3 males, 6 females; age=20±1.67 years) and 9 healthy varsity intercollegiate athletes (2 males, 7 females; age=20±1.22 years) participated. Athletes completed 4 tasks (agility T-test to the right, agility T-test to the left, sprint, and backpedal) under 4 different conditions (no distractions, auditory distraction, cognitive distraction, and auditory + cognitive distraction) in a counterbalanced order. The time to complete each task was recorded with a stopwatch. Participants completed visual analogue scales (VAS) for confidence after completing all trials (no confidence = 0mm, maximum confidence = 100mm). Group by condition comparisons of performance time were made with ANOVA. VAS scores for confidence were compared between

groups with an independent t-test. **Results:** No significant differences in time to complete the tasks were found between the LAS and Healthy groups during any of the 4 conditions ($p>0.05$). However, there were significant differences in sprint task times when the cognitive distraction condition (mean±SD = 4.20±0.14s) was compared to the auditory distraction (3.53±0.11s) and no distractions conditions (3.57±0.10s) in the LAS group ($p<0.05$); and between the cognitive distraction condition (4.42±0.48s) and the auditory distraction (3.51±0.31s) and no distraction conditions (3.60±0.31s) in the Healthy group. The LAS group (81.3±14.5mm) reported significantly less confidence in performing the functional tasks than the healthy group (97.6±2.4mm, $p=0.006$). **Conclusions:** Although significant differences in time to complete the functional tasks were not found between groups, the cognitive distraction yielded slower sprint task performance in both groups. Also, the LAS group reported feeling less confident in performing the tasks than the Healthy group. Clinicians should consider having athletes recovering from LAS perform functional tests that include cognitive distractions and assess athlete confidence in performing the tests when administering return-to-play evaluations.

Sagittal Plane Knee Angle at Initial Contact From Landing is Related to Self-Reported Function in Individuals With Chronic Ankle Instability

Hartzell JT, Kosik KB, Allison RL, Jones CL, Hoch JM, Hoch MC, Gribble PA: University of Kentucky, Lexington, KY

Context: Chronic ankle instability (CAI) is a clinical pathology associated with altered movement patterns throughout the lower extremity and decreased scores on patient reported outcomes (PROs) compared to their healthy counterparts. However, it remains unknown if self-reported ankle disability during activities of daily living and/or sport is associated with lower extremity movement alterations. Examining this relationship may provide a further understanding of how individuals with CAI modify their lower extremity movement patterns to minimize the symptoms arising from their ankle during dynamic activities. The purpose of this study was to examine the association between scores on the Foot and Ankle Disability Index Activities of Daily Living (FADI-ADL) and Sport (FADI-Sport) subscales and sagittal-plane ankle, knee and hip kinematics at initial contact during a single-leg jump landing task in participants with CAI. **Methods:** This was a research laboratory investigation that employed a cross-sectional study design. Eleven participants with self-reported CAI (F: 9, M: 2; age: 23.50±4.12 years, height: 170.14±7.80 cm, weight: 72.50±13.40 kg) volunteered. Inclusion criteria were based on criteria established by the International Ankle Consortium. During a single testing session, participants completed the FADI-ADL and FADI-Sport subscales followed by five vertical jumps (50% of maximal vertical jump height) with single-leg landings. The score on each FADI subscale was calculated and converted to a percentage of the total score (%). Lower scores represented greater self-perceived disability. During the landings, lower

extremity kinematics were collected on the involved side with a 3D motion capture system. Sagittal plane ankle, knee and hip kinematics were calculated at initial contact. Initial contact was identified as the point in the trial when the vertical ground reaction force exceeded 10 N. The average of the final three jump landing trials was used for statistical analysis. Pearson product moment correlations were performed and interpreted as weak (0.00-0.040), moderate (0.41-0.69), or strong (0.70-1.00). Significance was set a priori at $P < 0.05$.

Results: A strong negative correlation was observed between the FADI-Sport (68.75 ± 11.60) and sagittal-plane knee angle at initial contact (0.36 ± 7.52 ; $p = 0.003$, $r = -0.773$). No significant correlation was observed between the FADI-Sport and ankle (62.65 ± 14.07) or hip (11.18 ± 13.60) sagittal plane kinematics at initial contact. Similarly, no significant correlations were observed between the FADI-ADL (95.17 ± 8.01) and ankle, knee or hip sagittal plane kinematics at initial contact ($P > 0.05$).

Conclusions: These findings indicate participants with greater self-reported disability during sport land with less knee flexion and potentially a stiffer landing pattern. This landing strategy might reflect an adapted movement strategy to compensate for their perceived ankle instability. This may increase their risk of other subsequent injuries at the knee. Future research should explore the relationship between self-reported disability and other kinetic factors during single-leg jump landing tasks.

Free Communications, Poster Presentations: Bacterial and Fungal Infections

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;

Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Effectiveness of Four Decontamination Techniques on Strength Training Equipment After Use in an NCAA D-II Collegiate Weight Room

Bogner LR, Ritchie AM, Berry DC, Schaefer LJ, Roznowski RT, Castillo KH: Saginaw Valley State University, University Center, MI

Context: The Centers for Disease Control (CDC) recommends shared strength training equipment (STE) be thoroughly disinfected (ie., disposable anti-bacterial wipes) to reduce the risk of disease transmission. Therefore, identifying low-cost, efficient, and effective decontamination methods are imperative to improve health and safety, especially in collegiate weight rooms. The objective was to determine the degree of contamination on STE after routine use and evaluate the efficacy of four disinfecting methods to reduce bacterial growth. **Methods:** Descriptive laboratory study set in a National Collegiate Athletic Association D-II university strength and conditioning facility, microbiology laboratory. Four-45-lb and 25-lb Olympic plates; Four-adjustable benches (head, back, seat); Four-45-lb Olympic barbells (Troy®, Houston, TX) were used. The study consisted of 3-phases. Phase-1 (T1), selected STE were cleansed (baseline) using Clorox Disinfecting Wipes® (CDW) (Clorox Company, Oakland, CA) following manufacturer recommendations, aseptically swabbed and plated (sheep blood agar [SBA]), and incubated for 24-hours. Phase-2 (T2), 24-hours post-initial swab and post-scheduled workouts by athletes, selected STE were swabbed and plated (SBA). Phase-3 (T3), 4-cleaning interventions were randomly applied at 4-STE stations: (1) Swan 70% isopropyl alcohol (70%IA) (Vi-Jon, Smyrna, TN), (2) Simple Green Industrial Cleaner & Degreaser® (ICD) (Sunshine Makers, Huntington Beach, CA), (3) CDW, and (4) Clorox 1:10 bleach-to-water (Clorox Company). Cleaners were

applied according to manufacturer recommendations by two athletic training students; swabbing/plating by medical laboratory science (MLS) students blinded to interventions. The dependent variable, bacterial colony growth (count); independent variable, intervention group. Colony growths too numerous to count were defaulted to a minimal threshold level=100. Data were analyzed with descriptive statistics and repeated measures ANOVA (group X time [T1, T2, T3] set a priori at $p < 0.05$). **Results:** A RMANOVA revealed no significant main effect ($F_{2,40}=0.569$, $P=0.571$) or interaction ($F_{6,40}=1.091$, $P=0.384$) for colony count concerning STE. T2-to-T3 STE bacterial growth decreased in the 70%IA ($T_2=43.00 \pm 4.43$, $T_3=15.33 \pm 14.12$) and ICD ($T_2=35.83 \pm 34.85$, $T_3=22.82 \pm 39.76$) groups. STE bacterial growth using CDW ($T_2 = 16.83 \pm 14.27$, $T_3 = 136.67 \pm 41.29$) and 1:10 bleach-to-water solution ($T_2 = 29.50 \pm 36.67$, $T_3 = 38.00 \pm 43.36$) increased from T2-to-T3. In T3, 16% of 70%IA, ICD, CDW, and 1:10 bleach-to-water, showed no bacterial growth, all on the bench back. Identified colony growths were *Streptococcus epidermidis* and *Staphylococcus aureus* (normal flora). A fungal genus (Dematiaceae) was identified at T2 on one 45-lb plate. This genus is infectious to immunocompromised individuals. **Conclusions:** If unsanitized, STE may be a possible vector for bacterial growth. While no significant differences between the cleaning agents were observed, 70%IA and ICD groups did decrease STE colony count from T2-to-T3. Due to the inconsistent results, further research is required to determine the efficacy of disinfecting methods to reduce bacterial growth in STE. Athletic trainers and strength coaches must remain vigilant to reduce the risk of opportunistic bacterial (or fungal) growth on STE post-usage.

Sanitation Efficacy of 70% Isopropyl Alcohol Vs Blue Light Treatment on Reusable Electrodes

Miller RM, Eckman HM, Durrant DK, Bremner CB, Gold RS: Southern Utah University, Cedar City, UT

Context: Reusable self-adhesive electrodes are frequently used in Athletic Training facilities during the application of electrical stimulation treatments, but infection control is a major concern with their use. Traditionally, 70% isopropyl alcohol wipes are used as a sanitation method for these electrodes, but blue light treatment may be another option; as this is a therapeutic modality frequently available in Athletic Training facilities for sanitizing skin wounds and preventing infection. Previous studies have shown that both methods are capable of sanitizing various microorganisms. However, the efficacy of these treatments may not hold true with respect to reusable self-adhesive electrodes due to the adherent properties of the surface. There is a dearth of literature addressing the efficacy of sanitation methods for the specific purpose of disinfecting reusable self-adhesive electrodes. Therefore, our objective was to examine the efficacy of 70% isopropyl alcohol and blue light therapy for sanitizing *Staphylococcus aureus* bacteria on electrodes previously used in an Athletic Training facility. Based on studies examining the efficacy of these methods, we hypothesized that both methods would effectively reduce *Staphylococcus aureus* bacteria on previously used electrodes. **Methods:** This study was completed in a research laboratory on 30 previously used self-adhesive electrodes (2" X 4") collected from a local Athletic Training facility. Electrodes were randomly assigned to one of three treatment groups (alcohol wipe, blue light or control), with 10

electrodes in each group. The alcohol wipe group was treated with one single packaged wipe of 70% isopropyl alcohol (Dynarex®, Orangeburg NY) and three swipes were performed using a systematic approach to ensure complete coverage of the electrode. The blue light treatment group was treated with a light probe (Dynatronics Solaris η 708 Plus, Salt Lake City, UT) at a dosage of 3 J/cm² per point and six points were performed using a systematic approach to ensure complete coverage. The control group received no intervention. Electrodes were then incubated at room temperature for 24 hours, after which the number of staphylococcus aureus colony forming units (CFU) on each electrode was counted. The assumption of normality was violated, thus a Kruskal-Wallis test was used to analyze the data for between group differences with respect to the number of CFU. **Results:** There were no significant between group differences ($H_2 = 3.431$, $P = 0.180$; Alcohol = 123.1 ± 83.2 CFU, Blue Light = 285.3 ± 394.5 CFU, Control = 342.0 ± 339.6 CFU). **Conclusions:** Contrary to our hypothesis, sanitation treatments included in this study were no more effective than a control condition. This suggests that these treatments may not be clinically appropriate for sanitizing reusable self-adhesive electrodes. Further research is needed to better understand the influence of electrode adhesive properties on the effectiveness of sanitation treatments as well as the effectiveness of these treatments on other microorganisms.

Bacterial and Fungal Infections Initiated From Corneal Abrasion in a Collegiate Basketball Athlete Galletti N, Martinez RE, Odai ML, Felton SD: Florida International University, Miami, FL

Background: Level 4 CASE report focuses on the evaluation, diagnosis and treatment of an eye pathology in a 19-year-old female collegiate basketball player. The day before a 3-day trip the athlete stated she had scratched her right eye during practice while adjusting her contact lens. She presented with redness, tearing eye, and slightly swollen eye lids. She denied waking up with the eye sealed shut and denied the presence of mucous surrounding the eye. The athletic trainer diagnosed a corneal abrasion and it was further evaluated by the away team's physician. The physician used a florescent dye test to diagnose the patient with a corneal abrasion with concomitant bacterial conjunctivitis. Due to patient noncompliance and complications, the athlete developed a secondary infection that was successfully treated with anti-fungal eye drops. **Differential Diagnosis:** There was no differential diagnosis, but upon examination by the physician, a bacterial infection that had not fully manifested during the initial evaluation was noted. Clinical diagnosis of a corneal abrasion was consistent throughout patient's evaluations and treatments. **Treatment:** After initial diagnosis, the athlete was treated with Levofloxacin (anti-bacterial drops), 1-2 drops every 2 hours for precautionary measures while traveling. Once home, she was re-evaluated by an ophthalmologist who confirmed the diagnosis and noticed a minor infection developing. The ophthalmologist then prescribed fortified anti-bacterial drops and ordered a culture to identify the infection. In anticipation of culture results, the ophthalmologist also prescribed: Tobramycin every hour, Vancomycin every hour, and Acyclovir 5x per day to proactively stop the infection from developing further. Culture results were negative. Over the course of

6 days the infection showed significant improvement, but it was still present. During the athlete's next away-game trip, the patient was noncompliant with treatment, left the antibacterial drops unrefrigerated for an unknown amount of time, and lost the cap. Consequently, the patient's eye presented with redness, inflammation, tearing, and photophobia. At the conclusion of the away trip, the athlete was taken immediately to the ophthalmologist for reevaluation. The ophthalmologist prescribed additional fortified anti-bacterial drops and anti-fungal drops as a precaution and in direct response to the potentially contaminated drops that were not refrigerated and uncapped. The patient received the anti-bacterial drops, but the anti-fungal drops were administered 24 hours after the anti-bacterial medication. During this time the patient reported an increase in severity of signs and symptoms. However, with the anti-fungal treatment (Natamycin) the infection seemed to improve. After about a month of anti-fungal treatment the athlete experienced minimal symptoms and the infection had been resolved. **Uniqueness:** Although a corneal abrasion is a frequently encountered complication of wearing contact lens[i], this patient's case was unique because she had two different infections back-to-back with one being a fungal infection. **Conclusions:** Corneal abrasions are relatively minor acute injuries[i] that need to be treated efficiently and accurately to prevent sight-threatening consequences. This case especially highlighted the importance of corneal abrasion management and complications that may arise if not taken seriously. Complications like travel time, patient compliance, and contamination are factors that health care professionals should consider when taking care of this type of injury.

Staphylococcus Aureus Bacterial Infection of Biceps Femoris– Level 4 Clinical CASE Study

Key HE, Goins JM: University of South Carolina, Columbia, SC

Background: A 15-year-old female cross-country runner reported to the athletic training room on 10/8/18 complaining of right lateral knee pain when running. The patient had no signs of swelling, discoloration, obvious deformity, antalgic gait, or skin lesion(s). Palpable tightness was noted over her distal IT Band. Upon farther evaluation, ROM was WNL but pain was noted at end range of extension, and all ligamentous structures were in tact. Knee valgus was also noted when performing squats

Differential Diagnosis: IT Band friction syndrome, meniscal tear, hamstring tendinitis. Staphylococcus aureus bacterial infection

Treatment: Patient was initially treated by the athletic trainer for IT Band friction syndrome with gluteal muscle strengthening exercises and instrument assisted soft tissue mobilization. She continued to run as tolerated and ice was applied post-exercise. The patient had no change in pain or presentation for 3 weeks. On 10/31/18, patient presented to the athletic training room with diffuse swelling at the knee joint with no known MOI, signs of infection, or skin lesion. The athletic trainer applied a compression bandage, withheld her from practice, and recommended referral to an orthopedic physician. Patient presented to the athletic training room on 11/1/18 with obvious ecchymosis of her entire knee joint, but still no obvious signs of infection or lesions. The patient was withheld from activity until her doctor's appointment on 11/6/18. By the time of her appointment, she presented with pitting edema in the knee joint and lower leg, increased temperature at the knee joint, decreased temperature and circulation at her feet, and a low grade fever; therefore, she was immediately referred to the

emergency room. She was diagnosed with cellulitis and given an IV drip of Ancef and Septra due to an allergic reaction to Vancomycin. A MRI performed on 11/7/18 ruled out any ligamentous or meniscal involvement and they continued with antibiotic treatment for next 48 hours. Due to lack of improvement, the physician decided to drain the infection from the muscle tissue and take a culture to determine cause of infection. The culture was positive for staphylococcus aureus and patient was released from hospital with crutches & instruction to discontinue crutch use when pain free. Patient returned to school on 11/14/18 and is continuing rehabilitation for her gluteal strength, but has not begun running yet. **Uniqueness:** Patient had no skin lesions or signs of infection to indicate a staphylococcus infection. Tong et al, reports that a cutaneous abscess or other skin infection is the hallmark sign of staphylococcus aureus infection. There was a staphylococcus outbreak on the volleyball and football team approximately 1 month prior to her doctor's visit, but all of them presented with the classic skin lesion and no other cross-country runners were infected. It is still uncertain how the bacteria entered her system, given that she had no skin lesions. Her presentation with a fever is also unique as only 29% of young people with staphylococcus present with a fever. **Conclusions:** Staphylococcus can affect muscle tissue even without presenting with a skin infection first. If a known staphylococcus infection is being spread around, always keep staphylococcus as a differential diagnosis, even if it is not presenting as a classic presentation.

Free Communications, Poster Presentations: Baseline Concussion Assessments

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;
Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Association Between Symptom Cluster Severity and Baseline Neurocognitive Scores in Collegiate Student-Athletes

Bowman TG, Register-Mihalik JK: University of Lynchburg, Lynchburg, VA; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: In addition to tracking of symptoms, objective tests are used to measure neurocognitive performance to aid in informing diagnosis and return to play of concussed patients. Baseline tests are often completed prior to the beginning of athletic participation and are used to compare to scores after an injury is suspected. Modifiers of baseline test scores, such as previous concussion, learning disabilities, test anxiety, and sleep deprivation, among others have been studied to determine how they alter baseline scores in an effort to improve post-injury interpretation. However, it remains unknown how the presence of specific clusters of concussive symptoms at baseline may affect testing scores. Specifically, the purpose of this study was to examine if the presence of symptom clusters at baseline alters baseline concussion scores. **Methods:** We recruited 271 intercollegiate athletes participating in lacrosse, basketball, field hockey, and soccer (128 males, 143 females, age=19±1.15 years) for the present study. Participants completed a comprehensive baseline concussion battery which included the symptom checklist from the Sport Concussion Assessment Tool 5 and CNS Vital Signs neurocognitive testing. After completion, we grouped Sport Concussion Assessment Tool 5 symptoms into four symptom clusters (cognitive-sensory, sleep-arousal, vestibular-somatic, and affective) which served as the independent variables. The CNS Vital Signs subsection scores (Verbal Memory, Visual Memory, Executive Function, and Reaction

Time) served as the dependent variables. We ran a stepwise multiple linear regression model for each of the 4 CNS Vital Signs subsection scores using the 4 symptom cluster severity scores as the predictors in each model. **Results:** Participants reported cognitive-sensory cluster symptoms most often (68.6%, mean=3.11±3.97, range=0-20) followed by affective (38.2%, mean=1.36±2.77, range=0-21), sleep arousal (32.9%, mean=0.70±1.33, range=0-7), and vestibular-somatic (31.1%, mean=0.76±1.81, range=0-14). We found a significant regression equation to predict executive function using affective symptom cluster severity score ($R^2=.02$, $F_{1,255}=4.77$, $P=.03$); the equation is executive function=46.62-0.50(affective)). As executive function scores (mean=45.93±10.32) increased, affective cluster severity scores (mean=1.37±2.77) decreased. No other CNS Vital Signs subsections could be predicted using the 4 symptom cluster severity scores ($P>.05$). **Conclusions:** The presence of concussive symptoms was common during baseline neurocognitive testing prior to the start of athletic seasons. The presence of symptom clusters at baseline only altered the executive function subsection of CNS Vital Signs. Although the presence of specific clusters of symptoms at baseline may be concerning to healthcare practitioners, they do not appear to alter many of the commonly assessed neurocognitive domains that are examined at baseline to assist in concussion diagnosis.

Prevalence of Unexpected Brain MRI Findings and Relative Risk of Concussion Diagnosis During Sports Participation: A Prospective Longitudinal Imaging Study

Barber Foss KD, Leach J, Logan K, Diekfuss JA, Mangano FT, Myer GD: Cincinnati Children's Hospital, Cincinnati, OH

Context: There is limited prospective data on unexpected neuroimaging findings in asymptomatic pediatric athletes undergoing research evaluations. The risks of sports participation and head impact exposure in those with identified intracranial abnormalities is poorly understood. The objective of this prospective cohort study was to examine the prevalence of unexpected intracranial abnormalities in pediatric sport populations, monitor their relative risk for sustaining a diagnosed concussion during the season, and to evaluate any changes in the intracranial abnormalities acquired during the season. **Methods:** Athletes completed one magnetic resonance imaging (MRI) session before (preseason; n = 411; 247 football and 164 soccer) and after (postseason; n = 379; 239 football and 140 soccer) their competitive high school male football or female soccer season, as well as within seven days of a suspected concussion (n = 41; n = 28 football and 13 soccer). A single neuroradiologist reviewed T1 and T2 weighted MRI anatomic images for unexpected brain findings. A one tailed Pearson Chi-Square test of independence was used to determine differences in concussion incidence between those with and without intracranial abnormalities identified from the preseason MRI. **Results:** There were 31 unexpected, potentially clinically significant findings in 30 subjects at preseason (7.3% of the total subjects; 16 football and 14 soccer). Intracranial MRI findings (28 subjects) included : Chiari I

malformation (8), non-specific cerebral white matter signal consistent with gliosis (6), intracranial cyst (5), non-specific localized thalamic signal (4), cavernous malformation (3), encephalocele (1), cerebellar signal (1), and enlarged internal carotid artery (1). Two subjects had significant paranasal sinus or mastoid opacification. One of the subjects with a Chiari I malformation made the decision to stop playing football. Participants had 17,946 athletic exposures and those with an intracranial finding at preseason demonstrated significantly higher incidence of sport-related concussion (4.91; 2 football, 3 soccer; 2 with Chiari I, 3 with abnormal signal foci) compared to those with no intracranial abnormalities (2.13; 26 football and 10 soccer), $\chi^2(1) = 3.27$, $p = 0.04$. One soccer athlete with a Chiari I malformation at pre-season demonstrated increased cerebellar tonsillar ectopia and findings suspicious for intracranial hypotension during her post-concussion MRI scan. The subject was referred to a neurosurgeon, who recommended stopping soccer participation. Her subsequent follow-up scan at end of the surveillance period revealed stable tonsillar ectopia. Post-season scans of the remainder of the subjects revealed no further change in the unexpected findings. **Conclusions:** Our study found a comparable rate of incidental findings as previous studies of healthy populations, but our longitudinal injury surveillance of outcomes in competitive sport indicate that those with pre-existing intracranial findings may be at increased risk for concussions. These findings may help supplement the prevention, treatment, and management of sport-related concussion in youth sports.

Quality of Life and Presence of Symptom Clusters During Baseline Neurocognitive Testing
 Asewicz EA, Bradney DA, Bowman TG, Register-Mihalik JK: University of Lynchburg, Lynchburg, VA; University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Health related quality of life (HRQOL) measures are used to evaluate and monitor physical, mental, and social health. Measures of HRQOL are becoming more popular in collegiate student-athletes as mental health issues are becoming destigmatized and screening and treatment are incorporated into sport performance. Little research has studied factors that may affect HRQOL measures. The presence of symptoms during baseline neurocognitive testing may provide influence reports into a patient's HRQOL. Therefore, the purpose of this study was to determine the relationship between self-reported symptom cluster severity scores during baseline concussion testing and health related quality of life measures. **Methods:** We recruited 271 intercollegiate athletes participating in lacrosse, basketball, field hockey, and soccer over the past three years (age = 19.00 ± 1.15

years, height = 175.18 ± 4.29 cm, mass = 72.29 ± 12.03 kg). Participants completed a comprehensive baseline concussion battery which included the 22-item symptom checklist from the SCAT 5 and a HRQOL screen including the Patient-Reported Outcomes Measurement Information System® (PROMIS-29) inventory and the cognitive and fatigue scales from the Quality of Life in Neurological Disorders scale (Neuro-QOL). After completion, we grouped SCAT 5 symptoms into four symptom cluster severity scores (cognitive-sensory, sleep-arousal, vestibular-somatic, and affective) which served as the independent variables. The PROMIS subsection scores (anxiety, depression, fatigue, pain interference, pain intensity, physical function, sleep disturbance, social roles, fatigue, cognitive function) and the Neuro-QOL subsets (fatigue SF, Cognitive Function SF) served as the dependent variables. We ran stepwise multiple linear regression for each of the HRQOL subsection scores using the symptom cluster severity scores as the predictor variables. **Results:** Participants reported cognitive-sensory cluster symptoms most often (68.6%, mean=3.11±3.97, range=0-20) followed by affective (38.2%, mean=1.36±2.77, range=0-21), sleep arousal (32.9%,

mean=0.70±1.33, range=0-7), and vestibular-somatic (31.1%, mean=0.76±1.81, range=0-14). Higher cognitive-sensory and affective symptom cluster severity scores were associated with worse cognitive function SF (F_{2,262}=42.78, P<.001), fatigue SF (F_{2,258}=70.00, P<.001), fatigue (F_{2,262}=132.11, P<.001), and anxiety (F_{2,263}=62.79, P<.001) scores. Higher affective and sleep-arousal symptom cluster severity scores were associated with worse social roles (F_{2,260}=19.37, P<.001) and depression (F_{2,264}=75.58, P<.001) scores. Higher sleep arousal and affective symptom cluster severity scores were associated with worse sleep disturbance (F_{2,260}=50.63, P<.001) scores. Higher cognitive-sensory symptom cluster scores were associated with worse pain intensity (F_{1,262}=35.32, P<.001), pain interference (F_{1,262}=10.66, P<.001), and physical function (F_{1,265}=11.90, P<.001) scores. **Conclusions:** Findings suggest that quality of life is affected by self-reported symptom cluster severity scores. Identifying the presence of symptom clusters in collegiate athletes may provide insight into potential negative HRQOL outcomes. Healthcare professionals may use symptom scores and HRQOL measures to help identify those in need of referral to mental health professionals.

Table One- HRQOL and Symptom Cluster Severity Scores

DV	IV	B (Slope)	t	P	Lower CI 95%	Upper CI 95%	Model F	R ²
Cognitive Function	CS	-0.51	-5.67	<.001	-0.69	-0.33	42.78	0.23
	A	-0.35	-2.68	0.01	-0.61	-0.09		0.25
Fatigue SF	CS	0.52	6.26	<.001	0.35	0.68	70.00	0.30
	A	0.55	4.59	<.001	0.32	0.79		0.35
Social Roles	A	-0.15	-3.37	<.001	-0.28	-0.07	19.37	0.10
	SA	-0.25	-2.99	0.003	-0.42	-0.09		0.13
Sleep Disturbance	SA	1.05	7.36	<.001	0.77	1.33	50.63	0.26
	A	0.20	2.93	<.01	0.07	0.34		0.28
Pain Intensity	CS	0.13	5.94	<.001	0.09	0.17	35.32	0.12
Pain Interference	CS	0.06	3.23	0.001	0.03	0.10	10.66	0.04
Fatigue	A	0.59	8.12	<.001	0.45	0.73	132.11	0.42
	CS	0.34	6.78	<.001	0.24	0.44		0.50
Depression	A	0.37	9.98	<.001	0.30	0.44	75.58	0.35
	SA	0.16	2.10	0.04	0.01	0.31		0.36
Anxiety	A	0.50	7.80	<.001	0.37	0.63	62.79	0.31
	CS	0.09	2.03	0.04	0.00	0.18		0.32
Physical Function	CS	-0.04	-3.45	0.001	-0.07	-0.02	11.90	0.04
BSI Total	A	0.88	9.50	<.001	0.70	1.06	91.41	0.46
	CS	0.24	3.50	0.01	0.10	0.37		0.50
	SA	0.41	2.20	0.03	0.05	0.78		0.51

Current Evidence in Management of Concussion Baseline Testing in ADHD and Patients With Learning Difficulties

Fisher MA, Mansell JL, Russ AC, Tierney RT: California University of Pennsylvania, California, PA; Temple University, Philadelphia, PA

Context: Attention deficit hyperactivity disorder (ADHD) has a prevalence of 5.3% world-wide and is the most common neuro-behavioral childhood disorder. ADHD and learning difficulties (LD) have similar symptoms of a concussion without having an injury and often produce invalid results during baseline testing for concussion. In concussed patients, will having ADHD or LD versus not having ADHD or LD cause higher symptom severity scores or invalid baseline protocols? **Methods:** Ovid, PubMed, and Medline were searched in July 2018 using the Boolean phrases: concussion symptoms AND ADHD OR LD, concussion testing AND ADHD OR LD, concussion OR mTBI AND ADHD OR LD. Titles were reviewed for relevance, then full text. Articles from 2007-2018 only were included based on their ability to answer the research question. Articles that assessed concussion using methods other than Graded Symptom Checklist (GSC), Sport Concussion Assessment Tool (SCAT), or Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) were excluded. Validity was evaluated using the Strobe Checklist for cross-sectional studies and the PEDro scale for cohort studies. Outcome measures were representative of symptom type and severity, and composite data scores. Symptom type and severity score measures included GSC, SCAT, and ImPACT. For composite scores which measured invalid baseline testing, the measure included ImPACT. **Results:** The search returned 9 articles and 6 were selected for inclusion. Three cross-sectional studies had appraisal scores of 14/22, three cohort studies scored 4/5, 4/5, and 5/5.

One cross-sectional study revealed that children with ADHD had significantly more symptoms ($d=0.95$) and greater severity ($d= 1.13$) than controls. A second cross-sectional study reported students with ADHD performed worse on ImPACT composite scores (Phillai's Trace= 0.05) and were likely to produce invalid protocol results (7.7%) when compared to controls (2.6%). The third cross-sectional study indicated that those with ADHD reported more baseline symptoms (mean= 5.75, SD= 8.26) than controls (mean= 3.05, SD= 5.97). In cohort study one, mTBI subjects had significantly higher rates of ADHD than controls without mTBI (31% vs 9%, $P<0.012$). In a second cohort study, girls with ADHD and not taking medication had modestly great rates of invalid scores compared to controls (10.9% to 5.2%, OR=2.21, 95%CI=1.92-2.50). Lastly, athletes with ADHD and/ or LD, reported a higher number of prior concussions ($p <0.05$). **Conclusions:** Research demonstrates that individuals with ADHD or LD have significantly higher baseline symptom severity scores without experiencing a concussion and are slightly more likely to produce invalid composite ImPACT scores. Symptoms often identified by ADHD individuals include fatigue, difficulty concentrating, difficulty remembering, lack of balance, and trouble sleeping. Future research should be done to determine appropriate composite scores on the ImPACT test and different symptom ranking scales that can be used for individuals with ADHD or LD.

Gender Differences on Baseline Child Sport Concussion Assessment Tool 5th Edition Performance Among Middle School Students

Kelshaw PM, Cook NE, Terry DP, Iverson GL, Ambegaonkar JP, Caswell SV: George Mason University, Manassas, VA; Harvard Medical School, Boston, MA; Spaulding Rehabilitation Hospital, Boston, MA; Mass- General Hospital for Children, Boston, MA

Context: Baseline performance values for the Child Sport Concussion Assessment Tool 5th Edition (Child SCAT5) have yet to be reported. Research on the prior version of the measure (e.g., Child SCAT3) indicated differences by gender and pre-existing health conditions (PHC) at baseline and following concussion. The purpose of this study was to examine gender differences as well as the effect of PHCs on baseline Child SCAT5 performance measures in middle school students. **Methods:** A cross-sectional study was conducted on a sample of middle school students located in Virginia during the 2017-2018 academic year, (N=1,045; ages 11 to 14, M=12.6 years, SD=0.9; 45.6% girls, 54.4% boys). Athletic trainers proficient in Child SCAT5 administration and scoring, collected baseline assessments from middle school students during the first two weeks of sport seasons. Each student was administered the Child SCAT5 in a single session at their sports practice location. Each student was in a relaxed, resting state prior to assessment. Students self-reported their gender (boy or girl) as well as their PHC status (i.e., whether they had previous concussions, been diagnosed with ADHD, headache disorders, learning disabilities, or psychiatric disorders). Mann-Whitney U tests were used to examine gender differences in the full sample, and those without PHC ($n=755$). Cohen's d was calculated to characterize the magnitude of observed effects. Alpha was set

a priori at $p < 0.05$. **Results:** When analyzing the full sample, girls performed better than boys on immediate memory ($U=126043.0$, $p < 0.05$, Cohen's $d = -0.16$) and delayed recall ($U=119102$, $p < 0.01$, $d = -0.18$). Boys had more balance errors ($U=122060.5$, $p < 0.05$, $d = 0.20$) than girls. There were no significant gender differences on number of symptoms, symptom severity, or concentration. When limiting the sample to students without PHC ($n=755$), girls reported significantly more symptoms ($U=61310.0$, $p < 0.01$, $d = -0.26$) and greater symptom severity ($U=62342.5$, $p < 0.01$, $d = -0.24$) than boys. There were no statistically significant differences between boys and girls on immediate memory, delayed recall, balance, or concentration. **Conclusions:** Girls generally performed better than boys on cognitive and balance tasks. Additionally, girls reported more symptoms and symptom severity scores at baseline than boys when limiting the subsample to no PHC. Our findings are consistent with previous work reporting gender effects and PHC effects on the Child SCAT3. Clinicians and researchers should consider gender effects when using the Child SCAT5 to aid in concussion management among middle students.

The Association of Baseline Child Sport Concussion Assessment Tool 5th Edition Performance and Primary Language Spoken at Home Among Middle School Students

Abrams V, Kelshaw P, Cook NE, Terry DP, Iverson GL, Cortes N, Caswell SV: George Mason University, Manassas, VA; Harvard Medical School, Boston, MA; Spaulding Rehabilitation Hospital, Boston, MA; Mass-General Hospital for Children, Boston, MA

Context: No prior research has examined baseline Child Sport Concussion Assessment Tool 5th Edition (Child SCAT5) performance. In particular, there is no research investigating if and how cultural and linguistic variables might affect Child SCAT5 performance. Thus, the purpose of this study is to examine differences in Child SCAT5 performance based on the primary language spoken in their home among a diverse cohort of middle school students.

Methods: A cross-sectional study was conducted during the 2017-18 academic year assessing baseline Child SCAT5 performance among 1,002 middle school students (ages 11 to 14; $M=12.6$ years, $SD=0.93$; 45.5% girls, 54.5% boys), stratified by self-reported language spoken at home (English only, $n=830$; Spanish only, $n=87$; or English and Spanish, $n=85$). Students also self-reported pre-existing health conditions (PHC) including prior concussion, attention-deficit/hyperactivity disorder, headache disorders, learning disabilities, and psychiatric disorders. Athletic trainers proficient in administering the Child SCAT5 assessed students during the first two weeks of sport participation. Kruskal-Wallis tests were used to evaluate differences in student self-reported language spoken at home on Child SCAT5 performances for the full sample and sample without PHC ($n=755$). Planned pairwise comparisons using Mann-Whitney U tests were used. Cohen's d was calculated

to characterize the magnitude of observed effects. Alpha was set a priori at $p < 0.05$. **Results:** For the full cohort, the language groups differed on immediate memory ($\chi^2(2)=23.18$, $p < 0.01$) and concentration ($\chi^2(2)=9.79$, $p < 0.05$). Follow-up analyses revealed that students who speak English only scored higher than those who speak Spanish only on immediate memory ($U=26341.5$, $p < 0.01$, Cohen's $d = 0.53$) and concentration scores ($U=29342.5$, $p < 0.01$, $d = 0.37$). Those who speak English only scored higher on immediate memory compared to those who speak both English and Spanish at home ($U=29990.5$, $p < 0.05$, $d = 0.20$). There were no statistical differences of number of symptoms, symptom severity, delayed recall, and balance. Among those without PHC, significant group differences were noted for immediate memory ($\chi^2(2)=13.48$, $p < 0.01$), concentration ($\chi^2(2)=12.50$, $p < 0.01$), and delayed recall ($\chi^2(2)=6.58$, $p < 0.05$). Students who speak English only scored significantly higher than those speak Spanish only on immediate memory ($U=15465.5$, $p < 0.01$, $d = 0.41$) and concentration ($U=15438.5$, $p < 0.01$, $d = 0.42$). Students who speak both English and Spanish scored significantly higher than those who speak English only on delayed recall ($U=17118.0$, $p < 0.05$, $d = -0.31$) and higher than students who speak Spanish only on concentration ($U=2071.5$, $p < 0.05$, $d = -0.36$). There were no statistical differences of number of symptoms, symptom severity, and balance.

Conclusions: There were significant cognitive differences in baseline Child SCAT5 performance among middle school students based on their primary language spoken at home. These findings suggest the need for further research examining potential cultural and linguistic differences on baseline concussion assessment tools. Clinicians and researchers should be aware of cultural or linguistic differences on the Child SCAT5 when assessing patients.

Examining Age Differences on Baseline Child Sport Concussion Assessment Tool 5th Edition Performance Among Middle School Students

Piatchek E, Kelshaw PM, Cook NE, Terry DP, Iverson GL, Caswell AM, Caswell SV: George Mason University, Manassas, VA; Harvard Medical School, Boston, MA; Spaulding Rehabilitation Hospital, Boston, MA; Mass- General Hospital for Children, Boston, MA

Context: Little research has examined the Child Sport Concussion Assessment Tool 5th Edition (Child SCAT5). Prior research has established normative performance values for the Child SCAT3. However, currently such values do not exist for the performance of middle school students on the Child SCAT5. The objective of this study was to examine age differences on baseline Child SCAT5 scores in middle school students. **Methods:** A cross-sectional study was conducted among 1,045 middle school students (11 to 14 years old, $M=12.6$ years, $SD=0.9$; 45.6% girls, 54.4% boys) who completed baseline Child SCAT5 evaluations in their initial two weeks of sport participation during the 2017-2018 academic year. Athletic trainers trained on Child SCAT5 administration conducted all Child SCAT5 testing. Students self-reported pre-existing health conditions (PHC) (e.g., previous history of concussion, were diagnosed with ADHD, headache disorders, learning disabilities, or other psychiatric disorders). Kruskal-Wallis tests were used to evaluate differences in baseline Child SCAT5 performances across 4 age groups (11, 12, 13, or 14-year olds) among the full sample, and sub-sample without PHC ($n=755$). Planned pairwise comparisons using Mann-Whitney U tests were used. Cohen's d was calculated to characterize the magnitude of observed effects. Alpha was set a priori at $p<0.05$. **Results:** Among the full sample, age groups differed on immediate memory

($\chi^2(3)=16.39$, $p<0.01$). Follow-up analyses revealed that 11-years performed worse than 12-years ($U=19813.0$, $p<0.05$, Cohen's $d = -0.21$), 13-years ($U=231835.5$, $p<0.01$, $d = -0.31$), and 14-years ($U=106557.5$, $p<0.01$, $d = -0.29$) on immediate memory. Among those without PHC, age groups differed on immediate memory ($\chi^2(3)=12.76$, $p<0.05$) and follow-up comparisons indicated that 11-years performed worse than 12-year olds ($U=10379.5$, $p<0.05$, $d=-0.28$), 13-year olds ($U=12279.5$, $p<0.01$, $d=-0.34$), and 14-year olds ($U=5606.0$, $p<0.05$, $d=-0.29$). There were no statistical differences among number of symptoms, symptom severity, concentration, delayed recall, or balance for either the full sample or without PHC subsample. **Conclusions:** Our results indicate age effects on baseline Child SCAT5 assessments in middle school students. In general, older students appear to perform better on immediate memory and delayed recall than younger students; however, differences are also observed when limiting the sample to students with PHC. Clinicians and researchers should be aware that age affects Child SCAT5 performance in middle school students.

Baseline Differences Between High School and Collegiate Athletes on the Sport Concussion Assessment Tool 5 (SCAT5)

Petit KM, Anderson M, Bretzin AC, Savage JL, Tomczyk CP, Covassin T: Michigan State University, East Lansing, MI

Context: Several differences are reported to exist between youth, high school and collegiate athletes at baseline and following a sport-related concussion (SRC). These differences include symptom reporting, neurocognitive performance and postural control, with older athletes performing better and reporting less symptoms than their younger counterparts. The Sport Concussion Assessment Tool (SCAT5) was recently revised, therefore, it is important to determine if previously reported age differences still exist on the new domains of the SCAT5 (i.e. 10-word list) at baseline. The purpose of this cross-sectional study was to determine if pre-season baseline SCAT5 differences exist between high school and collegiate athletes. **Methods:** A sample of 144 high school athletes (male=49%, female=51%, age range=13-17 years, mean=14.4 \pm 1.2 years) and 276 collegiate athletes (male=52%, female=48%, age range=18-24 years, mean=19.2 \pm 1.3 years) completed the SCAT5 prior to the 2017-18 and 2018-2019 athletic seasons. Participants were recruited from 13 sports with almost half the athletes participating in soccer (19.3%), basketball (17.6%), and swimming and diving (13.8%). The SCAT5 is comprised of patient demographics, Post-Concussion Symptom Scale (PCSS), Standard Assessment of Concussion (SAC), neurological assessment, and the modified Balance Error Scoring System (mBESS). The SAC includes four components: orientation, immediate memory, concentration, and delayed recall. The independent variable was education level (high school and collegiate). Mean scores and standard deviations for high school and collegiate

athletes were calculated for the total number of symptoms (0-22), overall symptom severity (0-132), orientation (0-5), immediate memory (0-30), concentration (0-5), delayed recall (0-10), total SAC score (0-50), and the mBESS score (maximum 30 errors). Due to non-normality, separate Mann-Whitney U tests were conducted to determine if differences exist between high school and collegiate athletes. Alpha level was set a priori at .05. **Results:** There were several differences between high school and collegiate athletes. High school athletes reported more symptoms ($U=16923.50$, $p=0.005$) at a greater severity ($U=17201.00$, $p=0.011$), and performed worse on several components of the SAC (immediate memory: $U=17056.00$, $p=0.012$, concentration: $U=16422.00$, $p=0.002$, SAC total: $U=17159.50$, $p=0.016$) when compared to collegiate athletes. However, orientation ($U=19626.00$, $p=0.391$) and delayed recall ($U=19608$, $p=0.732$) did not differ between groups. Performance on the mBESS also differed between groups, with high school athletes committing more errors than collegiate athletes ($U=12461.50$, $p\leq 0.001$). **Conclusions:** This study suggests that high school and collegiate athletes significantly differ in several components of the recently revised SCAT5. These differences may be due to high school athlete's still developing brains and cognitive function, and further support the need to perform individualized baseline assessments to act as a personal reference during post-concussion evaluation. In addition, clinicians should consider re-administering the SCAT5 at baseline to athletes transitioning from high school to collegiate sports.

Examining Neurocognitive Performance Across Varying Levels of College Contact Sports Bretzin AC, Nogle S, Covassin T: Michigan State University, East Lansing, MI

Context: Neurocognitive function is influenced by a history of previous concussions; however, recent evidence suggests repetitive head impact exposure during contact sport participation may also result in structural and functional impairments. Therefore, the purpose of this study is to retrospectively compare baseline neurocognitive performance and total symptom scores between college athletes competing in various levels of contact sports. **Methods:** This was a retrospective cross-sectional design. Prior to the start of their season, college athletes were administered baseline neurocognitive performance. Based on previously reported concussion rates athletes were separated into high contact (cheerleading, football, ice hockey, soccer, wrestling), moderate contact (baseball, basketball, field hockey, gymnastics, lacrosse, softball, volleyball), and non-contact (dance, diving, golf, rowing, swimming, tennis, track & field, cross-country) groups. Independent sample t tests and chi square tests were used to analyze significant differences between groups for each of the demographic variables. Five separate one-way ANCOVA (covariates: age, sex, concussion history, learning disability, ADD/ADHD, treatment for headache and/or migraine) analyses were performed on neurocognitive composite scores (verbal memory, visual memory, visual motor speed, reaction time) and total symptoms. Post-hoc pairwise comparisons were completed when appropriate. Statistical significance was set at a Bonferoni adjusted $p\leq 0.01$. **Results:** Participants included 48.8% high contact ($n=745/1523$; 19.0 ± 1.4 years; freshman 66.9%; concussion history $\leq 1:29.8\%$), 22.0% moderate contact ($n=335/1523$; 18.9 ± 1.2 years; freshman 62.7%; concussion history $\leq 1:19.7\%$), and 29.0% non-contact

($n=443/1523$; 19.0 ± 1.3 years; freshman 60.0%; concussion history $\leq 1:15.1\%$) athletes. There were no significant differences between groups for age or learning disability; however, there were significant differences between sex, history of ≥ 1 previous concussions, ADD/ADHD, treatment for headache and/or migraine between groups (all $p\geq .05$). The one-way ANCOVAs revealed no significant differences between contact sport athletes on any neurocognitive composite score (all $p\geq .01$). However, there were significant differences between high contact (3.18 ± 6.2), moderate contact (3.20 ± 5.3), and non-contact (5.51 ± 7.8) athletes for total symptoms ($F(1,1519)=21.79$, $p\leq .001$, $\eta^2=.03$), as non-contact athletes reported more total symptoms than high contact ($p\leq .001$) and moderate contact athletes ($p\leq .001$). **Conclusions:** There were no significant differences in neurocognitive function between college athletes participating in various levels of contact sports. Non-contact athletes reported more symptoms at baseline compare to high and moderate contact athletes. The majority of participants completing baseline assessments were freshman or transfer athletes; therefore future research should evaluated the influence of multiple seasons of contact sport participation has on neurocognitive function.

Free Communications, Poster Presentations: Case Studies

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday,

June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;

Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Comparison of Secondary School Boys' and Girls' Lacrosse Injuries Sustained Above the Transverse Plane

Quetant SL, Wasserman EB, Collins CL: Datalys Center for Sports Injury Research and Prevention, Inc, Indianapolis, IN

Context: Boys' lacrosse rules allow for stick checking, whereas girls' lacrosse does not, affecting the style of play. Therefore, one would expect the injury rate to the upper body to be higher in boys than girls, but this has not been studied. The purpose of this study was to compare injuries sustained above the transverse plane between boys' and girls' secondary school lacrosse. **Methods:** As part of the National Athletic Treatment Injury and Outcomes Network (NATION), athletic trainers (ATs) reported injuries requiring medical attention and athlete-exposures (AEs) from secondary school student-athletes participating in 72 team-seasons of boys' lacrosse and 83 team-seasons of girls' lacrosse during the 2011/12-2016/17 seasons. Injury rates per 1,000 AEs and rate ratios (RRs) were reported with 95% confidence intervals (CIs), along with characteristics, of injuries sustained above the transverse plane. **Results:** The overall injury rate for injuries above the transverse plane was higher in boys' lacrosse (4.1, 95%CI:3.8-4.4) compared to girls' lacrosse (2.9, 95%CI:2.6-3.2; RR=1.40, 95%CI:1.24-1.58). Of the 272 boys' lacrosse injuries for which mechanism of injury (MOI) and activity were reported, the most common MOI were player contact (n=125, 46%) and stick contact (n=57, 21%). Of the 112 girls' lacrosse injuries for which MOI and activity were reported, the most common MOI were ball contact (n=34, 30%) and player contact (n=25, 22%). The proportion of injuries due to player contact was significantly higher

in boys' lacrosse than girls' lacrosse ($p<0.01$), but there was no difference in the proportion due to stick contact ($p=0.93$). The most common injury activities in boys' lacrosse were ball handling (n=54, 20%), general play (n=48, 18%) and defending (n=46, 17%). The most common injury activities in girls' lacrosse were general play (n=18, 17%), receiving pass (n=16, 14%), defending (n=13, 12%) and ball handling (n=13, 12%). The most common diagnoses for both boys and girls were contusions (n=339, 41% and n=137, 38%, respectively) and concussions (n=121, 15% and n=63, 17%, respectively). The most commonly injured body parts for boys were head/face (n=169, 20%), hand/fingers (n=148, 18%), and shoulder/clavicle (n=111, 13%). The most commonly injured body parts for girls were head/face (n=110, 30%), hand/fingers (n=63, 17%), and lumbar spine/lower back (n=52, 14%). **Conclusions:** Boys sustained injuries above the transverse plane at a higher rate than girls, and a larger proportion of boys' injuries were due to player contact than girls' injuries; this difference is likely attributable to rule differences. While the rate and MOI differed greatly, the body parts injured and types of injuries sustained were similar between sexes. Therefore, it is important for ATs to consider rule differences when instituting injury prevention strategies for lacrosse teams. Future research should examine the effect of using more and/or different protective equipment on reducing injury rates.

Outcomes Following Multi-Ligament Knee Reconstruction and Novel Meniscus Radial Repair Technique: Return to Olympic Level Skiing

Berning KR, DePhillipo NN, Martin BM, LaPrade RF: The Steadman Clinic, Vail CO; Steadman Philippon Research Institute, Vail, CO

Background: Multi-ligament knee injuries (MLKI) have a common occurrence during high-energy sports such as downhill ski racing. The occurrence of such injuries can be career-ending and are often complicated with associated injuries such as complex, irreparable meniscus tears. Current literature reports on outcomes following these injuries for patients returning to normal activities of daily life but there is a lack of evidence reporting on return to high level sports. Furthermore, acute surgical treatment (<3 weeks) has demonstrated superior outcomes compared to delayed treatment.

Patient: 28-year-old female Olympic-level alpine skier sustained an acute right knee injury during a competitive skiing event. She described a noncontact mechanism at the time of injury which included deep knee flexion with a varus force. She began to experience immediate anterolateral knee pain and swelling. Upon examination by the athletic trainer, there was effusion and swelling around the knee. Right knee extension was -7 degrees of hyperextension compared to -3 degrees of hyperextension on the left knee. Right knee flexion was limited to 90 degrees due to swelling and pain. Ligamentous exam revealed a 3+ Lachman's test with a soft endpoint, 3+ pivot shift, and 3+ varus stress test at 30 degrees. The dial test was 1+ at 30 degrees of knee flexion with rotation occurring from the anterolateral tibia. The proximal tibiofibular joint had increased anteroposterior motion at 90 degrees of knee flexion compared to the contralateral limb. An MRI demonstrated a complete tear of the ACL and attenuation of the LCL. The PCL, MCL, and popliteus tendon were intact. There was a possible tear noted in the

posterior horn of the medial meniscus. The lateral meniscus displayed a complex radial tear near the root attachment. The popliteofibular ligament appeared torn and there was increased swelling around the posterior ligamentous complex of the proximal tibiofibular joint. **Intervention or Treatment:** Examination under anesthesia revealed complete grade III ACL and LCL tears. Prior to the surgery, bone marrow aspirate was harvested from the left posterior superior iliac crest and whole blood was drawn. Both were processed in a centrifuge to isolate bone marrow concentrate and platelet-rich plasma, which were injected into the patient's knee at the end of the surgery for biological healing augmentation. Surgery was performed 4 days status post injury, which consisted of an open common peroneal nerve neurolysis, open LCL reconstruction with hamstring tendon autograft, open proximal tibiofibular joint reconstruction with hamstring autograft, open popliteofibular ligament repair, medial meniscus ramp repair, lateral meniscus two-tunnel transtibial radial repair, and ACL reconstruction with patellar tendon autograft. **Outcomes or Other Comparisons:** Following surgery, the patient was non-weight bearing for 6 weeks with limited knee flexion ROM to 90 degrees for 2 weeks. A return to snow progression was initiated at 7 months postoperatively. The athlete passed a functional sports test at 10 months postoperatively and was cleared to return to play with no restrictions. At 12 months postoperatively, the athlete placed in an Olympic qualifying ski race. At 14 months, the athlete competed in the 2018 Olympic Winter games and placed in the top 15 overall in super G and downhill events. **Conclusions:** Prompt diagnosis and surgical intervention are critical in the acute management of athletes with MLKI's. Anatomic surgical reconstruction provides the highest potential for any patient to return to activity following multi-ligament knee trauma. **Clinical Bottom Line:** This case highlights the ability of an athlete to return to elite level of competition following a multi-ligament knee injury in a safe, but timely manner. MLKI's should be treated within 3 weeks from injury to allow for optimal outcomes and return to pre-injury level of sport.

Non-Contact Femoral Fracture With No Preexisting Pathology in a High School Football Player: Level 4 Clinical CASE Study

Gezella TG, Tripp BT, Dunbar ZD: University of Florida, Gainesville, FL

Background: A 16-year-old male football wide receiver (ht=1.85m; mass=71.9kg) attempted to jump and catch a pass in a non-contact drill when he rotated, landed with full weight on his right leg and collapsed to the ground. The mechanism produced an audible "snap." The patient presented with an angulated deformity of his right thigh. The patient reported anterior thigh pain and stated no previous or existing injury to his affected leg. The patient remained calm and showed no signs of shock. The athletic trainer palpated the patient's anterior thigh and observed no visible wounds or lacerations. Manual muscle testing revealed 1/5 strength with pain for the quadriceps and iliopsoas and 3/5 for lower leg muscles. Neurovascular examination revealed normal distal neurological function, sensation, dorsal pedal and posterior tibial pulse. The athletic trainer and emergency medical personnel immobilized the extremity. **Differential Diagnosis:** Hip dislocation, knee dislocation, or femur fracture. **Treatment:** Emergency medical services administered 100mcg of fentanyl and transported the patient to the trauma center. Radiographs displayed a closed mid-shaft transverse femur fracture with approximately two shaft widths displacement of the distal fragment and 7cm of foreshortening with no preexisting pathological condition. The trauma team administered an anesthetic and injected the patient with 20cc of 2% lidocaine. The trauma team then performed a closed reduction and placed the patient in 15lbs. of traction. Follow up radiographs revealed adequate alignment. Surgeon and room availability caused the surgery to be delayed approximately 48 hours. The anesthesiologist inserted a femoral nerve block catheter because of persistent pain. The patient took a narcotic every 6 hours, a muscle relaxant twice a day, and an anticoagulant

until surgery. The surgeon placed the patient in a traction boot. Under guided fluoroscopy the surgeon reamed the femoral canal to 12mm and inserted a 10mm x 420mm Stryker antegrade femoral rod secured with two proximal and two distal 5mm screws. The next day the patient completed physical therapy that consisted of ascending and descending stairs and walking 50ft while partial weight bearing on his right leg with crutches. Two days after surgery the orthopedist discharged and instructed the patient to weight bear as tolerated with crutches and take narcotic medication for pain every six hours as needed. Three weeks post-surgery the patient discontinued narcotic medication, displayed a 10-degree extension lag, no areas of tenderness to palpation, no pain with axial loading of femur, and 4/5 strength for the quadriceps. Four weeks post-surgery the patient began full weight bearing without crutches. Three months post-surgery the patient returned to normal activity. Six months post-surgery the patient returned to full function. **Uniqueness:** The literature reports only one other non-contact femoral fracture with no preexisting pathology in an adolescent. Common preexisting conditions that result in femoral fracture for adolescent athletes include stress fracture, osteopenia, and osteogenic sarcoma. Our patient presented with none of these conditions. Femoral shaft fractures account for less than 2% of all fractures in adolescents and often occur in children under the age of 10. Our patient is 16 years old and suffered a midshaft transverse femoral fracture with a spiral fracture mechanism. Full weight bearing is normally accomplished 6 weeks post-surgery. Our patient began full weight bearing 4 weeks post-surgery. **Conclusions:** Although non-contact femoral fractures are extremely rare in adolescents, they can still occur without any preexisting pathologic conditions. The initial evaluation and treatment are important steps to ensure a successful prognosis. Proper surgical anatomical alignment and early functional rehabilitation is key for good prognosis and reduced postsurgical complications.

Parsonage Turner Syndrome in a Tactical Athlete: A Case Study

Bailey SK, Lam KC: A.T. Still University, Mesa, AZ

Background: A healthy, 25-year old male, second lieutenant in the U.S. Marine Corps presented to the athletic training clinic with chief complaints of right shoulder weakness and significant atrophy following a brief episode of shoulder pain. Symptoms were idiopathic in nature and presented a day after receiving immunizations 2 months prior to initial evaluation. Patient history was insignificant. Physical inspection by the athletic trainer (AT) revealed gross atrophy and significant weakness in the deltoid muscle group with no point tenderness or sensation changes. Patient provided consent to present his case. **Differential Diagnosis:** Cervical radiculopathy or brachial plexus palsy. Initial clinical examination revealed patient's difficulty with generating and controlling movement and significant weakness of his upper extremity during resistive testing. **Treatment:** Radiographic imaging revealed no cervical spine or glenohumeral abnormality but noted deltoid atrophy with diffuse T2 hyperintense signal without fatty infiltration, which the radiologist attributed to subacute denervation. The patient was referred to a neurologist who ordered a magnetic resonance image (MRI), sensory nerve conduction study (NCS), motor NCS, and intramuscular electromyography (EMG). The MRI noted no internal derangement of the cervical spine or shoulder. NCSs were also normal. However, the EMG revealed abnormal spontaneous/insertional activity and abnormal interference pattern. The abnormal interference pattern identified a decrease in neurological involvement. Ruling out cervical involvement combined with the patient's history and EMG results led to a diagnosis of Parsonage Turner Syndrome (PTS) (a.k.a. acute brachial neuritis or neuralgic amyotrophy). PTS is a neurological condition causing nerve demyelination, often of the brachial plexus, resulting in gross atrophy of involved musculature. The initial rehabilitation stage (months 1-5) addressed his lack of control and decreased muscle tonus using therapeutic exercise and functional electrical stimulation (FES).

FES was used during isometric shoulder abduction with 90-degrees of elbow flexion. Compensation was addressed via exercise in gravity-lessened positions. Isometric and isotonic exercises targeting rotator cuff and midback musculature were implemented with tactile and verbal feedback to stimulate his ability to generate and control movement. Care was taken to prevent secondary injuries including labral or rotator cuff pathologies. The intermediate rehabilitation stage (months 6-10) progressed by incorporating gravity, increasing resistance, and challenging his base of stability. As strength improved, training-related functional tasks were included during months 10-13. At discharge (13 months post-symptom onset), the deltoid group was not equal in girth but strength gains were achieved. EMG results showed decreased spontaneous muscle activity and increased motor unit action potentials consistent with known timelines associated with axonal damage and neurogenic processes. Functionally, the patient achieved first-class scores on his physical and combat fitness tests. The patient was cleared for unrestricted physical activity and completed training as an amphibious assault vehicle officer. **Uniqueness:** This case was unique due to its idiopathic onset, its potential cause, and the patient's age. Specifically, the idiopathic form of PTS has a minimum estimated incidence rate of 2-4 per 100,000 annually and the potential cause of "recent immunization" accounts for only 15% of all cases. Additionally, the patient was younger than the median age of idiopathic PTS cases (early 40's). However, this patient did present with common PTS characteristics including being male (incidence rates male-to-female estimated from 2-11.5-to-1) and unilateral presentation of symptoms (67% of patients with PTS report unilateral symptoms). **Conclusions:** PTS is a neurological condition that presents with idiopathic symptoms including pain and gross atrophy. Navigating a challenging clinical presentation of differential diagnoses with significant crossover and the potential for devastating outcomes such as prolonged loss of function or structural injuries (a.k.a labral or rotator cuff pathologies) highlights the need to recognize PTS in physically active individuals of tactical and traditional athletic settings.

Hemiplegic Migraines in a Female Collegiate Basketball Student-Athlete

Waddell KG, Garrett WZ: Marshall University, Huntington, WV

Background: A 19-year-old female collegiate basketball player with a history of complex partial seizures and epilepsy. No prophylactic seizure medication is currently being taken, the patient's last seizure was seven years ago. The patient attended a church service on September 9th that utilized a strobe light, and she began having migraines for the next three days. She began to experience right sided upper extremity weakness, vision loss, worsening of an existing tremor, persistent frontal headache, and confusion. Patient's friends transported her to the emergency room on September 12th because the patient became lethargic, less responsive, and was actively trembling. The patient was evaluated for a stroke due to similar presenting symptoms. The patient stated that she has had an event like this occur before after she attended a concert, but her symptoms did not persist for three days after. **Differential Diagnosis:** Todd's paralysis, Hemiplegic migraines, Stroke, Complex migraine, Cluster headaches, Seizure, Idiopathic epilepsy, Sinus headache, or an Atypical Migraine. **Treatment:** Consulting neurologist evaluated the patient for a suspected stroke, but CT, CTA, and MRI were all normal. Physician administered a headache cocktail of Benadryl, Reglan, and triptans, but right upper extremity weakness, vision loss, and tremor persisted while the patient's headache resolved. The patient was discharged from the emergency room with a referral to an outpatient neurologist. The outpatient neurologist diagnosed the patient with hemiplegic migraines on September 14th after reviewing the patient's medical history and evaluating the patient who was still experiencing right sided weakness and vision loss. It was suggested that the patient begin taking prophylactic medication to prevent another hemiplegic migraine from occurring, but the patient refused. The patient was

referred to an occupational therapist on September 25th to strengthen the upper extremity during ADLs. Sessions were conducted twice a week for four weeks, during this time the patient also worked with the university's athletic trainers.

Uniqueness: Todd's paralysis is a condition that can occur after a seizure that is characterized by one-sided weakness for up to 72 hours after a seizure. Since the patient's unilateral weakness and visual disturbances persisted for more than 72 hours, another differential diagnosis was added. Hemiplegic migraines present with symptoms of an ischemic stroke and have a prevalence of 0.01%. The aura associated with hemiplegic migraines, right-sided weakness, can last for over a week. **Conclusions:** After three weeks of OT, the patient regained equal strength bilaterally. The vision loss returned to normal, and the patient returned to participation on October 1st with no limitations. Patients that have a history of epilepsy are more like to experience a range of migraine disorders. The patient has returned to full participation and has not had another hemiplegic migraine episode at the current time.

Idiopathic Intracranial Hypertension in a Collegiate Softball Player: A Case Report Thompson AJ, Jacobs ME: Indiana Wesleyan University, Marion, IN

Background: Idiopathic intracranial hypertension (IIH) is a condition that affects the head, brain, and eyes. IIH is also known as 'pseudo tumor cerebri', and is defined as increased intracranial pressure without identifiable pathology in the brain along with normal cerebrospinal fluid (CSF) composition. Signs and symptoms of IIH include headaches, nausea and vomiting, elevated systolic blood pressure, bradycardia, visual obscurations, photophobia, and tinnitus. The cause of pathology is unclear as some patients have developed IIH after weight increase, presence of transverse sinus stenosis, and usage of a number of drugs. Diagnosis is made utilizing magnetic resonance imaging (MRI), computed tomography scan (CT scan), and elevated intracranial pressure (ICP) on lumbar puncture. During an away spring game, a 21 year old female softball player with no previous health conditions presented with a severe headache, blurred and distorted vision with sensitivity to light, vomiting, vertigo, and pain in the thoracic spine which is common among patient's diagnosed with IIH. There was no known etiology. The patient reported her pain level via a NPRS as a 9 out of 10 and persisted in pursuing advanced medical care immediately. The initial diagnosis was a migraine headache and she was treated and released from a local emergency room. The patient was removed from athletic participation and sought a second opinion. **Differential Diagnosis:** Migraine **Treatment:** Follow-up care included a Computed Tomography Scan of the head, cervical, and thoracic spine. No tumors were present, all cranial nerves were intact, and all cranial bones were identified as normal. The patient underwent a Complete Blood Count (CBC), and lumbar puncture. The opening pressure was 76 cc, with a normal range being 10-25.5 Based on

the physical findings, the patient was diagnosed with IIH. The supervising neurologist prescribed Acetazolamide (Diamox), Furosemide (Lasix), and Topiramate (Topamax) as an initial treatment option. The patient was instructed to rest completely for a week and was not permitted to participate in any physical activity besides ADL's. Vision alterations and partial loss of vision persisted, slowing recovery. The patient progressed slowly back into her undergraduate studies over 2 weeks and back to participation in softball the next fall season. **Uniqueness:** The highest percentage of patients with IIH are obese females of child-bearing age but the diagnosis can be found in other demographic populations.^{3, 5, 8} When treating IIH, specialists may suggest weight reduction, prescription medications, surgical procedures like CSF shunt insertion, optic nerve sheath fenestration or sub temporal decompression. These options were discussed with the patient, specifically shunt insertion and optic nerve sheath decompression, but she chose weight reduction and prescription medication. Optic nerve sheath decompression has been found to be safe and effective in managing vision loss in both the adult and pediatric with IIH. **Conclusions:** Practicing clinicians need to be keenly aware of headache and head injury complaints being diagnosed as migraines. IIH can manifest itself with a variety of other false-positive head injury pathologies. With appropriate medical treatment and rehabilitation, prognosis for this condition is successful. Collaboration with supervising physicians is imperative to ensure varying interventions are considered when choosing a course of action. Further research is recommended as the direct cause of IIH is unknown.

Closed Displaced Fracture of the Coracoid Process and Vitamin D Deficiency in Adolescent Athlete

Palumbo M, Wallace J, Foley M, Stefancin J, Saluan P: Youngstown State University, Youngstown, OH; Akron's Children Hospital, Akron, OH; University Orthopedics, Youngstown, OH; Cleveland Clinic, Cleveland, OH

Background: Patient was a thirteen-year-old male football player at the middle school level. Patient was tackled directly onto his right shoulder during a football competition. Patient reported pain and discomfort while moving his right arm. Through range of motion testing, the patient only had a minimal decrease in shoulder flexion. The patient went to the emergency room where x-rays were completed. X-ray examination revealed negative findings. The patient continued to complain of right shoulder pain and thus an MRI was completed two weeks later to reveal a right coracoid fracture. CT scans were then done to further identify the injury and confirm the diagnosis. The patient also had blood work done to find that he had very low vitamin-D levels. Secondary MRI and CT scan showed a closed displaced fracture of the right coracoid process. Further, laboratory tests showed that the patient had a deficiency in vitamin-D. Coracoid fractures are a very rare injury in sports. Since 1970, there have been a reported 21 cases of a coracoid fracture that have occurred from sporting activity. Most coracoid fracture injuries are sustained primarily by adolescents. **Differential Diagnosis:** Acromioclavicular joint sprain, shoulder contusion **Treatment:** The physicians decided to treat the fracture non-operatively. The patient was placed in a sling immobilizer for four weeks. A few weeks following the initial assessment, repeat x-rays were completed to show very minimal healing of the fracture, so bone stimulation therapy was initiated to speed up the healing process. The patient also began taking 50,000mg vitamin-D supplements weekly to aid the bone healing process. Repeat x-rays were then

completed six weeks from the previous appointment. **Uniqueness:** A fracture to the coracoid process is rare and is usually associated with a dislocation of the shoulder. However, with this case, an isolated coracoid process fracture was only found following an MRI and CT scan. The injury was not initially observed or diagnosed using initial x-ray imaging. Moreover, the healing capacity was hindered by the patient's low vitamin D levels. A fall mechanism of injury does not typically equate to an isolated fracture of coracoid process, especially in adolescent athletes that are growing and developing. Fall or FOOSH mechanisms typically result in acromioclavicular joint sprains, shoulder dislocations, shoulder trauma, or a fracture or sprain of the wrist. Further, it is unclear if the patient's low vitamin D levels were an underlying cause of bone weakness that resulted in the fracture. Vitamin D levels are not typically checked until later stages of care and healing. In turn, among adolescents, vitamin D levels may be a risk factor for bone injury. **Conclusions:** Although this injury is rare, there are few instances of a coracoid process injury resulting from sports. It appears that this injury can be over looked because it may not be seen on the initial x-ray, as shown from this study and others. Only after an MRI and CT scan is the fracture typically found and diagnosed. The initial assessment of the injury found that there was point tenderness over the coracoid process, which could be a red flag because it is not a common site of pain from a fall mechanism of injury. Further, sling immobilization is the most common intervention used to treat most nonoperative fractures. Due to the minimal healing, physicians believed that there may have been underlying pathology with this patient. The vitamin-D deficiency noted in this patient is a common problem noted in adolescents and it is associated with constant physiological changes. This in turn may lead to bone weakness and increase the likelihood of fractures from those physiological changes during puberty.

Torn Plantar Plate and Os Trigonum Irritation in Female Collegiate Soccer Athlete

Trella K, Wills J, Stefancin J, Solmen J, Wallace J: Youngstown State University, Youngstown, OH; Youngstown Orthopaedic Associates, Canfield, OH

Background: An 18-year-old female soccer player faced significant right toe and foot pain following an on-field collision with another player when going after the ball. The athlete presented with immediate swelling and discoloration along the dorsum of the foot and across the 1st digit. This injury occurred during the athlete's senior year of high school following her commitment to play collegiately. **Differential Diagnosis:** Turf toe, sesamoid fracture, metatarsal fracture **Treatment:** An MRI was done nearly one month after the initial injury. The MRI showed marrow edema and a plantar plate tear that involved the medial metatarsosesamoid ligament. A mild hallux valgus was also noted. The athlete was cleared to return to activity 2 months later and reported no pain. One month after returning to activity, the athlete started experiencing pain again and underwent a second MRI. When compared to the first MRI, the marrow edema had improved slightly. New mild patchy marrow hyperintensity within the great toe presented. The athlete entered her collegiate soccer season and played, although she was still experiencing pain and was receiving treatments from her athletic trainer. Treatment modalities included: Laser Light therapy, Blood Flow Restriction, tissue oscillation and intrinsic toe exercises. Still presenting with chronic pain, as well as new pain along the Achilles tendon, the athlete had x-rays taken of both feet for a bilateral comparison. The x-rays revealed no fractures, dislocations, or migration of the sesamoids. Pes Planus was noted in both right and left feet. The athlete was then placed into a walking boot along with crutches after being evaluated by a team physician. Due to compliance issues, the athlete

was then placed into a cast a week later. After being placed in a cast for 3 weeks, the physician reevaluated her. At that time there was no resolution of pain and the medical team decided to place her in a cast for an additional 3 weeks. Casting for a duration of 6 weeks did not resolve pain and the athlete was then referred for a third opinion and another MRI. The third MRI revealed possible early Morton's neuroma as well as a 4 mm ganglion cyst along the plantar aspect of the first metatarsal. X-rays also showed a large os trigonum which was likely the cause of the Achilles pain. Further, a steel plate was placed inside the athlete's shoe and custom carbon fiber orthotic with a Morton's extension was also inserted into the shoe. The athlete was then cleared for gradual increase in activity. Dry needling treatments were used in addition to the custom orthotic. The only pain the athlete was experiencing at this phase was within her posterior ankle. She then received a lidocaine injection around the area of the os trigonum. The athlete was finally released for full activity one year following the initial injury. **Uniqueness:** Plantar plate injuries are not commonly heard of within the athletic population. They can present as turf toe injuries or midfoot sprains. Also, the accompanying os trigonum irritation the athlete sustained was unusual as well. **Conclusions:** Plantar plate tears can present as various other toe and foot injuries. The anatomy of the plantar plate is less familiar to athletic trainers and it often presents as a turf toe injury. The plantar plate is a strong supporting ligament located at the MTP joint. In addition, os trigonum is an accessory bone located usually behind the talus. This athlete missed a year of activity and this case demonstrates the importance of making referrals because sometimes diagnostic tests allow clinicians to find more than they were looking for.

15-Year-Old Athlete Disqualified From Sport After Accumulation of Concussions

Skjoldahl AL, Odai ML, Felton SD, Martinez RE, Ledtke VM: Florida International University, Miami, FL; Belen Jesuit Preparatory School, Miami, FL

Background: Level 4 CASE Report presenting a 15 year-old high school football player with a history of three prior concussions who was medically disqualified from football and other contact sports after being diagnosed with his fourth concussion. The athlete's prior concussions occurred in 2012, 2014, and 2017, at ages 9, 11, and 14 respectively, with reports of headaches, dizziness and difficulty concentrating. The first two concussions occurred during participation in youth football at a prior school and were not reported by the athlete, his family, or his physician on his annual physical, and were not disclosed until his second (4th overall) concussion at his current school. In September 2018, he was diagnosed with his 4th concussion after he was tackled to the field and his head rebounded off the turf. He was removed from play, evaluated, and clinically diagnosed with a concussion by a Certified Athletic Trainer, which was confirmed during his follow up evaluation with a neurologist. In the weeks following his diagnosis, the athlete continued to report symptoms including severe headaches that increased with physical activity and schoolwork, dizziness, tiredness, difficulty concentrating, difficulty with memorization, irritability and trouble sleeping. He underwent a PET scan, MRI, EEG, ImPACT, and SCAT 5 testing and was examined by six different doctors, all of whom concluded that he not return to contact sports including, but not limited to, football. To date, his ImPACT scores and symptoms have not improved. **Differential Diagnosis:** None. **Treatment:** The athlete is currently undergoing vestibular rehabilitation and has been excused from all tests, homework, and assigned schoolwork.

He is not allowed to participate in physical activity and has been removed from all contact sports including football. In addition, he was prescribed 150mg of Lamotrigine, an anticonvulsant to help with sleeping. **Uniqueness:** Medical disqualification from sport at only 15 years of age after repeated concussions and lack of reporting of prior history of head injuries is extremely rare. In addition, this case highlights the challenges of diagnosis and evaluation of youth athletes. **Conclusions:** The severity and duration of symptoms, along with the disruption of schoolwork and physical activity, are consistent with research suggesting increased recovery time and severity with recurrent concussions. In addition, the symptoms exhibited by this athlete support the idea of greater cognitive impairment developing when youth athletes sustain head injuries. This presents a problem as medical coverage is often not provided at youth sporting events, which may lead to lower than accurate numbers of youth concussions being diagnosed and reported in their medical history. In addition, there is limited research examining incidence rates of head injuries for athletes under 14 and we are left with very little knowledge of the risks or actual incidence rates for this age group as they transition from youth to middle and high school aged sports. Such inaccurate reporting may predispose athletes to greater risk and disability with subsequent injuries as well as improper care due to lack of knowledge of prior conditions.

Plantar Plate Fracture in Male Collegiate Football Player

Acosta JJ, Martinez RE, Odai ML, Felton SD: Florida International University, Miami, FL

Background: This level 4 case study encompasses the diagnosis, treatment, and recovery of a 20-year-old male collegiate football player with a left plantar plate fracture of the first metatarsophalangeal (MTP) joint. After months of practice, this patient reported pain in his left great toe and was removed from all physical activity. During the athletic trainer's evaluation, the patient disclosed a 5-month-old injury that was not made public during the pre-participation examination. The physical findings included pain with active flexion and passive extension, as well as pain while weight bearing, specifically during toe off. Turf toe is a general term used to describe various types of injuries to the great toe. A severe injury may damage the sesamoid bones and result in a plantar plate rupture. **Differential Diagnosis:** The initial diagnosis by the athletic trainer was a possible flexor hallucis tear. Upon referral to a foot specialist, a sesamoid or plantar plate fracture was suspected. Subsequently, X-rays and an MRI were ordered to rule in or out any additional possible pathologies to the area. **Treatment:** The patient was evaluated for a flexor hallucis longus tear via MRI imaging. A multiplanar multi sequence MRI of the left forefoot, without IV contrast was ordered. The MRI findings presented with spurring/exostosis of the proximal aspect of the lateral hallux sesamoid with small joint effusion. A high-grade tear of the plantar plate of the first MTPJ, with mild proximal migration of the hallux sesamoids was shown as well. These results led to a final diagnosis of a sesamoid retraction/ plantar plate fracture. Post-op rehabilitation initially included non-weight bearing and open chain exercises, biking, and joint mobilizations daily to help decrease pain and increase ROM. Full ROM was achieved quickly, however the patient was not compliant

with non-weight bearing exercising at the start, which caused the sesamoids to retract. As a result, a Morton's extension orthotic was prescribed. As the patient progressed, manual resistance exercises for the great toe were integrated as well as weight bearing activities and plyometric training. Eventually, the patient progressed to sport specific activities. At the 4-5-month stage, significant healing had occurred, allowing the patient to run with limited complications and therefore discontinued use of the Morton's extension orthotic. **Uniqueness:** First MTP joint injuries are relatively common in athletes, however, limited information is available on operative and non-operative treatments of these injuries. Limited, if any, research is available on plantar plate fractures. It is worth noting that the initial evaluation was done by an Athletic Trainer who has 47 years of experience but had never seen this injury previously. **Conclusions:** In the athletic training profession, clinicians are exposed to numerous injuries on a weekly basis. This is a level 4 case study that highlighted the condition, diagnosis, treatment, and recovery of a patient with a plantar plate fracture. The signs and symptoms of a plantar plate fractures are similar to that of a turf toe injury. A plantar plate fracture may be more severe than a turf toe injury because it can progressively worsen if it is not identified, which may lead surgery. In knowing this, athletic trainers can take a different approach when it comes to injuries to the MTP joints of the foot, which will ultimately lead to more versatile clinicians in our profession.

Spontaneous Knee Effusion in an Adolescent Soccer Player: Level 4 Case Study

Joyce CJ, Buckley BD: University of North Florida, Jacksonville, FL

Background: A 13-year-old female recreational soccer player from Florida presented with spontaneous left knee effusion approximately two weeks after the start of soccer season. The athlete denied any previous history of injury to the knee. Further examination by the athletic trainer revealed normal, pain-free ROM and strength. Ligamentous and meniscal special tests were negative. Initial treatment included ice, compression, and elevation. After one week there was no significant change in swelling so the patient went to an urgent care facility for examination. Radiographs and a complete blood count were ordered based upon a paternal family history of autoimmune disease. **Differential Diagnosis:** Synovitis, gout, juvenile idiopathic arthritis, suprapatellar bursitis, septic arthritis, capsulitis, Lyme disease **Treatment:** Radiographs of the knee were negative and the blood work indicated Erythrocyte Sedimentation Rate (ESR) elevation. The patient returned to her pediatrician for further evaluation. Lab results continued to demonstrate an elevated ESR, as well as a positive antinuclear antibody (ANA) test. The patient was referred to a pediatric rheumatologist for consideration of lupus or juvenile idiopathic arthritis. Further examination of patient history revealed travel to the northeast region of the United States eight months prior to onset of symptoms. Thus, the patient's family requested laboratory tests to rule out *Borrelia burgdorferi* infection, or Lyme disease, due to the high endemicity in that region of the country. Although exposure to this species is rare in the southeast, and there was no evidence of a tick bite or erythema migrans, an enzyme-linked immunosorbent assay (ELISA) and an immunoblot analysis were ordered for confirmation. The initial ELISA test was high

(>12) with a positive test indicated by values >1.09. The immunoblot test was also positive with 2 Immunoglobulin M (IgM) and 7 Immunoglobulin G (IgG) bands reactive, exceeding the Center for Disease Control (CDC) criteria for Lyme disease diagnosis. The patient was given a diagnosis of Lyme arthritis and prescribed 100mg of Doxycycline for 28 days, per CDC guidelines. A month later the patient followed up with the pediatric rheumatologist who recommended a referral to a cardiologist to rule out Lyme carditis, which only occurs in 1% of Lyme cases but can be fatal. The echocardiogram and EKG were normal. The patient was then seen by an infectious disease specialist who continued the Doxycycline for an additional 28 days. The Lyme arthritis, now bilateral, continues to be present approximately nine months after the initial onset. **Uniqueness:** Approximately 93% of annual cases of Lyme disease, resulting from a black-legged tick bite, most often occur in the Northeast and Mid-Atlantic regions of the country. Roughly 67 cases per year are reported in Florida and the majority of those result from travel outside the state to endemic areas, which made the evaluation and diagnosis particularly challenging. In this case the athletic trainer was responsible for assisting the family in coordinating efforts with a variety of specialists (e.g. pediatrician, rheumatologist, infectious disease and cardiologist) who are often involved in the treatment of vector-borne illnesses. **Conclusions:** It is important to have an understanding of illnesses and conditions that are specific to certain regions of the United States. Athletic trainers and other health care providers need to inquire about travel as part of patient history. The presentation of knee effusion, and subsequently Lyme arthritis, is a common clinical manifestation of late stage Lyme disease. Early recognition of this infection and prompt treatment reduce the severity or chronicity of symptoms.

Myositis Ossificans Leads to Coupled Diagnosis of Vastus Intermedius Tear in Elite Junior Hockey Athlete

Abdelrasoul A, Zidar J, Wallace J: Youngstown State University, Youngstown, OH; University of Pittsburgh Medical Center, Youngstown, OH

Background: An 18 year old elite junior hockey player, previously healthy, suffered a severe trauma to the quadricep. He complained of pain and stiffness with noticeable effusion but continued to play until after the game where he was evaluated by the team athletic trainer for development of a quadricep contusion. He rehabilitated the contusion with a stability and strength protocol created by the treating athletic trainer, while managing pain with modalities, topical cream, and anti-inflammatories. The athlete recovered successfully and returned to play one week following initial injury, only to subsequently suffer from another direct muscular trauma to the same area. He then presented with edema, effusion, inflammation, acute pain, antalgic gait, along with decreased ROM and loss of function of the quadricep. Rehabilitation for the original contusion was reinstated for another two weeks until the athlete did not have any pain relief or improvement of symptoms. The athlete was diagnosed by the sports medicine team with myositis ossificans in the rectus femoris of the quadricep which lead to the prognosis of a tear in the proximal vastus intermedius. Myositis ossificans is defined as a heterotopic ossification that develops on the belly of large muscles, either due to hereditary factors or trauma to the muscle. **Differential Diagnosis:** Contusion of the quadricep, torn quadricep, extraskelatal parosteal osteosarcoma, bone cyst. **Treatment:** The original contusion was treated with a rehabilitation protocol focusing on the gluteal muscles, quadriceps, hamstrings, and core. Techniques for pain relief included anti-inflammatories, elevation, and light stretching. After the

initial physician evaluation and diagnostic ultrasound the athlete was conservatively treated with NSAIDs for inflammation, ultrasound therapy, rest, ice, elevation, and physical therapy to restore ROM for approximately two months before returning to the team. **Uniqueness:** In this series of events the first severe trauma to the quadricep occurred, followed by compression of the rectus femoris muscle against the femur. Bony tissue development in the rectus femoris was the site of myositis ossificans where the second trauma caused the bone-like growth to tear the vastus intermedius. Without the subsequent trauma that occurred, the progression to myositis ossificans and therefore the tear in the vastus intermedius would not have taken place. The development of myositis ossificans is unique in itself, but the capability of damage that the bone like growth can cause is uncommonly documented in literature. Important trends to take note of are the time between injury and location of second blow to the muscle. If persisting for more than three weeks the diagnosis of myositis ossificans stands, if under three weeks a differential diagnosis should be explored. There is a possibility of confusion with diagnosis between myositis ossificans and osteosarcoma due to similar diagnostic criteria. Distinct zoning patterns are exhibited in the case of ossification to differentiate between the two conditions. **Conclusions:** All sports medicine professionals and those working around contact sports should air on the side of caution when an athlete suffers from repetitive trauma to a large muscle. Symptom and pain management in correlation to time and diagnostic criteria is vital in this instance because persistent symptoms can lead to progressively worsening injury or differential diagnosis of sarcoma which are both difficult to detect.

**Mild Jugular Compression
Reduces White Matter
Alterations in High School-Aged
Males Playing Collision Sports**

Nye MN, Cacolice PA: Westfield
State University, Westfield, MA

Context: Treatment and prevention of brain injuries have recently been at the forefront of both professional literature, and popular media. This attention has been focused on those playing collision sports. Mild jugular compression (MJC) devices have been presented as a means to reduce long-term brain tissue changes through increased cranial space cushioning. Our research question then asks if MJC devices reduce White Matter Alterations (WMA) in high school-aged males playing collision sports. **Methods:** We utilized a PICO search of P: high school-aged, collision sport male athletes; I: mild, jugular compression collars (Q-collar, Neuroshield); C: controls not wearing the intervention; O: brain WMA. The following medical databases were searched utilizing this PICO search: PubMed, CINAHL, Medline, Sport Discus, ProQuest Health and Medicine, GoogleScholar. Additional resources were obtained via hand searches. Articles were included if they were published in English, within the last 10-years, examined males participating in high school collision sports, with investigations utilizing a control group, and at or above Centre of Evidence-Based Medicine Level 3 evidence study design. Investigations were excluded if they utilized females, athletes not participating in collision sports, or if they did not utilize control groups. The primary outcome measure was changes in WMA based on Diffusion Tensor Imaging. When reported, group mean measures, standard deviations, sample size, and F-scores were extracted. Calculation of effect sizes were calculated from these data. Internal validity was assessed through consistency of PICO and controls through the selected articles. **Results:** Eight investigations were found with our PICO search. Only

three investigations met all inclusion and exclusion criteria and were included in this Critically Appraised Topic. Without MJC, WMA were statistically significant in all three investigations. In each investigation, collar group WMA were significantly smaller than the non-collar group. Statistical significance in all studies included was set at $p < .05$, but group means, standard deviations, or analysis of variance was not reported in any selected article. As such, we were unable to calculate Effect size by any established method. Assessment of external validity is subsequently challenged. **Conclusions:** There is B-C Strength of Recommendation to support that MJC reduces WMA in high school-aged males playing collision sports. Unfortunately, we are unable to report any effect size measure due to unreported data. With the recent introduction of this device, there is a limited volume of investigations with which to explore effectiveness. Additionally, all articles which meet the stringent inclusion and exclusion criteria are funded by the primary manufacturer of mild jugular compression devices for collision sport. This presents a considerable potential for bias.

Free Communications, Poster Presentations: Concussion Assessment Techniques

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Factors Affecting the Timed Tandem Gait Test in Healthy Physically Active College-Aged Individuals

Santo AL, Winters S, Lisman P:
Towson University, Towson, MD

Context: The timed tandem gait test is recommended as a balance assessment following concussion, but little is known about the factors that may affect scores on the timed tandem gait test, such as sex, height, weight and foot length. Additionally, a cutoff score for the test may not be as accurate as a baseline post-injury comparison; however, the reliability of the timed tandem gait test in healthy physically active college-aged individuals must be established. Therefore, the purpose of this study was to determine factors affecting tandem gait test scores and one-week test-retest reliability of the timed tandem gait test in healthy physically active college-aged individuals.

Methods: Fifty-two participants (21 males, 31 females; 20.5 ± 1.77 yrs; 166.78 ± 12.90 cm, 69.22 ± 15.25 kg) completed the timed tandem gait test on two separate occasions, separated by one week. A trial of the tandem gait test was considered a failed trial if the participant stepped off the line, had a separation between their heel and toe or touched an examiner or object. All other trials were considered passed trials. Participants' trials were timed, and all participants completed four passed trials. Descriptive statistics were calculated for the dependent variables: best time of 4 passed trials, and a dichotomous variable of pass or fail for the first attempted trial. We performed linear regressions to determine the influence of sex, height, weight and right foot length on tandem gait test performance, with a pre-established removal level of $P < 0.05$. We computed ICC_{2,1} to determine the reliability of the tandem

gait test performance over a one-week test-retest interval. **Results:** The best time of 4 passed trials was: 16.23 ± 2.66 s at the first testing session and 15.24 ± 2.25 s at the second testing session. Twenty-nine participants (55.8%) passed their first trial at the first testing session and 28 (53.8%) passed their first trial at the second testing session. Based on our pre-established removal level, sex ($P = 0.99$), height ($P = 0.83$), and weight ($P = 0.62$) were removed from the linear regression model. There was a statistically significant bivariate correlation between right foot length and best time of 4 passed trials ($r = -0.39$, $P = 0.02$). The reliability analysis between the best time of 4 passed trials at time 1 and time 2 demonstrated excellent reliability (ICC_{2,1} = 0.83, $P < 0.005$).

Conclusions: In healthy, physically active college-aged individuals, foot length, but not sex, height or weight was related to performance on the timed tandem gait test. The timed tandem gait test demonstrated excellent reliability. Since factors such as foot length affect scores on the timed tandem gait test, and the test demonstrates excellent reliability, clinicians may consider a baseline post-injury testing paradigm for the timed tandem gait test.

Motor Performance During Single and Dual-Task Administration of a Novel Dual-Task Assessment for Sport Concussion

Erdman NK, Jimenez J, Howell DR, Buckley TA, Resch JE: University of Virginia, Charlottesville VA; University of Colorado at Denver, Denver CO; University of Delaware, Newark DE

Context: The dual-task (DT) paradigm consists of concurrent performance of a cognitive and motor task and has been used to observe subtle changes following a sport concussion (SC). DT assessments consisting of commonly used cognitive (Standardized Assessment of Concussion [SAC]) and motor (timed tandem gait [TTG] test) tasks can be easily integrated into current practice. The purpose of the current study was to evaluate changes in spatiotemporal gait measures during single task (ST) and DT administration of commonly used cognitive and motor tasks related to SC in a healthy collegiate sample. **Methods:** Participants consisted of sixty (32 female, 28 male) recreationally active adults (Age: 20.5±1.34

years, Height: 171.7±9.33 cm, Mass: 69.25±12.23 kg). Participants first completed the single task (ST) assessment which consisted of separate administration of the SAC and four trials of the TTG test on an instrumented walkway. Next, participants completed the SAC and TTG concurrently for the DT assessment. Spatiotemporal gait measures of time, cadence, foot angle, and single and double limb support were recorded by the instrumented walkway and calculated for every TTG trial during the ST and DT assessments. Maximum force, force-time integral, and maximum peak pressure were recorded by the instrumented walkway and calculated for each trial of ST and DT assessment. For ST assessment, gait measures from the best (fastest) trial were used for statistical analyses. Gait measures for the DT assessment were averaged across all trials within each SAC domain (immediate recall [IR], concentration, delayed recall [DR]). The concentration domain is comprised of two unique tasks (digit span [DS], months in reverse order [MONTHS]) for which average values for each gait measure were calculated and analyzed separately. Paired t-tests were used to compare gait measures from ST to DT performance

for each SAC domain. All analyses were performed with $\alpha=0.05$. **Results:** Participants had significantly slower gait time (IR: 18.4±4.50 sec, MONTHS: 16.0±3.83 sec, DR: 16.0±3.83 sec; all $p<0.05$) during DT assessment as compared to ST performance (14.3±2.96 sec) for all SAC domains with the exception of the digit span task ($p>0.05$). Participants also displayed significantly decreased cadence (IR: 94.8±17.10 steps/min, DS: 113.6±19.48 steps/min, MONTHS: 105.9±18.97 steps/min, DR: 105.9±18.97 steps/min; $p<0.05$) during DT assessment as compared to ST performance (118.2±17.21 steps/min) within each SAC domain. Mean differences for each gait measure are presented in Table 1. **Conclusions:** Completion of the DT assessment resulted in altered spatiotemporal measures of gait when compared to ST performance in a healthy collegiate sample, which is consistent with previous literature. Our findings suggest an altered allocation of cognitive resources which resulted in a more conservative gait pattern during a clinically relevant DT assessment consisting of commonly used cognitive and motor tasks related to SC as compared to ST performance.

Table 1. Mean Differences ($\mu \pm SD$) of Spatiotemporal Gait Measures of Single Task (ST) versus Dual-Task (DT) Performance for Each SAC Domain.

Gait Measure	Immediate Recall	Digit Span	Months in Reverse Order	Delayed Recall
Gait Time (sec)	2.1 ± 1.92†	0.3 ± 2.55	1.7 ± 3.11†	2.3 ± 3.05†
Cadence (steps/min)	23.4 ± 15.95†	4.6 ± 16.84*	12.3 ± 16.46†	16.0 ± 15.43†
Foot Angle (°)	0.4 ± 2.26	0.1 ± 2.65	0.2 ± 2.54	1.0 ± 2.59*
Max Force (% change)	0.6 ± 3.76	0.1 ± 3.67	0.5 ± 4.15	0.6 ± 4.21
Force-Time Integral (% change)	0.4 ± 5.21	0.3 ± 4.80	0.3 ± 6.09	0.1 ± 6.02
Max Peak Pressure (% change)	0.8 ± 7.20	0.1 ± 6.29	1.8 ± 12.54	0.2 ± 8.29
Single Limb Support (% gait cycle)	0.2 ± 7.28	0.2 ± 7.74	0.1 ± 9.39	0.7 ± 7.86

* $p < 0.05$

† $p < 0.001$

The Influence of Dual Task Paradigm on Reaction Time Utilizing a Light Board

Hattrup NM, Picha KJ, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: The utilization of dual task paradigms have been widely used as an assessment and treatment following traumatic brain injury. Following a concussion, deficits in time to completion and speed when utilizing a combined gait and cognitive dual task paradigm have been identified. Few studies have examined reaction time (RT) combined with a stability task, which may assist with assessment and rehabilitation progressions. The purpose of this study was to determine whether a cognitive load and stability task influences RT on a light board. **Methods:** A convenience sample of 20 healthy individuals (16 female, 4 male, age=24.4±3.5 years, mass=65.4±12.3 kg, height=164.5±7.6 cm) were recruited from a university population. Testing took place in

laboratory setting over a single 30-minute session. The Dynavision D2™ light board was used to measure participant’s RT during five different pre-set protocols randomized on both a stable and unstable surface (10 trials). For the unstable surface a Bosu Ball™ was utilized with the round surface facing down. Each participant was given three familiarization trails before testing. All trials required the participant to hit as many red lights as possible within 60 seconds. Protocols 1-5 varied slightly, some of which included differentiation of red versus green lights or identification of icons while simultaneously hitting the red lights. The independent variable was condition (stable, unstable) and the average RT (sec) was the dependent variable. Separate paired sample t-tests were used to determine differences between conditions for each protocol. **Results:** The RT means and standard deviations for each protocol on the stable surface and unstable surface is listed in the table 1. No significant differences were found between stable and unstable

surfaces for any condition: Protocol 1 (p=.540), Protocol 2 (p=.297), Protocol 3 (p=.577), Protocol 4 (p=.175), Protocol 5 (p=.947). **Conclusions:** Our primary findings were that the inclusion of the unstable surface did not influence RTs while performing a cognitive task. These findings differ from other studies of dual tasking using a paradigm that includes cognitive tasks during gait. The differences may be due to the static nature of the balance task and the ease of the cognitive task (icon recognition) in the Dynavision D2™ protocols used. Clinicians should be aware that combining a balancing task with the Dynavision D2™ might not affect the overall difficulty of the test. These protocols with the addition of a balancing task could be used in rehabilitation to provide variety, but not as a dual task exercise progression. Further research should identify if other independent tasks such as math problems or continuous verbal tasks could potentially affect the RT to create an effective dual task.

Table. Reaction Times (mean ± standard deviation) for Stable and Unstable Surface for Each Condition In Seconds

Surface Type	Protocol 1	Protocol 2	Protocol 3	Protocol 4	Protocol 5
Stable Surface (sec)	.761 ± .065	.588 ± .026	.601 ± .040	.607 ± .030	.606 ± .039
Unstable Surface (sec)	.755 ± .081	.593 ± .025	.605 ± .022	.599 ± .024	.606 ± .025

Exploring the Effects of a Neck Strengthening Program on Neurocognition Following Purposeful Soccer Heading

Waring MK, Smith ER, Austin GP, Bowman TG: University of Lynchburg, Lynchburg, Virginia

Context: Neck strengthening has been proposed as an important factor in concussion predisposition. However, the effect of neck strengthening programs on neurocognition after purposeful heading has not been identified. Therefore, the purpose of our study was to determine if a 6-week strengthening program increases soccer athletes' neck strength and causes changes in neurocognitive outcomes after a bout of repetitive purposeful soccer heading. **Methods:** Twenty collegiate soccer athletes (8 males, 12 females, age=20.15±1.35 years, height=171.67±9.01, mass=70.56±11.03) volunteered to participate. Time (pre and post) and group (experimental and control) served as the independent variables. Strength measurements in 7 directions (anterior, right anterolateral, left anterolateral, right rotation, left rotation, right posterolateral, left posterolateral) and 4 composite scores from CNS Vital Signs (CNSVS; verbal memory,

visual memory, executive function, reaction time) served as the dependent variables. Each athlete completed a baseline measure of neck strength and CNSVS after heading 10 soccer balls. We used a Microfet hand-held dynamometer to measure the participants' neck strength. The participants completed three trials in each direction and we calculated the average. The experimental group completed specific neck strengthening exercises twice a week for 6 weeks using a Shingo Imara. The neck exercises consisted of 2 sets of 4 neck movements until fatigue. The control group did not perform neck strengthening exercises. After six weeks, the athletes completed the same neck strength testing protocol and completed CNSVS again. We analyzed the data using 2x2 mixed model ANOVAs for each of the dependent variables. **Results:** The interaction between time and group was significant for anterior (F1,17=41.78, P=.04, $\eta^2=.22$), right anterolateral (F1,17=4.80, P=.04, $\eta^2=.22$), and left anterolateral (F1,17=6.48, P=.02, $\eta^2=.28$) strength measurements. Post hoc tests showed strength improved pre to post in the anterior direction for both the strengthening (P<.001) and the control (P=.02) groups, but only for the strengthening group for right anterolateral (P<.001) and left

anterolateral (P<.001). The interaction between time and group was not significant for right rotation (F1,17=2.12, P=.16, $\eta^2=.11$, 1- β =.28), left rotation (F1,17=3.20, P=.09, $\eta^2=.16$, 1- β =.39), right posterolateral (F1,17=2.98, P=.10, $\eta^2=.15$, 1- β =.37), or left posterolateral (F1,17=2.86, P=.10, $\eta^2=.14$, 1- β =.36) strength measurements. When determining the effects on neurocognition and symptoms, the interaction between time and session was significant for visual memory (F1,17=5.16, P=.04, $\eta^2=.23$). Interestingly, post hoc results revealed visual memory only improved for the control group (P=.02). The interaction between time and session was not significant for verbal memory (F1,17=.01, P=.91, $\eta^2<.001$, 1- β =.05), executive function (F1,17=.71, P=.41, $\eta^2=.04$, 1- β =.13), reaction time (F1,17=1.05, P=.32, $\eta^2=.06$, 1- β =.16), or symptom severity score (F1,17=2.40, P=.14, $\eta^2=.12$, 1- β =.31). **Conclusions:** The strengthening program our participants completed improved anterior and anterolateral neck strength, but not rotation or posterolateral strength. Improving strength in these locations did not alter neurocognition following repetitive soccer heading.

Exploring the effects of a neck strengthening program on neurocognition following purposeful soccer heading

Waring K, Smith ER, Austin GP, Bowman TG: University of Lynchburg, Lynchburg, Virginia

	Strengthening Group		Control Group	
	Pre	Post	Pre	Post
Anterior Strength	20.72±5.54	28.29±7.25	16.41±4.50	20.11±4.96
Right Anterolateral Strength	19.91±5.49	26.68±5.78	16.45±3.80	18.97±3.95
Left Anterolateral Strength	19.58±5.45	26.43±7.04	16.91±4.69	19.18±4.11
Right Rotation Strength	19.32±4.98	21.37±5.19	17.20±3.70	16.518±3.08
Left Rotation Strength	19.611±4.86	21.20±3.84	18.03±4.22	17.09±3.28
Right Posterolateral Strength	27.04±7.40	35.15±7.21	25.94±5.03	29.96±5.50
Left Posterolateral Strength	27.88±6.64	36.37±9.78	27.09±5.71	30.30±6.42
Verbal Memory	51.00±4.69	49.00±5.41	51.56±4.64	49.11±5.65
Visual Memory	46.67±4.77	47.67±4.90	46.89±4.73	39.50±4.21
Executive Function	53.78±8.06	48.44±10.92	51.67±8.76	49.00±9.70
Reaction Time	598.67±48.61	638.56±45.20	630.00±73.40	638.00±109.00
Symptom Severity Score	9.22±12.03	4.56±6.23	7.44±7.32	11.67±14.82

Examination of Concussions and Their Effect on Functional Movement Screen Scores in Collegiate Athletes

Roger SA, Wisthoff BA, Glutting JJ, Buckley TA, Kaminski TW:
University of Delaware,
Newark, DE

Context: It is estimated that between 1.6 and 3.8 million concussions are sustained annually in the United States from sport and recreational activity alone, with 3.9% of National Collegiate Athletic Association (NCAA) student-athletes experiencing a concussion each year. While impairments in postural control, including static and dynamic balance are known acute effects of a concussion, there has been evidence in recent studies hypothesizing that these deficits may persist beyond the initial 5-10 day recovery stage. One commonly used measure of overall movement quality in collegiate athletics involves the Functional Movement Screen (FMS), however its' use in concussion management has not been thoroughly examined. Therefore, the purpose of this study was to retrospectively

compare FMS scores in a group of concussed and non-concussed student-athletes. **Methods:** Longitudinal cohort design. University Laboratory Setting. Sixty-five (34 Concussed, 31 Control) student-athletes were included in this analysis (age = 19.6 ± 1.0 yrs, height = 173.9 ± 10.0 cm, mass = 74.6 ± 20.2 kg). Concussion injury history, as well as FMS baseline data from the 2015-2017 academic years were retrospectively analyzed. Concussion history and baseline FMS scores were derived from a large database. The FMS composite score (ranging from 0-21), as well as the individual component scores (ranging from 0-3) were derived for each subject. The independent variables were group status: concussed vs. control, previous concussion history, and baseline 1 vs. baseline 2 FMS test time points. The dependent variables were the FMS component and composite scores. A two-group growth curve was performed to determine the difference between FMS scores in those that have versus have not experienced a concussion during the academic year for both component and composite scores. Covariates included: matched

control group, sex, height, weight, and age. **Results:** There were no statistical differences between FMS composite scores and component scores (deep squat, hurdle step, in-line lunge, shoulder mobility, active leg raise, push-up, and rotary stability) from Baseline 1 to Baseline 2, or between groups (Table 1). **Conclusions:** The results of our study provide further evidence in support of the current literature suggesting that FMS scores have little to no ability to detect lingering functional movement deficits up to one-year post concussion. Those responsible for athlete performance and well-being may need to look at other measures of functional movement such as the Tandem Gait Task, Y Balance Test, or other balance and strength measurements; to better recognize potential movement deficiencies that may pose additional risks for student-athletes returning to sport.

Table 1: FMS Scores Across Groups

	Concussed		Control		p-value	95% Confidence Interval
	Baseline 1	Baseline 2	Baseline 1	Baseline 2		
Composite FMS	15.0 ± 1.8	15.1 ± 2.0	15.5 ± 1.5	15.2 ± 1.5	0.079	(-1.04, 0.06)
Deep Squat	1.5 ± 0.5	1.8 ± 0.7	1.7 ± 0.7	1.9 ± 0.6	0.300	(-1.22, 0.39)
Hurdle Step	1.8 ± 0.4	1.9 ± 0.4	2.0 ± 0.2	2.0 ± 0.5	0.683	(-0.23, 0.15)
In-Line Lunge	1.9 ± 0.4	1.9 ± 0.6	2.0 ± 0.0	2.1 ± 0.5	0.747	(-0.26, 0.19)
Shoulder Mobility	2.4 ± 0.6	2.1 ± 0.9	2.5 ± 0.7	2.6 ± 0.6	0.975	(-0.32, 0.31)
Active Leg Raise	2.6 ± 0.5	2.7 ± 0.5	2.5 ± 0.6	2.5 ± 0.5	0.660	(-0.32, 0.21)
Push-Up	2.7 ± 0.5	2.6 ± 0.8	2.6 ± 0.5	2.5 ± 0.6	0.158	(-0.40, 0.07)
Rotary Stability	2.0 ± 0.0	1.9 ± 0.2	2.0 ± 0.0	1.8 ± 0.4	0.576	(-0.15, 0.08)

Values are represented as means ± standard deviations

* = Significant difference between baseline time points, p<0.05

Establishing Reliability of the Dynavision D2 Reaction Tests in Female Adolescent Athletes

Gray H, Williams RM, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: The assessment of visual function and reaction time (RT) are key components of concussion assessment and used frequently in sports vision training. The emergence of computerized measures allows for more precise assessment of RT; however, understanding the measurement properties is important for clinician interpretation. Therefore, our purpose was to evaluate test-retest reliability of the Dynavision D2 central and peripheral vision reaction tests in female high school athletes.

Methods: Seventeen female adolescents (age=16.6±1.1 years, mass=62.0±5.9 kg, height=169.2±5.1cm) participated in this reliability study. Participants completed two testing sessions one-week apart using the Dynavision D2 system. The RT series consisted of one familiarization and two test trials on the

first testing day and two test trials on the second day. Each trial consisted of four total tests: two central vision (CV) tests (left and right hand) and two peripheral vision (PV) tests (left and right hand) with each test consisting of six strikes of an illuminated target. At the starting position, a single light illuminated, alerting the participant to strike the target as quickly as possible and return to the starting or “home” position. With the participant standing centrally and instructed to direct vision to the single anticipated target, the first test measured central vision RT. The second test measured peripheral RT with the participant in an off-centered starting position and instructed to fix their vision on the centrally located starting button as opposed to the anticipated target. Dependent variables included motor, visual, and physical RT for the left and right hand, for both CV and PV. Within-day (WD1, WD2) and between day (BD) test-retest reliability were analyzed with two-way random effects, consistency interclass correlation coefficients (ICC). **Results:** The results are presented in the table as ICC values and 95% confidence

intervals. Within-day 1 reliability for left and right hand CV was excellent for visual, motor, and physical RT. Left and right hand PV demonstrated moderate reliability for visual RT, while yielding good reliability for motor and physical RT. The within-day 2 reliability was good-to-excellent for left and right hand CV visual, motor, and physical RT. Left and right hand PV demonstrated good-to-excellent reliability for visual, motor and physical RT. Between day reliability for left and right hand CV was good for visual and excellent for motor and physical RT. Similarly, left and right hand PV yielded moderate-to-good reliability for visual RT, and good-to-excellent reliability for motor and physical RT. **Conclusions:** We found good to excellent test-retest reliability of most central and peripheral RT tests on the Dynavision D2 in healthy adolescent females. This stability is important for tasks that may be used to assess deficiencies in RT serially following concussion or as part of a sports vision training protocol.

Table. Intraclass correlation coefficients (95% confidence interval) for within and between-day reliability.

	ICC (95% CI)								
	Visual			Motor			Physical		
	WD1	WD2	BD	WD1	WD2	BD	WD1	WD2	BD
CVLH	.87 (.68-.95)	.82 (.51-.94)	.67 (.09-.88)	.92 (.79-.97)	.80 (.45-.93)	.87 (.63-.95)	.95 (.89-.98)	.92 (.79-.97)	.96 (.89-.98)
CVRH	.93 (.81-.97)	.63 (-.01-.87)	.76 (.33-.91)	.86 (.64-.94)	.74 (.29-.91)	.89 (.70-.96)	.91 (.76-.96)	.75 (.32-.91)	.84 (.56-.94)
PVLH	.57 (-.08-.83)	.72 (.23-.90)	.53 (-.29-.83)	.79 (.47-.92)	.89 (.69-.96)	.90 (.73-.97)	.68 (.20-.87)	.78 (.38-.92)	.88 (.67-.96)
PVRH	.53 (-.20-.81)	.83 (.52-.94)	.78 (.40-.92)	.75 (.37-.90)	.88 (.67-.96)	.78 (.38-.92)	.69 (.20-.88)	.92 (.77-.97)	.88 (.66-.96)

CVLH- Central vision left hand, CVRH- Central vision right hand, PVLH- Peripheral vision left hand, PVRH- Peripheral vision right hand

Free Communications, Poster Presentations: Concussion History

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Comparison of Symptom Frequency and Symptom Severity in Recently Concussed Athletes and Orthopedic Controls

Worts PR, Mason JR, Petty SD, Burkhart SO: Tallahassee Orthopedic Clinic, Tallahassee, FL; The Florida State University, Tallahassee, FL; University of Florida, Gainesville, FL; Centre Pointe Health and Rehabilitation, Tallahassee, FL; Children's Health Andrews Institute, Plano, TX

Context: Symptom scales are frequently used by allied healthcare professionals during concussion management, however, these scales may not be robust and are not always psychometrically validated. Furthermore, most scales attempt to quantify symptom severity, but symptom frequency is often overlooked. The purpose of this study was to compare the reporting of symptom severity and symptom frequency between adolescent concussed athletes (SRC) and orthopedic controls (OC). Our first hypothesis was that concussed participants would report higher on the symptom frequency and symptom severity scales than the orthopedic controls. Our second hypothesis was that symptom severity would be moderately associated with symptom frequency. **Methods:** 165 student-athletes (15.4 ± 1.4 years; 104 males; 61 females) were administered the 22-item Post-Concussion Symptom Scale (PCSS) and the 28-item Frequency of Concussion Symptoms (FOCS) within seven days of their sport-related injury in this case-control study. The groups were treated in a concussion clinic or orthopedic walk-in clinic. The OC group's injury was not head- or neck-related. Analyses included descriptive statistics, a one-way MANOVA, and Pearson's Product Moment Correlation Coefficients using SPSS 25. Significance was set at $p <$

0.05 . **Results:** The FOCS ($\alpha = 0.92$) and PCSS ($\alpha = 0.96$) displayed a high level of internal consistency. The PCSS total score displayed a strong relationship with the FOCS total score ($r = 0.73$, $p < 0.001$). The relationship between PCSS and FOCS total scores for the OC group ($r = 0.91$, $p < 0.001$) and SRC group ($r = 0.71$, $p < 0.001$) were strong. The one-way MANOVA revealed a significant effect for injury type on FOCS and PCSS total scores, $F(2,162) = 6.424$, $p < 0.01$, partial $\eta^2 = 0.73$. The SRC group reported significantly greater total scores compared to the OC group for both the PCSS (27.9 ± 21.9 vs. 14.2 ± 13.3) and FOCS (37.9 ± 25.4 vs. 13.9 ± 11.9). There were no significant differences for gender, $F(2,160) = 1.09$, $p = 0.34$ nor the interaction between gender and injury type, $F(2,160) = 1.32$, $p = 0.27$. **Conclusions:** Our findings suggest that symptom severity and symptom frequency have a strong relationship. The FOCS and PCSS displayed excellent internal consistency and significant group differences for injury type which is important for scale development and warrants further exploration. On-going data collection of the OC group will further elucidate if these current findings are consistent in a larger sample size. To date, this is the first study to examine symptom frequency in the context of concussion management and the fourth study to use the PCSS in an orthopedic cohort. Just as symptom severity is used to help guide concussion management, symptom frequency may also provide clinical value.

Concussion History Influences Neurovascular Coupling Response to Visual Tasks in Special Operations Forces Personnel

Combs PR, Chandran A, Barczak N, DeLellis SM, Ford CB, Healy ML, Kane SF, Lynch JH, Means GE, Mihalik JP: University of North Carolina at Chapel Hill, Chapel Hill NC, United States Army Special Operations Command, Fort Bragg, NC

Context: Visual dysfunction is common following concussion and can persist into subacute recovery in military personnel. Post-concussion physiological deficits may outlast traditional clinical recovery. The duration of these physiological effects remains unknown. Neurovascular coupling (NVC) uniquely describes cerebrovascular response to neural activation and is commonly assessed in response to visual stimuli. Assessing NVC provides a physiological measure of visual function following injury. The study purpose was to test the hypothesis that NVC response to progressively challenging visual tasks demonstrates impaired response profiles in Special Operations Forces (SOF) personnel with a concussion history relative to those with no concussion history. **Methods:** Thirty-six SOF

personnel were enrolled in a cross-sectional study conducted in a clinical research center (age=34.4yrs±4.0yrs; height=179.0cm±5.0cm; mass=85.3±7.9kg). The SOF personnel completed a demographic survey self-reporting concussion history (n with 1+ concussions=20; 55.6%). They were instrumented with transcranial Doppler (TCD) ultrasound to measure our primary outcome: posterior cerebral artery velocity (PCAv) in cm/s. Baseline PCAv measurements were collected for 2 minutes. Changes in PCAv were measured in response to two progressively challenging visual tasks: 1) reading and 2) search. Each task was presented in 5 one-minute trials (20s eyes-closed/40s eyes-open). All raw PCAv data were measured at 125Hz and filtered using a dual-pass 4th-order Butterworth filter (2Hz cutoff). Baseline PCAv data were derived by averaging PCAv across the 2-minute baseline period. Filtered task data were converted to time-series profiles representing 40 consecutive 1-second averages for each trial. Profiles were then averaged across the 5 trials and time-aligned to stimulus onset (eyes-open) to generate a single ensemble-averaged 40-second profile representing NVC response for each participant. Custom Matlab scripts were used to filter and reduce all data. We employed linear mixed effects models to

assess differential effects of visual task on PCAv response profiles by concussion history group (Wald X^2). **Results:** Baseline PCAv did not significantly differ ($t_{34}=0.30$, $P=0.77$) between those with (36.9 ± 8.3 cm/s) and without (37.6 ± 4.8 cm/s) concussion history. The effect of visual task on PCAv response profiles was influenced by concussion history (Wald $X^2(1)=64.16$, $P<0.001$). PCAv response to the search task was 1.7cm/s greater than PCAv response to the reading task among those with a concussion history ($P<0.001$, Figure 1). Those without a concussion history did not differ between tasks ($P=0.19$). **Conclusions:** The SOF personnel with concussion history demonstrated greater average NVC response when faced with a more complex visual task. This likely results from cerebrovascular overcompensation, indicating that previously injured participants had to work harder to respond to visual center activation. This finding was not observed in those not reporting a concussion history. While long-term neurophysiological effects associated with head impact and blast-related injury are currently unknown, assessing NVC response may provide further insight into cerebrovascular function and overall physiological health.

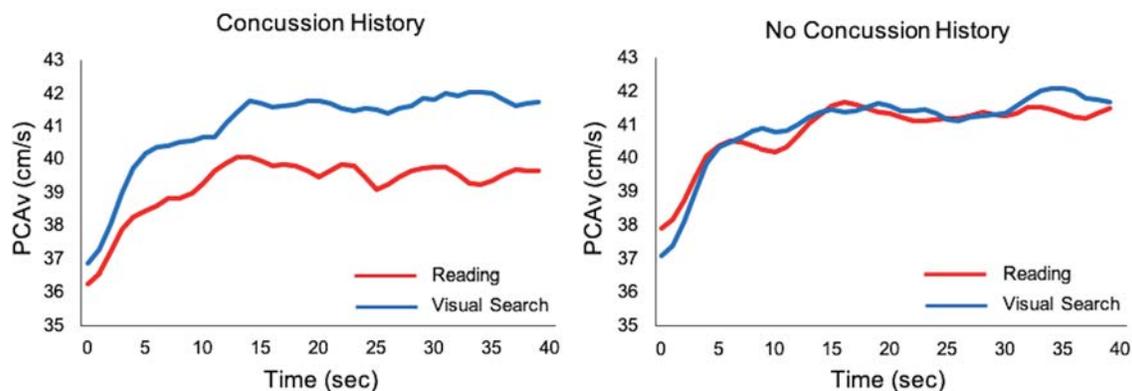


Figure 1. PCAv response to reading task and visual search task in SOF personnel with and without a concussion history. There is a significant difference between tasks for SOF personnel self-reporting concussion history; no difference between task for those without a concussion history.

Dynamic Postural Stability Deficits in Collegiate Athletes With a History of Concussion

Heebner NR, Hoch MC, Vadhera A, Quintana C, Abt JP: University of Kentucky, Lexington, KY; Johns Hopkins University, Baltimore, MD

Context: Athletes with a history of concussion may be at greater risk of sustaining musculoskeletal injuries (MSI). Postural control deficits have been identified as a risk factor for MSI and are also known to occur following concussion. However, limited balance assessments have been sensitive enough to identify residual postural control deficits and allow for easy clinical integration. Wireless accelerometer and inertial measurement technology have previously been used to quantify postural control, however, further research is needed to determine their sensitivity to identify postural control deficits in athletes with a history of concussion. Therefore, the objective of this study was to determine if wireless inertial measurement unit (IMU) worn during a dynamic balance test can discriminate between collegiate athletes with and without

a history of concussion. **Methods:** A total of 136 Division-I athletes, 60 with a history of concussion (CON, Male: n=36 Female: n=24 Age: 20.1±1.4 years; Height: 174.6±14.3 cm; Mass: 82.0±25.3 kg; Time Since Concussion: 27.7±24.6 months) and 76 without a history of concussion (CTR, Male: n=42 Female: n=34 Age: 19.5±1.4 years; Height: 174.7±13.3 cm; Weight: 76.1±22.1 kg) volunteered to participate. To assess dynamic postural control, participants performed a double-leg jump over a 15cm hurdle, landing on one leg, and balancing for at least three-seconds. Following three practice trials, three successful attempts were completed on each leg. During the task, acceleration and gyroscopic data were recorded using a nine-axis IMU placed at the lower lumbar vertebrae, approximately at the level of L4. Acceleration and gyroscope axes were each combined to create a resultant vector. The root-mean-square (RMS) was calculated during the first three seconds of balancing upon landing in the medial-lateral (RMS-ML), anterior-posterior (RMS-AP), and resultant (RMS-R) directions. Higher RMS values indicated poorer postural

control. Mann-Whitney U tests were used to compare RMS values between those with and without a history of concussion. The alpha level was set to 0.05 a priori. **Results:** The accelerometer RMS measures (Table) only identified significant group differences in the resultant vector on the right side (Right RMS-R, CON: 13.33 ± 1.52, CTR: 12.61 ± 1.68, p = 0.003). All other accelerometer measures were not significantly different (p = 0.051-0.810). However, all gyroscopic RMS measures identified significant differences between CON and CTR groups (p ≤ 0.015) except the left RMS-AP (p = 0.183). **Conclusions:** RMS postural stability values from the gyroscope data, specifically in the medial-lateral and the resultant directions were able to identify significantly worse postural control in collegiate athletes with a history of concussion. These results highlight that athletes with a history of concussion may exhibit lingering postural control deficits. Longitudinal follow up is needed to determine if these deficits in postural control predispose these athletes to MSI in the future.

Table. Dynamic Postural Stability Between Groups

	No-Concussion (n=76)				Concussion (n=60)				p value
	Mean	SD	Median	IQR	Mean	SD	Median	IQR	
Accelerometer									
RMS-ML Right	4.44	1.65	4.11	2.03	4.94	1.67	4.46	2.17	0.051
RMS-AP Right	5.98	2.19	5.76	2.89	6.07	2.42	5.89	3.82	0.962
RMS-R Right*	12.61	1.68	12.05	2.46	13.33	1.52	13.08	2.27	0.003
RMS-ML Left	5.46	7.34	4.32	2.15	5.45	7.49	4.24	1.84	0.810
RMS-AP Left	6.02	2.30	6.01	3.11	5.99	2.49	5.33	4.22	0.782
RMS-R Left	12.85	1.87	12.21	1.91	13.09	1.79	12.73	1.94	0.149
Gyroscope									
RMS-ML Right*	61.75	39.50	55.67	65.23	87.98	81.17	81.17	65.31	<0.001
RMS-AP Right*	25.92	10.86	23.08	15.82	31.14	11.18	28.96	15.00	0.004
RMS-R Right*	80.67	41.14	73.02	63.37	106.00	41.24	98.51	65.48	<0.001
RMS-ML Left*	63.86	40.95	57.77	54.99	83.37	46.95	75.83	57.28	0.005
RMS-AP Left	27.13	11.95	24.89	19.00	28.94	10.65	28.40	14.12	0.183
RMS-R Left*	84.17	42.47	73.55	60.40	100.73	46.34	94.81	58.67	0.015

All not normally distributed

*Mann Whitney-U tests significantly different between groups (p<0.05)

The Influence of Concussion History on Postural Stability in Collegiate Athletes

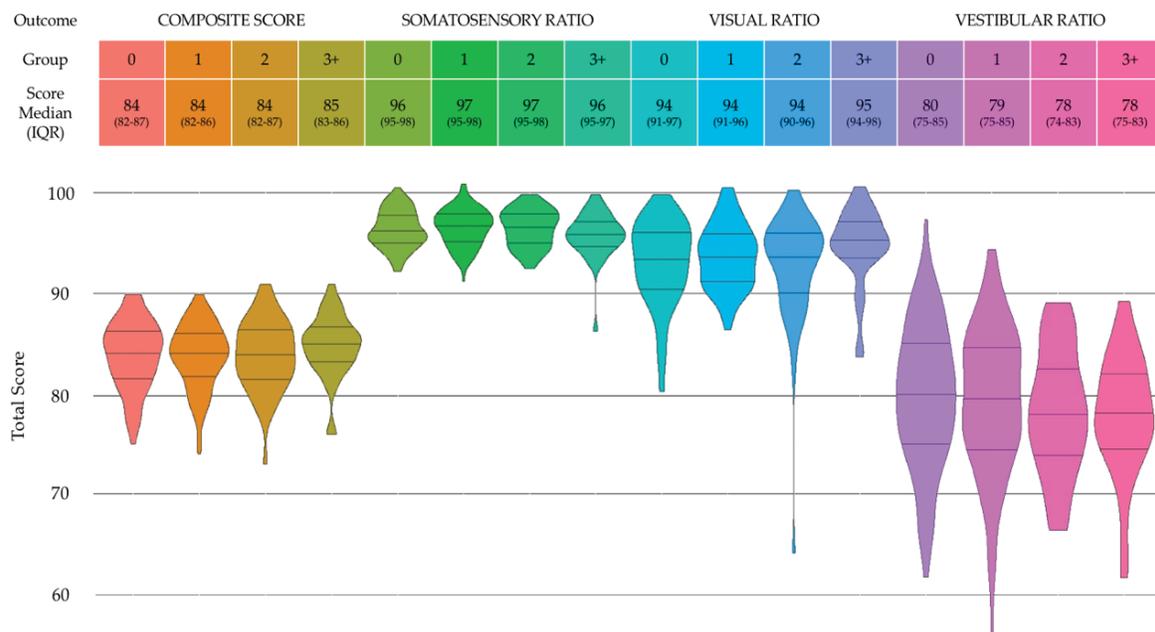
Rosenblum DJ, Walton SR, Hart J, Resch JE: University of Virginia, Charlottesville, VA

Context: Prior history of concussion has been reported to increase the risk of sustaining lower extremity injury. The underlying mechanism by which this occurs remains unknown; however, we suspect that an altered ability to maintain postural control subsequent to one or more concussion may partially explain these observations. The purpose of this study was to evaluate the postural control profiles of collegiate student-athletes with varying histories of concussion. **Methods:** This descriptive laboratory study included 306 NCAA Division I university student-athletes (175[57.2%] males, aged 19.1±1.5 years, 1.79±0.1 m, 82.1±20.9 kg). Athletes were categorized into 4 groups based on self-reported concussion history: 3+ concussions (n=34; range=3-6), 2 concussions (n=52), 1 concussion (n=91), and 0 concussions (n=129).

Participants in the 2, 1, and 0 prior concussion groups were matched to those in the 3+ group based on sport, sex, height, weight, and age. Sensory Organization Test (SOT) clinical outcomes of mean stability, and the somatosensory, visual, and vestibular ratios were assessed while the athletes were injury-free. Due to non-normally distributed data (skewness and/or kurtosis > 2), group differences for each SOT outcome were assessed by Kruskal-Wallis H tests. Additional Mann-Whitney U tests were used to compare those with any prior concussion(s) to those without for each outcome. Coefficient of variation (CV) was also calculated for each outcome in each group. The CV's were compared using two-sample tests with 95% confidence intervals (CI). All analyses were performed with a-priori $\alpha=.05$. **Results:** No differences were observed between concussion history groups (0, 1, 2, and 3+) for any SOT outcome score ($p>0.09$; Figure 1). Similarly, those with any history of concussion did not perform differently than those without a history ($p>0.19$). The CV for the somatosensory ratio was highest in the 3+ group (CV=2.5%) compared to all other

groups (CVs=1.9% each). However, when the CVs were compared using two-sample tests with 95% CI, no significant differences were observed between those in the 3+ concussion group and the 2 ($z=8.86 [-0.54, 1.66]$, $p=0.99$), 1 ($z=4.99 [-0.51, 1.56]$, $p=0.99$) or 0 previous concussion ($z=3.17 [-0.41, 1.46]$, $p=0.99$) groups. **Conclusions:** Our findings suggest that postural stability as measured with the SOT was not influenced by the number of self-reported previous concussions in collegiate student-athletes. Similarly, those with no prior concussions were not different than those with any history of concussion. If lingering postural control deficits occur as a result of sustaining one or more concussion, our study provides evidence that these changes do not occur from concussions sustained during adolescence, which is the time frame in which our participants reported their previous concussions. Alternatively, it is possible that either the SOT cannot detect more subtle postural control deficits, or that these purported differences do not exist.

Figure 1. Sensory Organization Test Outcome Scores



Ultrasound Imaging of Neck Musculature in Individuals With and Without History of Concussion

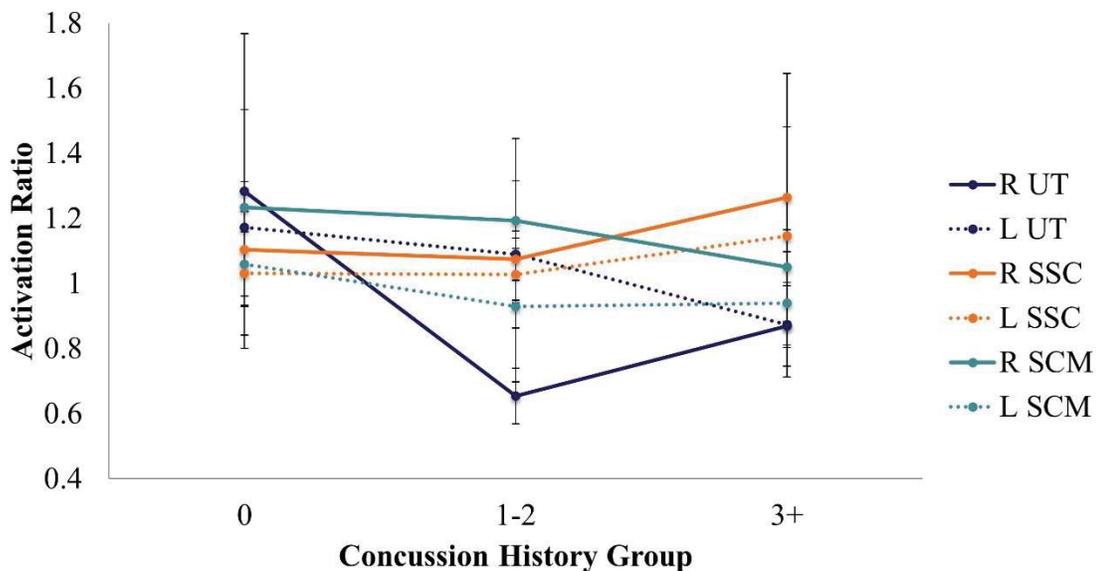
Paizs SC, Walton SR, Higgins MJ, Resch JE: University of Virginia, Charlottesville, VA

Context: Neck muscle activation and morphology are hypothesized to be related to the susceptibility of sustaining a sports-related concussion (SRC). Muscle activation studies have shown gender, but not concussion history, differences and morphological assessment of cervical muscle activity has not been examined. The purpose of our study was to examine resting and active muscle morphology in the upper trapezius (UT), semispinalis capitis (SSC), and sternocleidomastoid (SCM) muscles in relationship to concussion history in female collegiate athletes. **Methods:** This descriptive laboratory study included 9 NCAA Division I female athletes (Aged 19.9+1.8 years, 1.71+0.1 m, 73.6+6.9 kg) who were divided into three groups of three based on self-reported concussion history: C0) no prior concussions,

C1-2) 1-2 prior concussions, and C3) 3+ prior concussions. Participants in groups C0 and C1-2 were individually matched to those in group C3 based on height, weight, and age. Ultrasound imaging (USI) was used to capture images of the UT, SSC, and SCM muscles in resting and activated states. Resting USI was performed with the participant seated in a neutral head position. Activated USI was performed while the participant isometrically contracted their neck to 40 to 60% of MVIC for 5 seconds with their head in the neutral position against stable resistance in the primary motion of the given muscle. Three images were captured for each muscle bilaterally in each activity state. ImageJ software was used to calculate muscle thickness measurements. Measures of muscle thickness were averaged for each contracted state (rested vs. activated). Muscle activation ratios and percent change were calculated for each of the UT, SSC and SCM. Separate ANOVAs were used to examine group differences in demographics, muscle thickness, activation ratio and percent change. Effect size was calculated using η_p^2 . All analyses were performed with

$\alpha = .05$. **Results:** C₁₋₂ (81.4+3.0 kg) had greater body mass (C₀=66.9+4.2 kg, C₃=72.6+0.6 kg; F₍₂₎=17.660, p=0.003, $\eta_p^2=0.86$) and head-neck mass (C₀=5.5+0.35 kg, C₁₋₂=6.7+0.25 kg, C₃=6.0+0.05 kg; F₍₂₎=17.660, p=0.003, $\eta_p^2=0.86$) than the other groups. C0 was significantly older than the other groups (F₍₂₎=6.333, p=.033, $\eta_p^2=0.68$). No statistically significant group differences (p>0.68) were observed for muscle thickness, activation ratio, or percent change; however, average activation ratios (of all muscles) trended toward a decrease with a greater number of self-reported SRCs: C₀=1.15+0.19, C₁₋₂=1.04+0.03, C₃=1.02+0.14 (Figure 1). **Conclusions:** Our data showed a trend of decreased activation of neck musculature with increasing history of SRC. These results should be interpreted with caution but may reflect that muscle thickness and activation do not relate to SRC injury. Previous studies have shown that acceleration and force of impact may not be directly related to concussion susceptibility. The role of neck musculature in attenuating head motion may be poorly understood with the addition of our study's findings.

Figure 1. Average Activation Ratio



R = Right-sided muscle, L = Left-sided muscle, UT = Upper Trapezius muscle, SSC = Semispinalis Capitis muscle, SCM = Sternocleidomastoid muscle.

The Influence of Concussion History on Kinesiophobia in Collegiate Athletes.

Manetz K, Walton SR, Erdman NK, Thompson X, Resch JE:
The University of Virginia,
Charlottesville, VA

Context: The link between musculoskeletal injury and subsequent fear of movement (kinesiophobia) has been investigated previously. The Fear Avoidance Model suggests that injury may lead to disuse and disability due to fear of re-injury. Our study examined self-reported levels of kinesiophobia in collegiate athletes based on self-reported concussion history.

Methods: The current cross-sectional study consisted of 207 NCAA Division I collegiate student-athletes (133 males [64.3%], 74 [35.7%] females) who had an average age of 21.0 ± 1.41 years and 14.0 ± 1.41 years of education. All participants completed the Tampa Scale of Kinesiophobia (TSK) as well as the ImPACT™ during a preseason baseline concussion assessment as part of their university's concussion management protocol. Participants were then divided into those with ($n=71$ [45 males, 26 females]) and without ($n=136$ [88 males, 48 females]) a self-reported history of a diagnosed concussion by a medical provider which was collected as part of each athlete's baseline ImPACT™ assessment. Due to the non-normality of the collected data, two separate Mann-Whitney U tests were performed to compare overall TSK composite scores between genders and between those with and without any history of concussion. Two subsequent Mann-Whitney U tests were performed to compare males with and without a history of concussion as well as females with and without a history of concussion. Similar tests were used to compare males and females with a history of concussion as well as without a history of concussion. All analyses were performed with $\alpha=0.05$. **Results:** In terms of the overall gender comparison, regardless of concussion history, men

(median=24.0, IQR=21.0-30.0) self-reported a significantly higher ($p=0.046$) level of kinesiophobia compared to females (median=22.5, IQR=19.0-28.0). Among male and female athletes with no self-reported concussion history, no differences ($p=0.064$) were observed. Similarly, a gender difference was not observed in those with a self-reported history of concussion ($p=0.310$). No significant difference was observed between athletes with and without a history of concussion. Participants without a self-reported history of concussion (median=24.0, IQR=21.0-29.0) did not report significantly different ($p=0.186$) kinesiophobia compared to those with a history of concussion (median=24.0, IQR=19.0-29.0). Kinesiophobia also did not vary for males ($p=0.259$) or females ($p=0.456$) with a history of concussion compared to those without.

Conclusions: Our findings indicate that gender as a whole, irrespective of concussion history, represented the only significant difference with regard to endorsement of kinesiophobia. However, these differences disappeared with subsequent analysis of separate concussion history groups. Concussion history did not influence self-reported kinesiophobia. This finding does not align with the Fear Avoidance Model and calls into question the influence of prior concussion on kinesiophobia-related changes regarding participation in sport and subsequent risk for injury.

Persistent Neurological Impairment is Not Present Six Months Following Unrestricted Return-to-Play From Concussion

Thompson X, Erdman NK, Walton SR, Resch JE: The University of Virginia, Charlottesville, VA

Context: Recent evidence suggests that the accepted clinical recovery from a concussion may not align with true physiological recovery. Moreover, some researchers hypothesize that even a single concussion may lead to subsequent long-term impairment (months to years). A dearth of research exists that has systematically assessed neurocognition, postural control and self-reported symptom burden of athletes beyond what is currently considered clinical recovery. The objective of this study was to examine computerized neurocognitive test performance, postural control, and symptom burden of collegiate athletes six months after unrestricted return-to-play from a concussion. **Methods:** Thirty-seven Division I collegiate athletes (28 males, 9 females) who were 18.0 ± 1.41 years of age with an average height of 185.5 ± 7.78 cm and mass of 87.63 ± 10.78 kg participated in the current study. Participants completed the ImPACT™ battery and the Sensory Organization Test (SOT) at baseline, upon self-reporting symptom-free, and at a follow-up assessment approximately six months after returning to full academic and athletic participation. Repeated measures ANOVAs were used to assess the SOT (equilibrium score and somatosensory, visual and vestibular sensory ratios) and ImPACT (Verbal and Visual Memory, Visual Motor Speed, Reaction Time, and Total Symptom [TSS]) outcome scores. Post-hoc analyses were performed using paired t-tests. All analyses with $\alpha = 0.05$. **Results:** ImPACT Verbal Memory scores improved significantly ($F_{(2,35)} = 3.72$, $p = .03$) over time. More specifically, Verbal Memory performance was significantly better ($t_{(36)} = -2.70$, $p=.011$) at the six-month follow-up

(93.1±6.74) compared to the baseline assessment (89.7±9.10). ImPACT TSS was significantly different across time ($F_{(2,35)} = 4.06$, $p = .03$) indicative of lower symptom burden ($t_{(36)} = 2.84$, $p = .007$) at the symptom-free assessment (0.62 ±1.60) compared to the baseline (2.16±3.33). Though not statistically significant, Total Symptom Score was higher (1.16± 2.03) at the six-month follow-up assessment compared to the symptom-free assessment. The SOT equilibrium score significantly improved ($F_{(2,35)} = 0.08$, $p = <0.001$) across time such that the SOT equilibrium score at baseline (83.3±3.32) was significantly lower ($t_{(36)} = -2.64$, $p = .012$) than in the symptom-free (85.17±4.50) and six-month follow-up (85.7±3.50, [$t_{(36)} = -4.34$, $p < .001$]) assessments. There were no significant differences in the SOT somatosensory, visual or vestibular sensory ratios or the remaining ImPACT outcome scores across time.

Conclusions: Our findings indicate that collegiate athletes did not experience persistent neurologic impairment or an increased symptom burden approximately six months following their symptom-free assessment. In fact, an improvement in performance was observed in Verbal Memory and overall postural control. Given this information, our findings may support a need to obtain a new baseline assessment approximately six months following unrestricted return-to-play to account for this improved performance.

(GT)n Promotor Polymorphisms and Concussion Recovery: An Exploratory Study

McDevitt J, DeSimone FI, Tierney RT, Phillip JM, Langford D: Temple University, Philadelphia, PA

Context: Variability in recovery between concussed athletes can be attributed to several risk factors. One risk factor not definitively explored is genetic variation. Genetic variations [e.g., variable number tandem repeats; (VNTR)] in the promoter region are normal in the population, and can lead to disparities in the amount of protein produced, which could be associated with neuronal recovery. Little research has been conducted to investigate promoter VNTRs within genes responsible for recovery following a concussion. Therefore, the purpose of this study was to determine the association between promoter (GT)n VNTR polymorphisms and recovery time within concussed athletes. **Methods:** The authors implemented a prospective cohort design using a standardized concussion protocol to diagnose and follow 122 athletes (70% male, 19.92+5.22 y/o, 21

different sports) to full recovery at 3 different sites (i.e., Sport Concussion and Athletic Neurotrauma Center, Division I & II Universities). Researchers collected saliva samples from athletes to extract DNA. The (GT)n VNTR within the promoter region of GRIN2A, KCNH2, GRIK1, NEFL were genotyped using capillary electrophoresis. (GT)n VNTR promoter polymorphisms were dichotomized into long (L) and short (S) alleles (Table 1). Participants' recovery time were followed prospectively and were categorized as normal (≤ 60 days) or prolonged (>60 days). Chi-square analyses were used to determine association between allele frequencies and recovery. A binary logistic regression analysis was used to estimate the extent to which (GT) VNTRs and non-genetic factors (i.e., age, sex, race, number and history of previous concussions) contributed to prolonged recovery. SPSS 24.0 (IBM SPSS Inc., Armonk, NY) was used for all analyses, and the alpha level was set at $p \leq 0.05$. **Results:** The athletes were seen within 25.93+71.61 days post injury and were returned to full recovery after 60.91+97.22 days. All GT(n) distributions for LL, SS, LS

genotypes for each gene were in Hardy Weinberg equilibrium. GRIN2A L allele ($X^2=9.491$; $p=0.002$) was overexpressed in the prolonged recovery group when compared to S allele carriers. There were no other significant associations between (GT)n allele within KCNH2 ($p=0.060$), GRIK1 ($p=0.086$), NEFL ($p=0.289$) and recovery. Each predictor was examined using a binary logistic regression and found age to be the largest predictor of recovery ($X^2=15.58$; $p=0.000$). None of the genetic variants were significant predictors of recovery. **Conclusions:** The authors demonstrated that the carriers of the L allele were more likely to suffer prolonged concussion recovery. These findings suggest that the protein GRIN2A codes for, plays an important role during neuronal recovery. However, when compared to other risk factors, genetic variance was not found to be a significant predictor, a larger population will be necessary to validate findings. Prospective genotyping of athletes will allow athletic trainers to improve concussion management, counsel athletes, and make safer return-to-play decisions.

Table 1. Gene Function and GT(n) genotype

Gene (Gene Abbreviation)	Primers	GT(n) cut point (n Per Group)	Protein	Protein Activity
Glutamate Receptor Ionotropic Kainite Type subunit 1 (GRIK1)	Forward: CGCAAAGTTGAGGGAGAGAA Reverse: GTTTCTGGCCCCACCCTTTATTTACT	Long Allele: ≤ 27 n=218 Short Allele: >26 n=16	Glutamate receptor ionotropic kainite type subunit 1	Ionotropic glutamate receptor that acts as an excitatory neurotransmitter necessary for postsynaptic actions.
Glutamate Receptor Ionotropic NMDA Type Subunit 2A (GRIN2A)	Forward: GAAGGAAGCATGTGGGAAATGCAG Reverse: GTTCTGCTGGGTACAGTTATCCCCCT	Long Allele: ≤ 25 n=117 Short Allele: >25 n=109	Glutamate receptor ionotropic NMDA type subunit 2A	Ligand and voltage dependent to aid in synaptic transmission for brain function
Potassium Voltage-Gated Channel Subfamily H Member 2 (KCNH2)	Forward: TACAGCAGCCTGAACAAACG Reverse: GTTCTGGAGTCTGGACCAACTCCA	Long Allele: ≤ 12 n=138 Short Allele: >11 n=82	Voltage-activated potassium channel belonging to the eag family	Voltage dependent channel shapes neuronal action potentials, and in neuronal excitability, plasticity
Neurofilament Light (NEFL)	Forward: CAGTAGTGCCGAGTTTCAC Reverse: GTTCTTAGCTTTCTGGCACTTTCTGC	Long Allele: ≤ 6 n=91 Short Allele: >5 n=129	Neurofilament light polypeptide	Provide stability of cytoskeleton of neuron

Characteristics and Cost Savings of a Telehealth Consultation Service for Sport-Related Concussion

Herseth S, Cardenas JF, Valovich McLeod TC: Barrow Neurological Institute, Phoenix, AZ; A.T. Still University, Mesa, AZ

Context: Concussion management requires an interdisciplinary team to assess and treat the various aspects of this injury. However, athletic trainers in the secondary school setting may work in isolation from other healthcare providers, limiting their ability to collaboratively manage patients with concussion. Telehealth may provide athletic trainers an avenue for collaboration with other healthcare providers, reduce the need for patients and families to travel to medical appointments for care, and limit the financial burden of such visits. Our purpose was to characterize the use and associated cost savings of the Barrow Concussion Network, a telehealth service provided to athletic trainers in Arizona. **Methods:** This retrospective study reviewed data from the Barrow Concussion Network consultation service from July 2013 - November 2018. The Barrow Concussion Network Barrow Concussion Network was developed in 2011 and provides the interscholastic association mandated concussion education program, licenses for neurocognitive testing, and a telehealth consultation service. The consultation service is available to all ATs providing synchronous and asynchronous access to concussion experts. The consultation platform has evolved over time with data extracted from three iterations of the database (2013-2016, 2017, and 2018). Extracted variables included, patient age, sex, sport, consultation outcome, and associated cost savings. Usual and customary rates (UCR) for services provided were calculated using national average new patient visit (\$318). Data is reported as frequencies and percentages. **Results:** The consultation service was used by ATs for consultation on 515 patients (324 male, 121

female, 70 unknown, age=15.4 years). The majority of consultations were for football athletes (40.9%), followed by soccer (7.9%), basketball (4.9%), wrestling (4.9%), and cheer (4.7%). Over three-quarters of case outcomes were coded as a consultation (75.4%), followed by referral to outpatient or primary care (7.1%). Data from 2018 captured specific recommendations from the consultations with 48.8% recommending return to full practice and 25.6% recommending return to non-contact practice. Regarding school, the majority of recommendations (81.4%) were to return without accommodations, 9.3% to return with accommodations, and 7.0% to rest at home. The estimated direct cost savings of the consultations was \$163,770. **Conclusions:** The use of a telehealth consultation system to support secondary school ATs demonstrated a significant direct cost savings for patients and families. Recommendations provided by the concussion experts provides a second opinion for the ATs and specific recommendations regarding patient progression to return to sports and school. Not included in these costs are indirect savings of travel to appointments and time out of work or school to attend appointments.

Test-Retest Reliability of the Brief Symptom Inventory-18 in United States Service Academy Cadets: Findings From the NCAA-DoD CARE Consortium

Bookbinder HA, Houston MN, O'Connor KL, D'Lauro C, Brodeur RM, Cameron KL, Campbell DE, Kelly TF, Malvasi SM, McGinty GT, O'Donnell PG, Peck KY, Posner MA, Roach SP, Svoboda SJ, Pasquina PF, Broglio SP: United States Military Academy, West Point, NY; University of Michigan, Ann Arbor, MI; United States Air Force Academy, Colorado Springs, CO; United States Coast Guard Academy, New London, CT; Walter Reed National Military Medical Center, Washington, DC

Context: Post-concussion, patients experience cognitive, vestibular, and oculomotor impairment, as well as a myriad of symptoms. In addition to cognitive and physical symptoms, patients also express affective symptoms, such as depression and anxiety. If ignored or improperly managed, these symptoms may contribute to poor outcomes following concussion or develop into serious mental health concerns. Thus, it is important to assess these symptoms both pre- and post-concussion. To do so, the Brief Symptom Inventory-18 (BSI-18), a symptom checklist measuring psychological distress, has been incorporated into baseline concussion batteries. The BSI-18

is comprised of a Total score and three subscales: Anxiety, Depression, and Somatization. Test-retest reliability of the BSI-18 has been established, but never in military cadets. Therefore, the purpose of this study was to examine test-retest reliability of the BSI-18 among service academy cadets from year-to-year. **Methods:** A prospective, repeated-measures design was used to evaluate BSI-18 test-retest reliability and determine clinical interpretation ranges. At the time of analysis, 10,603 cadets from three Service Academies were enrolled in the Concussion Assessment, Research and Education (CARE) Consortium. Cadets completed a standard baseline battery of concussion assessments, including the BSI-18. At the time of analysis, 3,698 male cadets (19.26 ± 1.30 y, 70.87 ± 2.91 in, 174.16 ± 24.82 lbs) and 1,106 females cadets (18.89 ± 1.20 y, 65.66 ± 2.88 in, 138.72 ± 17.14 lbs) had completed a baseline BSI-18 in year one (Y1) and year two (Y2) and 206 of those cadets had completed a baseline BSI-18 in Y1 and year three (Y3). Descriptive statistics were calculated as mean±standard deviation. Dependent variables included BSI-18 Total, Anxiety, Depression, and Somatization scores. Intraclass correlation coefficients (ICC3,1) were used to measure stability from Y1-to-Y2 and Y1-to-Y3. ICC values range from 0.0-1.0, with a more stable performance represented by a higher value. Test-retest reliability strength was interpreted as poor (<0.50), moderate (0.50-0.75),

good (0.75-0.90), and excellent (>0.90). Reliable change indices (RCI) were calculated using 95% confidence intervals. Change scores were calculated for clinical interpretation post-injury. **Results:** From Y1-to-Y2, BSI-18 Total Score (Y1 = 41.88 ± 8.51, Y2 = 39.08 ± 5.94, ICC = 0.34, RCI = 16.53) had the most consistent test-retest reliability, followed by the Depression (Y1 = 44.81 ± 5.98, Y2 = 43.69 ± 4.45, ICC = 0.30, RCI = 12.22), Anxiety (Y1 = 42.83 ± 6.98, Y2 = 40.80 ± 4.35, ICC = 0.23, RCI = 14.15), and Somatization Subscales (Y1 = 45.92 ± 6.91, Y2 = 43.48 ± 3.79, ICC = 0.21, RCI = 13.73). From Y1-to-Y3, BSI-18 Anxiety (Y1 = 41.48 ± 5.51, Y3 = 40.24 ± 3.79, ICC = 0.32, RCI = 10.81) was the most consistent, followed by the BSI-18 Total Score (Y1 = 40.82 ± 7.00, Y3 = 38.16 ± 4.90, ICC = 0.28, RCI = 14.21), BSI-18 Somatization (Y1 = 45.00 ± 5.34, Y3 = 43.24 ± 3.07, ICC = 0.20, RCI = 10.80), and BSI-18 Depression (Y1 = 44.00 ± 5.19, Y3 = 42.75 ± 2.70, ICC = 0.17, RCI = 10.45). Change scores are reported in Table 1. **Conclusions:** Overall, BSI-18 test-retest reliability strength from year-to-year was poor. This is comparable to BSI-18 scores in NCAA athletes within the CARE Consortium. Due to a lack of stability, BSI-18 scores may be most useful post-concussion. Future research should explore the association of baseline BSI-18 scores with time to symptom resolution and return to activity to validate the baseline assessment.

Table 1. Brief Symptom Inventory-18 Change Scores

	n	75%	80%	87.5%	90%	92.5%	95%	97.5%	99%
BSI-18 Total Score									
Years 1-2	4797*	3	4	7	8	9	11	14	17
Years 1-3	206	2	3	6	7	8	9	12	14
BSI-18 Anxiety									
Years 1-2	4805	3	4	6	7	8	10	12	15
Years 1-3	206	2	3	5	6	7	8	10	12
BSI-18 Depression									
Years 1-2	4804	3	4	6	7	8	9	11	13
Years 1-3	206	2	3	5	6	6	8	9	11
BSI-18 Somatization									
Years 1-2	4805	2	3	6	7	8	9	11	14
Years 1-3	206	2	3	5	5	6	7	9	11

*Note: Total score could not be calculated for all cadets due to missing items

Effect of Concussion History on Instrumented and Clinical Balance Performance

Gaudet JA, Decoster LC, Hollingworth AT, Valovich McLeod TC: New Hampshire Musculoskeletal Institute, Manchester, NH; A.T. Still University, Mesa, AZ

Context: Studies of college-aged athletes suggest balance deficits may persist beyond apparent concussion resolution. However, the effect of concussion history on balance performance in high school athletes is unclear. The objective of this study was to determine if a history of concussion(s) affects performance on baseline balance exams. The researchers hypothesized athletes with a history of concussion(s) (CONC) would have significantly worse balance in single leg and tandem stances versus athletes without a history of concussion (NON-CONC). **Methods:** This retrospective study used de-identified data from 589 high school athletes (299 males, 290 females) who took baseline

BESS tests in mass baseline settings at several high schools. IRB approval was granted to use the clinically-collected de-identified data. Baseline BESS testing was conducted using the C3 Logix iPad application strapped to the participant's back. Errors in each stance were counted and recorded by the test administrator. Postural sway was recorded automatically by the application. De-identified data were exported and analyzed. The data were separated into two groups consisting of 469 NON-CONC athletes (age 15.13±2.52 years, 232 males, 237 females) and 120 CONC athletes (age 15.67±1.13 years, 67 males, 53 females). Outcome measures included BESS error scores and iBESS volumes (mathematical representation of three-dimensional sway) for each stance. Multiple t-tests were used to compare results between groups. A priori p-value was set at p<0.05. A Bonferroni correction to 0.003 was calculated to account for multiple analyses. **Results:** Descriptive data is presented in the table. Total BESS errors were significantly higher in the NON-CONC

group versus CONC. Single-leg stance on a firm surface error count was significantly higher in the NON-CONC group versus CONC. BESS errors in other stances were not significantly different. Double-leg stance on foam had significantly higher iBESS volume in the NON-CONC group versus CONC. All other iBESS findings were not statistically significant. **Conclusions:** The CONC group had statistically significant better balance in certain stances compared to the NON-CONC group. However, clinical significance is questionable due to low-moderate effect sizes and the differences between total BESS errors were within the reliable change index. A possible explanation is the CONC group in our clinical practice typically completes rehabilitation and multiple testing episodes before returning to sport; thus giving them more exposure to the BESS test than athletes without a history of concussions. The possible practice effect observed in the CONC group may obscure the presence of a persistent balance deficit.

Table 1. BESS Results

	BESS Errors			iBESS Volume		
	Concussion History	No Concussion History	p-value (effect size)	Concussion History	No Concussion History	p-value (effect size)
Double leg-firm	0.01±0.091	0.00±0.07	0.266	-4.88±1.15	-4.84±1.04	0.842
Single leg-firm	2.02±1.58	2.80±2.20	0.001* (0.454)	-0.14± 1.75	0.36±1.69	0.926
Tandem-firm	0.59± 0.98	0.67±1.08	0.401	-1.72± 1.59	-1.52± 1.48	0.304
Double leg-foam	0.06± 0.30	0.09±0.38	0.079	-2.08± 0.85	-1.75± 1.09	0.002* (0.343)
Single leg-foam	6.33± 2.18	6.63±2.09	0.615	1.96± 1.50	2.30±1.47	0.642
Tandem-foam	2.58± 2.42	3.11±2.35	0.340	1.09± 1.83	1.43±1.64	0.065
Total Error Scores	11.58± 4.91	13.31± 5.46	0.002* (0.333)	----	----	----

*Indicates a statistically significant difference

The Treatment of Sports-Related Concussion With Co-Morbid Whiplash: A Systematic Review

Ramirez-McKinley RJ, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Sport-related concussion (SRC) and whiplash associated disorder (WAD) may occur co-morbidly, however, there is conflicting opinion on the appropriate treatments. The objective of this study was to systematically review the evidence for treatment of co-morbid WAD with SRC, answering the clinical question: “What are the current treatments for SRC and co-morbid WAD acutely and in athletes with post-concussion syndrome?”

Methods: A search was performed in October 2017 in PubMed, EBSCO, Ovid MEDLINE, Cochrane Central Registrar of Controlled Trials, Cochrane Database of Systematic Reviews, Database of Abstracts and Reviews of Effects, SPORTDiscus, and CINAHL. The search terms included: “concussion,” “post-concussion syndrome,” “neck pain,” “neck injury,” “cervical spine injury,” “whiplash associated disorder,” “MTBI,” “treatment,” “rehabilitation,” “intervention,” “co-morbid injury,” and “co-morbid whiplash.” The inclusion criteria were: diagnosed concussion, diagnosis of WAD, participation in athletics, English language, original research, level IV evidence or higher. Articles that met the inclusion criteria were placed into the data extraction table, assessed for quality using the Downs and Black Checklist, and assigned a level of evidence. Data extracted included patients, study design, interventions, outcomes, results and conclusions as appropriate. A qualitative synthesis was used to synthesize the findings of the included studies.

Results: The search resulted in 1,770 articles, five of which met the inclusion criteria. Patients underwent treatment for the cervical spine, including manual therapy, flexibility programs and cervical spine rehabilitation. Four of the five studies addressed the cervical spine

component with manual therapy and/or cervical spine rehabilitation, with only one study identifying a flexibility component. All studies reported positive improvements in outcomes measures, including symptom scores and time to medical clearance for return to sport after treatment. One study showed that with cervical spine and vestibular treatments, patients were 3.91 times (95% confidence interval 1.34 to 11.34) more likely to return to sports participation within 8 weeks of treatment initiation. While these studies showed that cervical spine rehabilitation facilitates recovery and is beneficial to those with these co-morbidities, there is a lack of high-level consistent evidence in regards to specific treatment protocols.

Conclusions: This systematic review evaluated the various treatment options for co-morbid WAD with SRC, however there was limited evidence (Grade C) surrounding the most effective treatment of WAD with SRC. The recommendations for treating SRC and WAD are not well established, proving difficult for clinicians to determine how and when to treat co-morbid WAD. The results of this review suggest that the early detection and treatment of WAD result in positive outcomes, highlighting the importance of identifying cervical spine co-morbidities and including that in early treatment. Future studies should evaluate the specific interventions with respect to the duration and frequency of various treatments on clinician- and patient-reported outcomes.

Self-Reported Sports and Recreational Concussion History in Male Collegiate Gymnasts

Gardiner RL, Root HJ, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Gymnastics is a rigorous sport with high potential for head injury due to the complexity of the skills performed in air, including twists, flips and dismounts. Concussion history and symptom self-reporting can be influenced by phrasing of questions. Little is known about concussion self-reporting behaviors in male gymnasts. The objective of this study was to characterize self-reported sport and recreational activity concussion history in collegiate male gymnasts. **Methods:** Descriptive survey design. Forty-five male collegiate gymnasts (age=19.9±1.9 yrs, height=172.5±7.6 cm, mass=69.5±6.9 kg, 13.6±4.5 years gymnastics participation) from one university completed a concussion symptom survey (CSS) as part of their preseason baseline testing. The CSS consisted of twenty-three questions, eight questions related to sport and recreational concussion history and fifteen concussion-related symptoms experienced following an injury to the head from participating in sports or recreational activities. Positive concussion history was determined as a “yes” response to any one of the six primary questions regarding past concussions, being knocked out, or having a ding or bell-ringer in sports and recreational activities (RA). The CSS has been validated in collegiate and high school athletes. Responses are reported as percentages and frequencies. **Results:** Seventy-three percent of participants reported a positive concussion history in sport or RA, with 66.7% (n=30) classified as having a positive concussion history in sport and 31.1% (n=14) in RA. Concussion history responses varied by phrasing of the question with 44.4% (n=20) reporting a prior concussion in sport, 6.7% (n=3) reporting a concussion history in RA, 22.5% (n=10) losing

consciousness in sport, 4.4% (n=2) losing consciousness in RA, 51.5% (n=23) reporting ding/bell-ringer in sport and 26.7% (n=12) ding/bell-ringer in RA. Participants reported an average of $.93 \pm 1.39$ past concussions (range 0-5) in sport and $.14 \pm .35$ (range 0-1) in RA. Based on the symptom reports, 71.1% (n=32) were classified as having a probable concussion history with headache reported the most often (70.5%, n=31), followed by dazed/confused (53.5%, n=24), and dizziness/balance problems (40.9%, n=18). Of those participants reporting concussion symptoms on the CSS, only 25% did not report a concussion history in sport or RA.

Conclusions: Our findings suggest better concordance between the prior concussion history questions and the concussion symptom survey than in prior studies. This may be in part due to the increased attention placed on concussion education in collegiate athletics and the general improved awareness regarding concussion symptoms in athletes. These findings also suggest that a majority of collegiate gymnasts have had at least one prior concussion, which should be identified during the pre-participation examination and preseason baseline testing. However, the reporting of concussion history may depend on the phrasing of questions, which clinicians should note to ensure the concussion history is accurate.

Free Communications, Poster Presentations: Concussion Recovery Outcomes

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Predicting Time to Symptom Resolution in Collegiate Athletes Diagnosed With Sport Concussion: A Cross-Validation Study

Monge J, Green RM, Walton SR, Erdman NK, Thompson X, Marshall AN, Hertel JN, Resch JE: The University of Virginia, Charlottesville, VA

Context: Symptom burden and clinical recovery following a sport concussion (SC) are unique to each individual. Previous studies have discussed the influence of acute symptom burden on symptom resolution. A previously published prediction formula correctly identified time to symptom resolution in 76% of collegiate athletes who self-reported symptoms for less than 10 days. However, this formula has yet to be cross-validated. The purpose of the current study was to cross-validate the aforementioned prediction formula using an independent sample of collegiate athletes. **Methods:** Participants included 37 Division I student-athletes (26 males, 12 females), aged 19.5±1.24years, 185.0±8.38cm, 85.3±17.36kg) who were diagnosed with SC. Participants were administered the Revised Head Injury Scale (HIS-r) by their athletic trainer <24 following SC diagnosis. The HIS-r is a 22-item symptom checklist in which participants endorsed the presence, duration, and severity for concussion-related symptoms within the previous 24hours. When present, symptom duration and severity are indicated on a 6-point and 7-point Likert scale, respectively, with higher scores indicating worse outcomes. Total symptom severity (TSS) was calculated by summing all severity scores and may range from 0-132. The prediction formula included TSS and individual duration values for nervousness, neck pain, tingling, and drowsiness. Days to symptom resolution were retrieved from each athlete's medical file.

Pearson correlation coefficients were used to correlate the predicted days to symptom resolution to the actual days to symptom resolution. All analyses were performed with $\alpha = 0.05$. **Results:** Participants self-reported symptoms for 7.8±5.01 days with a range of 2-26 days. Overall, predicted days to symptom resolution was observed to have a moderate correlation ($r=0.49$, $r^2=0.24$, $p=0.002$) with actual days to symptom resolution. The prediction formula accurately predicted 72% (21/29) of participants who reported symptom-free within 10 days of injury. The prediction formula also accurately predicted 70% (26/37) of athletes who reported symptom resolution within or beyond 10 days of injury. **Conclusions:** The previously established prediction formula correctly identified 72% of concussed collegiate student-athletes who self-reported symptom free within 10 days and 70% of the overall sample, which aligns with the previously published value. This formula may allow clinicians to sufficiently identify athletes who are at risk of self-reporting symptoms greater than 10 days following their injury and/or those who might benefit from additional support or therapy (e.g., academic adjustments, education, targeted therapies [e.g. massage]). The identification and treatment of factors that potentially prolong symptom recovery may improve overall recovery outcomes following a SC in collegiate student-athletes.

Relationship Between Symptom Score and Cognitive Test Performance Following Concussion in High School and Collegiate Athletes

Lake AW, Linder J, Brier CS, Linder S, Figler R, Lear A, Alberts JL: Cleveland Clinic, Cleveland, OH; Cleveland Clinic-Akron General, Akron, OH

Context: Concussion assessment requires a multi-dimensional approach. This includes both the assessment of self-reported symptoms as well as performance on cognitive tests. We sought to investigate differences in performance on cognitive testing based on symptom severity following concussion. The study objective was to evaluate performance on a battery of cognitive tests as it relates to symptom severity. **Methods:** The study design was a retrospective cohort consisting of 1257 (66% male, 34% female) high school and collegiate athletes, average age 16.7, who had sustained a concussion, and had a previous baseline assessment with at least 1 follow up assessment utilizing C3 Logix. Two groups were created for comparison, symptom score ≤ 7 or > 7 , utilizing the 27 item graded symptom checklist (total possible symptom score 162) within the C3 application. Assessments were identified as occurring during the acute (0-7 days post injury), sub-acute (8-20 days post injury), or post-concussive (≥ 21 days post-injury) phase. Outcome measures were performance on individual modules within C3 Logix. These were simple reaction time (SRT), choice reaction time (CRT), processing speed test (PST), trail taking test A (Trails A), and trail making test B (Trails B). Performance on each test module was analyzed with separate linear mixed effect models for each module comparing within-phase differences. Models included a random component for each athlete, as well as a random component for each time phase

nested within each athlete. **Results:** Performance on each of the C3 Logix outcome measures (SRT, CRT, PST, Trails A, and Trails B) were significantly better in athletes reporting a symptom score of ≤ 7 compared to those reporting a symptom score >7 at each of the phases (acute, sub-acute, and post-concussive). Significance for each module at each phase was tested at $P < .05$. **Conclusions:** We found that student athletes with more severe symptoms uniformly performed worse on cognitive testing, supporting the role of computer based testing in the management of sport related concussion. While this decrease in performance among those with more severe symptoms is not unexpected it provides further evidence that return to play criteria and clearance should rely on a comprehensive evaluation. The decrease in cognitive test performance within each phase also provides further evidence that time from injury alone should not be used an indication of recovery.

The Effects of Aerobic Exercise on Post-Concussion Symptoms in Patients With Persistent Symptoms

Kulpa TA, Mansell JL, Russ AC, Tierney RT: King's College, Wilkes Barre, PA; Temple University, Philadelphia, PA

Context: Patients who do not fully recover from a concussion in 7-14 days may require an impairment-based rehabilitation program. Recent evidence indicates improved outcomes with rehabilitation compared to traditional passive rest. In patients with persistent symptoms (>4 weeks) following concussion, how does aerobic exercise affect post-concussion symptoms? **Methods:** PubMed, SPORTDiscus, CINAHL, and Medline databases were searched in May and June 2018 using the phrase: (Concussion OR "Mild Traumatic Brain Injury*" OR mTBI OR "Sport-Related Concussion*") AND ("Subsymptom Threshold Exercise" OR "Aerobic Exercise" OR Exercise OR Rehabilitation OR Therap* OR Treatment*) AND (Symptom* OR "Symptom Improvement" OR "Symptom Reduction"). Studies were included if they were < 10 years old, included patients with a concussion that had persistent symptoms for > 4 weeks and evaluated an aerobic exercise (AE) intervention. Outcome measures evaluated were patient reported post-concussion symptoms as assessed on the Post-Concussion Symptom Inventory or Graded Symptom Checklist. Pre- and post-intervention symptom scores were analyzed using calculated 95% confidence intervals (CI). Additionally, effect sizes were calculated between the pre- and post-intervention time frames. The PEDro scales and Strobe Checklist were used to assess validity. **Results:** Titles and abstracts of 542 studies were reviewed and 7 articles were provisionally selected for full-text review. Five articles with the highest quality evidence were included. CI and effect sizes (ES) were calculated, except for one reported by authors. Moderate to very large clinically relevant improvements existed

after intervention. In the RCT, the AE group had lower post-intervention symptoms ($4.17+7.36$; $95\%CI=-0.08, 8.42$) than the stretching/control group ($15.93+20.18$; $95\%CI=5.14, 26.72$) with a moderate ES ($d=0.774$). The quasi-experimental study found that AE group scores decreased pre-intervention ($17.5+1.66$, $95\%CI=15.84, 19.16$) to post-intervention ($2+1.22$; $95\%CI=0.78, 3.22$), demonstrating a very large ES ($d=10.64$). There was a large ES ($d=2.65$) between the post-intervention scores for the AE group and the stretching/control group ($15+6.83$; $95\%CI=8.17, 21.83$). In the first case series, symptoms decreased ($9.67+5.87$; $95\%CI 6.13, 13.21$ to $5.42 + 4.54$; $95\%CI=2.68, 8.16$), demonstrating a large ES ($d=0.81$). The second case series also found lower post-intervention scores ($2.7+3.2$; $95\%CI=0.68, 4.72$), compared to pre-intervention scores ($17.4+12.8$; $95\%CI=9.30, 25.50$) with a very large ES ($d=1.83$). The final case series found similar results with post-intervention symptoms ($6.7+5.7$; $95\%CI=3.85, 9.55$) lower than the pre-intervention ($30 + 20.8$; $95\%CI=19.60, 40.40$) with a very large ES ($d=1.53$). PEDro scale RCT = 6/10, quasi-experimental study = 19/22 Strobe Checklist = 19/22, 18/22, and 20/22 on the case series. **Conclusions:** Moderate SORT Level B evidence supports the inclusion of aerobic exercise into multimodal treatment plans for patients after concussions. Although this recommendation is based on mostly moderate to low-level evidence, the available literature presents consistent patient-based outcomes indicating a clinically-relevant benefit of aerobic exercise.

Headache Impact Test-6 Scores Pre- to Post-Concussion in Service Academy Cadets

Malvasi SR, Peck KY, Roach SP, Cameron KL, Posner MA, Houston MN: Keller Army Community Hospital, United States Military Academy, West Point, NY

Context: Healthcare providers rely heavily on self-reported symptom inventories to diagnose concussion and monitor recovery. However, symptom inventories only record the type of symptoms and degree of symptom severity, not how those symptoms may be influencing the patient's daily activities. With more emphasis on managing concussion through a multifaceted approach, patient-reported outcomes, such as the Headache Impact Test-6 (HIT-6), are being incorporated into concussion care. Therefore, the purpose of this study was to describe changes in HIT-6 scores from baseline to return-to-participation (RTP) in Service Academy cadets with concussion. We hypothesized that HIT-6 scores would be elevated immediately post-injury and return to baseline levels upon RTP. **Methods:** A prospective cohort study was used to examine HIT-6 score change over time in concussed cadets. During pre-season concussion baseline testing, cadets who agreed to participate were asked to complete the HIT-6. The HIT-6 is a 6-item questionnaire that addresses the impact of headache pain, vitality, psychological distress, social role, and cognitive functioning over the past month. Each item is scored on a 5-point Likert scale that spans from "never" to "always." All six items are summed for a total score ranging from 36-78, with larger scores indicating greater disablement. Following concussion, cadets completed the HIT-6 within 48 hours of injury and at the time of RTP. A repeated-measures analysis of variance was used to describe HIT-6 score changes across time. Tukey's post hoc tests were performed to identify significant differences, when there was a significant main effect for time. Alpha was set a-priori at $p < 0.05$.

Descriptive statistics were calculated as mean \pm standard deviation. **Results:** Of the 2,058 cadets (479 females) that completed a baseline HIT-6, 27 cadets (14 male, 13 female; age=20.02 \pm 1.32y, height=174.32 \pm 12.09cm, mass=75.77 \pm 16.78kg) sustained a concussion during the follow-up period and completed the HIT-6 within 48 hours of injury and upon RTP. The concussions occurred during athletics (55%), physical education courses (26%), and free time activities (19%). The average time from concussion to HIT-6 collection was 23h59m \pm 14h26m for the <48hr time point and 23.0 \pm 12.5days for RTP. Overall, there was a statistically significant effect of time on HIT-6 scores in concussed cadets, $F_{(2,52)}=11.18$, $p < 0.001$. Tukey post hocs revealed that HIT-6 scores were significantly higher immediately post-injury (51.56 \pm 6.77, $p < 0.001$) and at RTP (49.30 \pm 5.84, $p = 0.007$) compared to baseline (44.19 \pm 6.41). However, no differences were detected between post-injury and RTP HIT-6 scores ($p = 0.341$). **Conclusions:** Overall, there was a significant effect of time on HIT-6 scores following concussion. Compared to baseline, cadets reported increased headache symptom scores immediately post-injury and upon RTP. Thus, despite being medically cleared to RTP by their healthcare provider, cadets described increased symptom scores on the HIT-6, suggesting that their daily activities may still be influenced by headaches.

Free Communications, Poster Presentations: Concussion Visual Assessments

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Effect of Administrative Variance on Near Point of Convergence in a Healthy, Active Population

McGinnis IM, Tierney R, Mansell J, Phillips J: Temple University, Philadelphia, PA

Context: The Near Point of Convergence (NPC) assessment is used to identify oculomotor dysfunction and in recent years has been used in the management of sport-related concussion. NPC is the nearest point at which an individual's eyes can maintain binocular focus on a target and is administered by moving a target toward a person's face until they experience diplopia. In the literature, NPC administration has varied (e.g., target speed and verbal instruction). It is currently unknown if target speed or clinician verbal instruction influence the outcome of an NPC assessment. The purpose of this study is to evaluate the effect of target speed on NPC measures and examine the difference between when the target becomes "blurry" versus when the target becomes "double." **Methods:** The study employed a repeated measures design in a laboratory setting. Participants were 20 healthy and physically-active individuals aged 24.3 ± 2.92 years with no history of concussion within six months and no ocular abnormalities. The independent variables were target speed (i.e., 1 cm/s, 3 cm/s, 5 cm/s, and participant self-paced) and verbal instruction (i.e., "double vs. "blurry"). For the NPC assessments, a Bernell Accommodative Ruler was used and a target (i.e., 12-pt font letter "L") was moved at varying speeds toward the participant's face until diplopia was reported or exophoria was observed. Three trials were performed under each speed condition. NPC was defined as the distance (cm) from the participant's upper lip to the target location where diplopia occurred. One additional condition was tested at a speed of 1 cm/s, but the participant

was instructed only to report when the target became "blurry". Data were analyzed using a one-way repeated measures ANOVA and paired samples t-tests with IBM SPSS statistics version 25 ($p < .05$). **Results:** The one-way repeated measures ANOVA revealed a significant difference among the target speed conditions, $F_{(3,57)} = 5.12$, $p = .003$. Paired-samples t-tests revealed significant differences between the 5 cm/s speed (5.44 ± 2.01) and the 1 cm/s (6.72 ± 2.39 , $p = .003$), 3 cm/s (6.10 ± 2.36 , $p = .030$), and self-paced (6.63 ± 2.26 , $p = .005$) speeds. The paired-samples t-test showed a significant difference ($p < .001$) between the "double" (6.72 ± 2.39) and "blurry" (10.82 ± 3.08) conditions. **Conclusions:** Target speed and verbal instruction used influenced NPC measurements. Target speeds ranging from 1-3 cm/s, and patient self-paced speed are similar. However, a speed of 5 cm/s may result in shorter distances leading to false negative results. Additionally, ensuring the patient understands their role in the assessment (i.e., identifying when the target is "double" versus "blurry") is imperative for obtaining an accurate measurement. Therefore, it is essential to use consistent administration methods when performing the NPC assessment.

Pre-Season Baseline and Post-Concussion Near Point of Convergence in High School and College Student-Athletes: Findings From the Active Rehab Study

Klotz A, Register-Mihalik JK, Guskiewicz KM, Ranapurwala SI, Gildner P, Marshall SW, McCulloch KL, Mihalik JP, Prim JH, Vander Vegt CB, McCrea M, The Active Rehab Study Consortium: Medical College of Wisconsin, Milwaukee, WI; University of North Carolina, Chapel Hill

Context: Convergence insufficiency (CI) is common following concussion and may result in visual discomfort and functional difficulties such as double vision, discomfort reading, and difficulty with attention. Baseline and post-concussion CI screening (via near point of convergence (NPC) measures) in high school and college athletes may be warranted given the visual demands essential for academics and sport. The aims of this study were to report CI (NPC \geq 6cm) prevalence at both pre-season baseline and acutely post-injury, and to compare pre-season baseline and post-injury NPC in high school and college-aged student-athletes. **Methods:** Student-athletes (n=108) from 24 different

sports at six Canadian and US colleges and six US high schools who suffered a concussion and completed pre-season baseline testing participated in this quasi-experimental study [median age=18 years (range: 14-26); 34 (31.2%) female; 51 (46.8%) with 1+ prior concussions; 90 (82.6%) played a contact sport]. Participants completed a concussion assessment battery at pre-season baseline and within 24-48 hours following injury in a classroom-style setting that included demographics and NPC. NPC was measured according to the Vestibular-Ocular Motor Screening instructions. Three trials were collected and averaged at both timepoints. The independent variable was time (post-injury vs. pre-season baseline) and the primary outcomes were CI, defined as NPC \geq 6cm (yes vs. no) and average NPC (measured in cm). All analyses were adjusted for age, sex, contact sport participation, and previous concussion history. Logistic regression was used to compare the odds (Odds Ratio=OR) of CI (NPC \geq 6cm) at post-injury vs. pre-season baseline. Linear regression models, utilizing generalized estimating equations to account for study site clustering, examined the difference in NPC post-injury vs. pre-season baseline. **Results:** Of the 108 participants, 90 completed

post-injury NPC testing. At 24-48 hours post-injury, 38/90 (42.2%) had CI (NPC \geq 6cm) compared to 16/108 (14.8%) at baseline, indicating significantly higher odds of abnormal CI post-injury (adjusted OR=4.3, 95% CI 2.2, 8.3). Overall, the median baseline NPC was 3.2 cm (IQR: 1.5, 5.05), which increased to 5.3 cm (IQR: 2.8, 8.8) post-injury. After adjusting, there was a 2.45 cm (95% CI: 1.32, 3.58) increase in post-injury NPC compared to baseline. Table 1 outlines the NPC medians and IQRs for key baseline and post-injury categorical variables. **Conclusions:** Convergence insufficiency affects a significant number of student-athletes immediately following concussion. Adequate convergence is essential for those completing daily academic and sport activities. Athletic trainers should consider baseline and post-concussion CI screening for student-athletes in order to appropriately adjust academic and other activities following injury. Funded by a research grant from the National Football League.

Table 1. Median and IQR values for NPC at pre-season baseline and post-injury

Variable	Category	Baseline		24-48 Hours Post-Injury	
		Median	IQR	Median	IQR
Overall	n/a	3.2	1.5, 5.1	5.3	2.8, 8.8
Sex	Male	3.0	1.3, 5.2	5.2	3.0, 7.8
	Female	3.6	1.7, 4.8	5.2	2.0, 8.3
Contact Sport	Yes	2.5	1.3, 3.7	4.8	2.8, 9.2
	No	4.3	1.8, 5.6	5.8	2.8, 7.8
Previous Concussion	Yes	3.4	1.6, 5.2	5.3	2.8, 9.0
	No	2.3	1.3, 4.8	3.4	2.2, 6.9

The Effect of Sex, Sport Participation and Concussion History on Gaze Stabilization in Division I Collegiate Athletes

Quintana C, Hoch MC, Heebner NR, Mattacola CG, Abt JP: University of Kentucky, Lexington, KY

Context: Vestibular-ocular reflex (VOR) is objectively measured with a gaze stabilization test (GST). It quantifies the greatest rotational head velocity that can be achieved while maintaining the ability to see clearly and accurately. VOR has been shown to be affected following concussion, thus, this assessment may have utility in concussion management. However, normative data specific to sport, sex, or concussion history have not been established. Therefore, the purpose of this study was to report normative values in collegiate athletes and explore the effect of sport, sex, and concussion history on GST measures. We hypothesized that differences in GST performance would exist between sex, sport, and concussion history. **Methods:** GST was completed on 121 collegiate athletes (70 males, 51 females, age: 19.76±1.44yrs, height:

174.10 ± 13.95 cm, mass: 80.17 ± 26.63 kg) recruited from Division I sports (football, soccer and cheer). GST was performed in the leftward and rightward directions during a single session in a standardized environment. Participants were seated 8-feet away from a laptop screen and wore a mounted head piece accelerometer that measured the direction and velocity (deg/s) of head turns. The tester moved the participants head in the transverse plane at varying velocities while the participant focused on the screen to determine the direction of an “E” which appeared facing either left, right, up or down. This continued until the fastest velocity at which 60% of responses were accurately identified. Normative values for the individual GST measures (leftward, rightward and asymmetry) were expressed as percentiles. Kruskal-Wallis tests with post-hoc Mann-Whitney U tests were used to examine differences between sports. Mann-Whitney U tests were used to compare GST differences based on sex and concussion history (yes, no). Alpha was set a-priori at 0.05. **Results:** Normative GST values were organized into percentiles (Table). A significant main effect for sport was detected for gaze stabilization

rightward (p=0.017) and asymmetry (p=0.021). For rightward gaze stability, cheer (173.82±43.88 deg/s) demonstrated faster rotational velocities compared to soccer (147.89±25.33 deg/s; p=0.004). For gaze stability asymmetry, cheer (35.56±32.64 deg/s) values were greater than soccer (16.22±14.51 deg/s; p=0.008). No significant differences in leftward gaze stability were identified across sports (p=0.07). No significant differences were identified in any GST measures based on sex (p≥0.24) or concussion history (p≥0.97). **Conclusions:** Normative estimates for GST may enhance concussion evaluation for collegiate athletes with suspected VOR involvement following concussion such as diminished function or provocation of symptoms with head movement. Although sex and previous concussion history had no effect on gaze stabilization, performance on GST may be influenced by sport. Sport-related differences in GST may reflect VOR adaptations based on the individual sport-specific demands of the athletes. Specifically, athletes from acrobatic sports may require greater GST performance to make a successful return to participation following concussion.

Table: Percentile Distribution of Gaze Stability Test Scores (Degrees/Second)

GST Measure	Percentile						
	5	10	25	50	75	90	95
GST Leftward	120	120	130	145	170	205	233
GST Rightward	120	120	130	150	175	205	224.50
GST Asymmetry	74.5	59	30	15	5	5	0

Accommodative Insufficiency in Pediatric and Adolescent Student-Athletes Following Sport-Related Concussion

Vander Vegt CB, Phillips K, Fonseca J, Bloom OJ, Kay MC, De Maio VJ, Register-Mihalik JK: The University of North Carolina at Chapel Hill, Chapel Hill, NC; Carolina Family Practice & Sports Medicine, Cary, NC

Context: Visual impairment following sport-related concussion (SRC) requires appropriate management paradigms for pediatric and adolescent student-athletes. Adequate shape and curvature changes of the eye's crystalline lens (accommodation) is essential to achieve and sustain a focused image and is often impaired following SRC. Acute accommodative insufficiency (AI) can result in various visual complaints including blurred vision and difficulty reading. Acute AI prevalence and influence on initial post-concussion clinical measures is currently unknown. Therefore, we aimed to report AI prevalence within the first 3 days following SRC in student-athletes ages 8-18 years and to examine AI influence on initial post-concussion clinical measures. **Methods:** A prospective cohort of pediatric and adolescent student-athletes presented to a sports medicine clinic

within 3 days following SRC and consented to study participation (N=333; males=60.3%; mean age=14.4±2.1 years). Participants completed a standardized concussion assessment including a clinical exam, symptom inventory, the Immediate Post-Concussion Assessment and Cognitive Test (ImPACTTM), and bilateral monocular accommodative insufficiency (AI) screening using the push-up method. Accommodative insufficiency (yes versus no) was determined based on patient age using Hofstetter's formula—accommodative amplitude greater than or equal to 2 diopters below mean for age $[15-(1/4age)]$ —and served as the independent variable. Primary outcomes included ImPACTTM composite verbal memory, visual memory, processing speed, and reaction time scores, and total symptom severity. Descriptive statistics were used to report initial visit AI prevalence and separate multiple linear regression models examined the influence of AI on initial visit ImPACTTM outcomes controlling for age, sex, and symptom severity. Another regression model examined the effect of initial visit AI on total symptom severity controlling for age and sex (a priori $\alpha=0.05$). **Results:** Of the 325 participants with accommodation measures at initial visit, 151 (46.5%) presented with AI, 264 participants ages 10 years and older had valid initial visit ImPACTTM

test scores, and 282 participants reported initial visit total symptom severity. Means and standard deviations by outcome group—AI versus no—are summarized in Table 1. Accommodative insufficiency had a significant effect on all initial visit outcomes after controlling for covariates. Specifically, those with AI had significantly lower verbal memory ($\beta=-4.09$; 95%CI: -7.34,-0.83; $p=0.01$), visual memory ($\beta=-4.97$; 95%CI: -8.52,-1.42; $p=0.01$), and processing speed scores ($\beta=-2.36$; 95%CI: -4.19,-0.54; $p=0.01$). Those with AI also had significantly slower reaction time scores ($\beta=0.07$; 95%CI: 0.03,0.11; $p=0.001$) and reported significantly higher total symptom severity ($\beta=9.16$; 95%CI: 4.50,13.83; $p<0.001$). **Conclusions:** Accommodative insufficiency was highly prevalent in this student-athlete sample within 3 days following SRC. Those with AI demonstrated significantly worse neurocognitive test performance and reported higher symptom severity. Early AI screening along with post-concussion academic adjustments and close monitoring for student-athletes with AI is therefore warranted. This study was funded in part by the National Operating Committee on Standards for Athletic Equipment.

Table 1. Initial visit clinical outcomes in student-athletes with and without accommodative insufficiency—means (sd).

Initial Visit Outcomes	Accommodative Insufficiency	
	Yes n=101	No n=163
Verbal Memory*	78.53 (14.29)	84.61 (11.55)
Visual Memory*	67.02 (14.33)	73.84 (14.14)
Processing Speed*	31.61 (7.77)	35.34 (7.32)
Reaction Time	0.75 (0.21)	0.66 (0.12)
	Yes n= 112	No n= 170
Total Symptom Severity	31.39 (20.75)	23.65 (19.64)

*Indicates that higher scores are better. Only those 10 years old and older completed ImPACT™ testing.

Normative Values for Near Point of Convergence in High School Student Athletes

Griffiths A, Tsalatsanis A, Del Rossi G: University of South Florida, Tampa, FL

Context: Near point of convergence (NPC) is a measure of the ability to view a near target without double vision. Assessment of NPC as part of a vestibular/ocular-motor screening (VOMS) tool is useful in the management of sport-related concussions as it assists the practitioner in the decision-making process for rehabilitation. Currently, the clinical cutoff score for the NPC component of the VOMS is based on a distance ≥ 5 cm, which is based on normative data obtained from the general population. However, according to the literature, NPC values are age-dependent, which suggests that a one-size-fits-all cut-off value may not be appropriate for all patients. In addition, it's unknown if gender, a history of concussion, or medical conditions such as ADD/ADHD, impacts NPC scores. Thus, the primary goal of this investigation was to establish normative NPC data for high school-aged individuals (14-17 years old) and determine the percentage of individuals who exhibit NPC scores that fall outside the currently accepted clinical cutoff value. Secondly, the objective was to determine the effect of gender, concussion history, and ADD/ADHD on NPC scores. **Methods:** For this observational investigation NPC was assessed in high-school student-athletes. An accommodation convergence ruler was used to measure NPC. To obtain an NPC score, subjects were asked to focus on a small target placed on a notecard held at arm's length. Subjects were then asked to slowly slide the notecard along the ruler toward the tip of their nose. The moving target was stopped when the subject either saw two distinct images or when researchers observed an outward deviation of one eye, whereupon the distance between the target and the tip of the nose was measured

in centimeters and recorded. NPC was assessed a total of 3 times for each participant. Descriptive statistics for NPC values were then calculated. Chi-square tests were conducted to assess the association between NPC scores and gender, history of concussion, and pre-existing diagnosis of ADD/ADHD.

Results: A total of 838 student-athletes (173 females, 665 males) with an average age of 15.9 ± 1.2 years were included in the study. The average NPC score was 3.48 ± 3.44 cm across all trials, and the 95% confidence interval was 3.25 - 3.72. On average, 20.8% of NPC scores across each of the 3 trials were >5 cm. Lastly, there were no statistically significant effects of gender ($p = 0.3$), history of concussion ($p = 0.813$), and ADD/ADHD ($p = 0.825$) on NPC scores. **Conclusions:** Results indicate that in high-school aged subjects, approximately 1/5th of individuals may have NPC values that fall outside of the established cut-off value, and may lead to an incorrect diagnosis of ocular dysfunction. Also, NPC does not appear to be affected by gender, history of concussion and a pre-existing diagnosis of ADD/ADHD.

Examining Near Point of Convergence in High School Athletes

Sellers WE, Oldham JR, Glutting JJ, Buckley TA, Kaminski TW: University of Delaware, Newark, DE

Context: Recent evidence has indicated convergence dysfunction to be a complication following SRC and near point of convergence (NPC) has been reported to be useful in the examination of convergence deficits following SRC. The primary purpose of this study was to determine if instrument method (tongue depressor or accommodative ruler) influenced NPC values in high school athletes. **Methods:** We used a quasi-experimental, ex post facto design enrolling 201 interscholastic student-athletes (age = 15.7 ± 1.2 years, height = 170.5 ± 10.0 cm, mass = 69.9 ± 16.2 kg) from 14 different sports. NPC measures the distance of the subject's ability to view a near target without double vision. The subject focused on a small target letter "T" taped to the tip of a tongue depressor (NPC-TD) and attached to an accommodative ruler (NPC-AR). All subjects were tested under both instrumentation protocols. The subject was instructed to focus and try to keep the target in single view. While assessing NPC-TD, the subject would stop the target when they saw two distinct images; and with NPC-AR, the subject would verbalize when they saw two distinct images, and the examiner would stop the moving target block. Blurring of the image was ignored. The distance in centimeters was recorded. Three NPC measures were taken and then averaged to determine the analysis value. A paired samples t-test was used to analyze differences between the NPC-TD and NPC-AR values for all participants. To understand the secondary purpose, participants were separated into contact and limited/non-contact sport type groups and an independent samples t-test was used to analyze differences. **Results:** There was a significant difference between NPC-TD (2.0 ± 2.8

cm) and NPC-AR (2.8 ± 2.7 cm) values, $t(200)=5.85$, $p<0.001$. Additionally, there was a significant difference between contact and limited/non-contact groups with NPC-TD, $t(199)=4.01$, $p<0.001$, and NPC-AR, $t(199)=2.71$, $p=0.004$. **Conclusions:** Our results indicate a significant difference between NPC-TD and NPC-AR instrumentation methods in this high school student-athlete sample and support the use of consistent methods when assessing NPC in both a clinical and research environment. As we hypothesized, both NPC-TD and NPC-AR values were significantly different between contact sport athletes and limited/noncontact sport athletes, which lends support to the growing body of evidence suggesting repetitive head impacts may cause changes in brain function, including eye convergence.

Comparison of King-Devick Test and Senaptec Sensory Station Scores at Preseason in High School and Collegiate Athletes

Manfresca EJ, Grooms DR, Starkey C, Simon JE: Ohio University, Athens, OH

Context: While there are many established concussion baseline tools that have been successfully validated in the literature, there has been no established gold-standard assessment due to the multifaceted nature of concussion related performance deficits. The King-Devick has become an accepted assessment of visual-motor ability post-concussion, but only measures one facet of visual-motor performance. The newly developed Senaptec Sensory Station (Senaptec) provides a more comprehensive assessment of visual-motor abilities, but has not been assessed as a potential baseline concussion assessment. The purpose of this study was to determine if any neurocognitive domains of the Senaptec assessments overlap with the King-Devick test. **Methods:** This investigation was a cross-sectional study that enrolled 119 high school and collegiate athletes (17.1 ± 2.3 years, 174.3 ± 9.6 cm, and 75.1 ± 17.1 kg) participating in football, volleyball, soccer, wrestling, basketball, tennis, and track & field at one local college and two local high schools. Participants had no diagnosis of ADD/ADHD, no previous concussion within three months, and no attendance to a sports performance/vision training camp within six months. Data collection took place in an athletic training clinic and/or computer lab. The King-Devick Test was administered by the clinician using 3 paper test cards to quantify saccadic movements. The Senaptec 7 tablet assessments were administered in a group fashion via multiple 22-inch touch screen tablet and smart phone. The Senaptec evaluated a variety of visual-motor constructs. Participants completed these assessments during preseason of his/her respective sport. The King-Devick time and Senaptec assessment

preseason scores (Visual Clarity, Depth Perception, Contrast Sensitivity, Reaction Time, Multiple Object Tracking speed and score, Near-Far Quickness score, and Perception Span score) were compared using eight correlations. Alpha level was set at 0.006 to correct for the multiple correlational analysis. **Results:** Descriptive statistics for the measured variables were King-Devick (43.27 ± 7.22 seconds), Visual Clarity (-0.08 ± 0.28 LogMAR), Depth Perception (171.06 ± 89.51 arcsec), Contrast Sensitivity (1.56 ± 0.36 LogCS), Reaction Time (336.59 ± 37.35 msec), Multiple Object Tracking speed (446.99 ± 119.50 degrees/second) and score (1404.60 ± 529.41), Near-Far Quickness score (21.54 ± 7.37), and Perception Span score (38.13 ± 11.80). There were no statistically significant correlations between King-Devick time and each Senaptec variable; specifically, all correlations were weak ($r = -0.17$ to 0.08 , $p>0.006$). **Conclusions:** The lack of correlations between the King-Devick and any Senaptec domains is suggestive that the Senaptec assesses different visual constructs than the King-Devick. Although, the Senaptec lacks a strong saccadic assessment, it assesses varying visual-motor constructs beyond saccades that may be impacted by concussion and are currently not being quantified in standard of care assessments.

The Relationship Between the ImPACT and Senaptec Neurocognitive Assessments

Blunt L, Simon JE, Starkey C, Grooms DR: Ohio University, Athens, OH

Context: Neurocognitive assessments are a key aspect of concussion diagnosis and management. Baseline assessments are important to assess differences in post-concussion results and assist with return to play decisions. Currently, no gold standard assessment tool exists, as current measures may lack the ability to assess the full spectrum of oculomotor dysfunction following concussion. The objectives of this study are to quantify normative data for a new visual-motor assessment, the Senaptec Sensory Station (Senaptec) for high school and college athletes and to determine which neurocognitive domains of the Senaptec overlap with the current method of care (Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT)). **Methods:** The study was a cross-sectional study completed at two area high schools and one local college. One-hundred nineteen male and females (17.1±2.3 years, 174.3±9.6 cm, and 75.1±17.1 kg) who participated in football, soccer, volleyball, basketball, softball, tennis, and/or track and field and were medically cleared for activity were enrolled. Informed assent/consent was obtained, and health history via questionnaire was reviewed to determine inclusion criteria. Participants who had been diagnosed with a concussion in the previous three months, had a learning disability, attention deficit disorder and/or a psychiatric condition were excluded. Participants completed both the ImPACT (Impulse Control, Verbal Memory, Visual Motor, Visual Ability, and Reaction Time Composites) and the Senaptec (Visual Clarity, Depth Perception, Contrast Sensitivity, Reaction Time, Multiple Object Tracking speed, Near-Far Quickness score, and Perception Span score) prior to the start of their respective sport season. Descriptive statistics

were computed, and an exploratory 35 Pearson correlations were completed across all ImPACT (5 tests) and Senaptec (7 tests) measures with an a priori alpha level at 0.05 as this study was exploratory. **Results:** ImPACT Impulse Control Composite (7.12±6.09 score) and Verbal Memory Composite (82.50±12.09 score) were not correlated to any Senaptec test ($p>0.05$). ImPACT Visual Motor Composite (37.14±7.13 score) and Visual Ability Composite (72.76±15.108 score) were significantly weakly correlated with the Senaptec test Perception Span (38.13±11.79 score; $r=0.22$, $p=0.01$ and $r=0.26$, $p=0.01$, respectively). ImPACT Visual Motor Composite and Visual Ability Composite were also significantly weakly correlated with the Senaptec test Multiple Object Tracking Speed (1404.56±529.4 degrees/sec; $r=0.34$, $p=0.01$ and $r=0.31$, $p=0.01$, respectively). ImPACT Reaction Time Composite (0.63±0.09 sec) was significantly weakly correlated with the Senaptec test Near Far Quickness (21.54±7.37 score; $r=-0.27$, $p=0.01$) and the Senaptec test Reaction Time (336.59±37.35 msec, $r=0.33$, $p=0.01$). **Conclusions:** Results show that the Senaptec may assess novel aspects of visual motor function with minimal overlap with the ImPACT. Clinicians may consider the use of the Senaptec for clinical practice as an adjunct to current standard of care assessments to provide further oculomotor data to ensure complete function restoration before return to play post-concussion.

Clinical Utility of the Senaptec Sensory Station, ImPACT, and King-Devick as Concussion Assessment Tools

Spataro MR, Grooms DR, Starkey C, Simon JE: Ohio University, Athens, OH

Context: Baseline and post-concussion testing is imperative in the management of concussion. However, there is a lack of a gold standard assessment tool when returning athletes safely to play post-concussion. The objective of this study was to determine the clinical utility of the Senaptec Sensory Station (Senaptec), Immediate Post-Concussion Assessment and Cognitive Test (ImPACT), and King-Devick as concussion assessment tools. **Methods:** One hundred nineteen high school and college athletes participated in the baseline portion of this study (17.1±2.3 years, 174.3±9.6 cm, and 75.1±17.1 kg). At baseline all individuals completed the ImPACT, King-Devick, and Senaptec in the athletic training clinic and/or computer lab. The ImPACT was administered via a computer. The King-Devick test was administered by the participant reading the cards with numbers aloud to the clinician. The Senaptec (Visual Clarity, Depth Perception, Contrast Sensitivity, Reaction Time, Multiple Object Tracking speed and score, Near-Far Quickness score, and Perception Span score) was administered using an interactive tablet to assess a variety of visual-motor properties. Individuals who suffered a concussion during the sports season ($n=8$, 17.5±1.3 years, 175.1±12.3 cm, and 94.1±26.1 kg), with no history of ADD/ADHD, a learning disability, previous concussion in the past three months, and who did not attend a sports performance/vision training enrolled in the post-concussion portion of the study. The post-concussion cohort were administered the ImPACT, King-Devick test, and Senaptec assessments at return to play, as determined by a certified athletic trainer. The dependent variables were the 5 ImPACT composite scores, King-Devick time

(seconds), and the 7 Senaptec variables. As this study was exploratory in nature 14 one-sample t-tests were conducted between the post-concussion cohort and the mean baseline value for each variable with alpha level set at 0.05 for all analyses. Post-concussion data was compared to the baseline cohort mean value as not everyone had baseline data. **Results:** Data was first explored by high school and college athletes and there was no difference found between groups so all individuals were analyzed in one group. Near Far Quickness and Multi-Object Tracking Speed and Score of the Senaptec were found significant ($p < .05$) between the baseline cohort and at return to play for the post-concussion cohort. Specifically, Near Far Quickness score was worse post-concussion (baseline: 21.54 ± 7.37 score; post-concussion: 16.25 ± 1.49 score, $p = 0.01$), Multi-Object Tracking Score was worse post-concussion (baseline: 1404.60 ± 529.41 score; post-concussion: 1046.28 ± 298.62 score, $p = 0.01$), and Multi-Object Tracking Speed was slower post-concussion (baseline: 446.99 ± 119.50 degrees/sec; post-concussion: 372.5 ± 64.34 degrees/sec, $p = 0.01$). No other variables were found significant between the two cohorts ($p > 0.05$). **Conclusions:** The Senaptec detected deficits when the current standard of care (ImpACT & King-Devick) indicated recovery. The use of additional oculomotor assessment such as Senaptec may provide further metrics to ensure athlete recovery post-concussion.

Age Related Vestibular and Ocular Motor Symptom Outcomes Following Sport-Related Concussion

Tomczyk CP, Anderson M, Petit KM, Bretzin AC, Savage JL, Covassin T: Michigan State University, East Lansing, MI

Context: Sport-related concussion (SRC) is an individualized neurological injury that results in a multitude of cognitive, physical, and emotional consequences. Vestibular and ocular motor symptoms commonly present immediately following SRC, and can lead to prolonged recovery. The complexity of SRC leads to unique injury outcomes regarding age for many facets of concussion, but hasn't been examined for vestibular and ocular motor outcomes following SRC. Therefore, the purpose of this study was to examine the effect of age on vestibular and ocular motor outcomes following SRC. **Methods:** A cross-sectional study design was used to compare 73 high school (HS, $n = 26$, age: 15.19 ± 1.47 years) and collegiate athletes (COL, $n = 46$, age: 19.43 ± 1.26 years). All athletes were administered the Vestibular/Ocular Motor Screening (VOMS) within 72 hours following SRC. The VOMS assesses symptom provocation on the following 7 components: smooth pursuits, horizontal and vertical saccades, near point convergence (NPC), horizontal and vertical vestibular ocular reflex (VOR), and visual motion sensitivity. Symptomology (headache, dizziness, nausea, and foggiess) is self-reported using an 11-point Likert scale (0=none, 10=severe) prior to VOMS administration and following each VOMS component. Change scores were calculated by subtracting the total symptom score for each component from the pre-VOMS administration total symptom score. Higher scores indicate greater symptom provocation. Change scores were compared between groups (high school, collegiate) using separate one-way ANOVAs ($\alpha \leq 0.05$, set a priori).

Results: High school athletes had significantly greater symptom provocation following the NPC (HS: 2.19 ± 3.21 , COL: 0.82 ± 1.58 , $F_{1,73} = 6.22$, $p = 0.02$), horizontal VOR (HS: 3.07 ± 3.68 , COL: 1.62 ± 2.19 , $F_{1,75} = 4.73$, $p = 0.03$), and vertical VOR (HS: 2.96 ± 3.75 , COL: 1.50 ± 2.15 , $F_{1,75} = 4.76$, $p = 0.03$) components. No significant differences were observed between high school and collegiate athletes for any other VOMS components (all $p > 0.05$). **Conclusions:** Collegiate and HS athletes have been shown to differ in many aspects of SRC including symptom reporting, cognition, and balance. The current study found that HS athletes suffered greater vestibular and ocular motor symptom provocation when performing NPC and VOR taxing activities within 72 hours of a SRC. Clinicians need to be aware that these activities can be more consequential to adolescent athletes, as a result they should consider targeted treatment strategies for concussed athletes with vestibular and ocular motor impairments.

Test-Retest Reliability of a Coincidence Anticipation Timing Assessment: Implications for Concussion Management

Yang K, Vander Vegt CB, Barczak N, Register-Mihalik JK, Mihalik JP: The University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Reaction time is often impaired following sport-related concussion. Most assessment paradigms do not incorporate anticipation reaction skill assessment, which is important for sport performance and injury prevention. Coincidence anticipation timing (CAT) is an individual's ability to perceive a moving stimulus, estimate a trajectory pathway, and time a motor response to coincide with the arrival of that stimulus. The purpose of this study was to determine the test-retest reliability of a novel CAT task in a healthy, physically active population. **Methods:** Physically active, college-aged individuals (N=42; 11 males; mean age=21.0±1.0 years; height=170.6±9.4cm) consented to participate in this cross-sectional study. Participants completed two identical CAT testing sessions, our

independent variable, separated by one hour; each session consisted of both seated and standing assessments. A single CAT assessment (Senaptec Synchrony) consisted of 15 trials. Each trial consisted of a light stimulus traveling down a light strip (length=17'4" or 5.28m) at various speeds (ranging from 5 to 40 mph) towards the participant who responded to each stimulus with a terminal foot pad. The primary outcome for each trial was timing error (in milliseconds), which was computed by subtracting the participant response time from the expected time for stimulus arrival. Negative timing error values occurred when participants responded early to the stimulus, and positive timing error values indicated late responses. The mean timing error was computed across all 15 trials for each assessment (seated or standing) for both sessions (first or second) and served as our dependent variable. This resulted in 4 separate mean timing error values for each participant who was able to complete all test sessions. Intraclass correlation coefficients (ICC_{2,k}) and Standard Errors of Measurement (SEM) were calculated from our outcome

measures to assess test-retest reliability. **Results:** Strong reliability was exhibited for both the standing (ICC_{2,k}=0.92; SEM=15.86ms; F_{1,39}=7.78, p=0.008) and seated (ICC_{2,k}=0.87; SEM=15.86ms; F_{1,36}=8.19, p=0.007) CAT assessments. Table 1 summarizes the mean, standard deviation, minimum, maximum, ICC_{2,k}, and SEM values for both testing positions, across both sessions. **Conclusions:** These preliminary data suggest the Senaptec Synchrony CAT assessment is highly reliable in both seated and standing positions. As such, this task may provide reliable information with respect to an individual's anticipatory reaction skill. Given concussion adversely affects reaction time, the Senaptec Synchrony may be useful to assess post-injury functional reaction times or used as a pre-injury anticipatory training tool to enhance sport performance or improve return to play readiness. Future research longitudinally examining the effect concussion may have on anticipation skill in athletes is warranted.

Table 1. Average timing error data and results in seated and standing positions for both test sessions.

	Mean ± SD (ms)	Minimum (ms)	Maximum (ms)	ICC _{2,k}	SEM (ms)
Standing (n=40)^a					
Session 1	8.48 ± 55.36	-106.50	123.00	0.92	15.86
Session 2	-4.10 ± 55.43	-163.00	105.00		
Seated (n=37)^a					
Session 1	15.94 ± 47.17	-61.50	145.50	0.87	15.86
Session 2	-1.04 ± 39.53	-108.50	75.50		

^a Sample sizes include only those where participants successfully completed all trials for both sessions

The Effect of an Interval Fatigue Protocol on Vestibular/Ocular Motor Screening (VOMS) Performance

Ratka J, Mansell JL, Cheever KM, Tierney RT: University of Pennsylvania, Philadelphia, PA; Temple University, Philadelphia, PA; University of Texas at San Antonio, San Antonio, TX

Context: The presence of exertional fatigue may affect vestibular and/or ocular motor system functions which could limit the accuracy of the Vestibular/Ocular Motor Screening (VOMS) during an immediate, sideline concussion assessment during the acute stages of injury management. The purpose of this study was to examine the effect of an exertional fatigue protocol on VOMS performance. **Methods:** A within subjects, repeated measures, crossover design was utilized in a University gymnasium. Fifteen healthy, physically-active participants (22.20 ± 1.424 years of age), who were recruited by word-of-mouth, completed two sessions under two randomized conditions. The VOMS has been validated and assessed for an internal consistency of (Cronbach alpha=0.92-0.97) and consisted of assessments in five different domains: smooth pursuit, saccadic eye movements, convergence, vestibular ocular reflex (VOR), and visual motion sensitivity (VMS). During each session, a pre-test VOMS was performed, condition protocol was completed, and a post-test VOMS was performed. The control condition consisted of a 20-minute rest protocol. The experimental condition consisted of a 20-minute fatigue protocol. The primary outcome measures were VOMS performance scores and measurements for Near Point of Convergence (NPC). Heart rate (HR) using a Polar wrist heart rate monitor and Rate of Perceived Exertion (RPE) using the Borg Scale were also recorded. Descriptive statistics were used to describe the participant sample and two 2 x 2 repeated measures analyses of variance (ANOVA) were used to assess

significant differences between conditions (control, experimental) over time (pre-, post-) for total VOMS score and NPC measurements. Follow-up paired t-tests were used to assess significance as needed. SPSS software version 25 was used for all analyses with an a priori significance set at $p \leq 0.05$. **Results:** Statistically significant interaction effects for NPC, $F_{(1,14)} = 9.38$, $p = .008$, and total VOMS score, $F_{(1,14)} = 10.96$, $p = .005$ were observed. For NPC, post-test (9.12 + 4.99cm) was significantly different, $t(14) = -2.60$, $p = .021$, than pre-test scores (7.12 + 3.19cm) for the experimental condition. For total VOMS score, post-test scores (4.93 + 5.12 severity score) were significantly different, $t(14) = -3.06$, $p = .009$, than pre-test scores (1.73 + 3.67 severity score) for the experimental condition. **Conclusions:** Significant increases were found in total VOMS score and NPC measurements following an exertional fatigue protocol in physically-active individuals. The presence of exertional fatigue affects vestibular, and/or ocular motor system functions by eliciting symptoms associated with the VOMS. The use of the screening should be cautioned against immediately following physical activity, such as during a sideline concussion assessment. Clinicians should allow for a period of time in which athletes can recover from the effects of acute exertional fatigue prior to administration.

Free Communications, Poster Presentations: Concussions in Female Athletes

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Comparing the Incidence of Head Impacts Sustained in Conference Versus Non-conference Women's Soccer Games

Acors CD, Bradney DA, Breedlove KM, Bowman TG: University of Lynchburg, Lynchburg VA; University of Michigan, Ann Arbor, MI

Context: Investigating head impacts in women's soccer has become of increased interest due to the fact that women's soccer has one of the highest concussion injury rates among organized sports. Our objective was to determine frequency and magnitude differences in head impacts sustained by collegiate women's soccer players during conference and non-conference games. **Methods:** 24 intercollegiate women's soccer players volunteered to participate in this descriptive epidemiology study (age = 19.65 ± 1.27 years, height = 165.80 ± 4.87 cm, mass = 64.45 ± 7.38 kg). Game type served as the independent variable (non-conference and conference). We measured frequency and magnitude (peak linear accelerations in g-forces and peak rotational accelerations in deg/sec²) of head impacts with the X2 Biosystems xPatch sensors that participants wore during every practice and game. We used video footage of all practices and games to confirm all head impacts over a 10 g threshold. Frequency was determined by calculating incidence rates (IRs), incident rates ratio (IRRs), and 95% confidence intervals (CI95). We used MANOVA in order to examine magnitude differences. **Results:** Participants sustained more head impacts during non-conference games (IR = 11838.71, CI 95 = 10627.48-13049.94) compared to conference games (IR = 5153.85, CI 95 = 4441.34- 5866.35; IRR = 2.30, CI 95 = 1.93-2.73). Game type did not alter the combined dependent

variables ($F_{2,565} = 2.00$, $P = 0.45$, $\eta^2 < .01$, $1-\beta=.19$). Follow up ANOVAs showed game type failed to alter linear accelerations ($F_{1,566} = 1.51$) and rotational accelerations ($F_{1,566} = 1.41$). **Conclusions:** Our findings suggest that collegiate women's soccer players sustained more head impacts while competing in non-conference games. However, the magnitude of head impacts were similar between non-conference and conference games. Given the concerns regarding subconcussive head impacts, it is interesting to note the increased frequency of head impacts in non-conference contests. The higher frequency of head impacts sustained in non-conference contests could be attributed to the players perceiving that they may be more likely to engage in risky behavior during non-conference contests since conference contests determine postseason participation.

The Effect of Hormonal Contraceptives on Length of Recovery in Female Collegiate Athletes

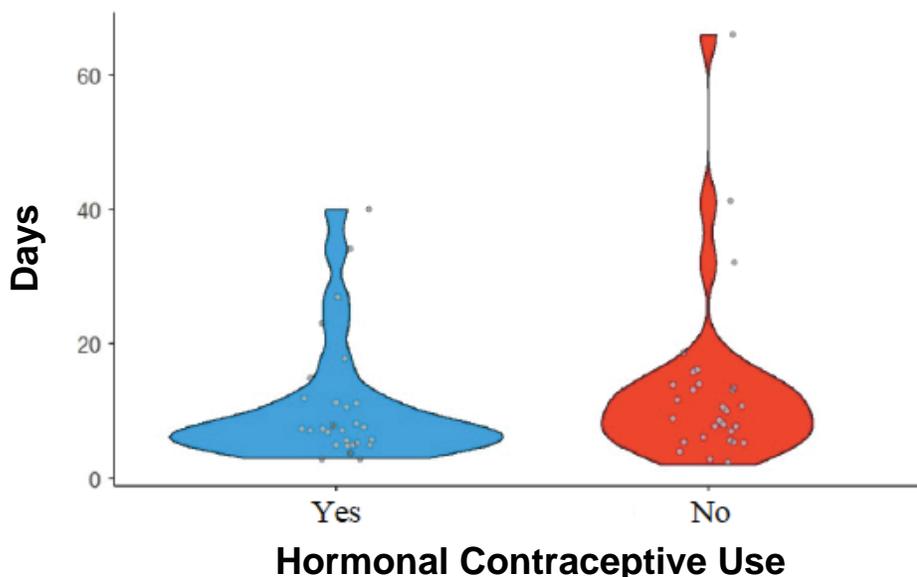
Carrington H, Thompson X, Erdman NK, Watson SR, Resch JE: University of Virginia, Charlottesville, VA

Context: Decreased estrogen and progesterone levels in women have been purported to have neuroprotective effects in relationship to traumatic brain injury. Oral contraceptives (OCP) lower estrogen and progesterone levels and have been demonstrated to reduce symptom burden following a concussion. However, conflicting evidence exists regarding the influence of OCP on recovery time in concussed female athletes. The purpose of this study was to evaluate the effect of OCP use in female collegiate athletes on time until asymptomatic from a concussion. **Methods:** Fifty-nine concussed NCAA Division I female athletes who self-reported taking (n=30 [OCP+]) or not taking (n=29 [OCP-]) OCP participated in the current study. OCP+ participants were similarly matched to OCP- participants based on sport, height, weight, and

age. Participants had an average age of 19.8 ± 1.25 years, height of 171.9 ± 9.66 cm and mass of 66.2 ± 10.90 kg. All participants completed a baseline and return-to-play assessment consisting of the ImpACT™ battery and the Sensory Organization Test (SOT). The return-to-play assessment occurred after each participant self-reported symptom free following a diagnosed concussion by their respective athletic trainer. Participants were included if they had valid ImpACT and SOT performances at each time point. Independent t-tests were used to compare the number of days until asymptomatic between OCP+ and OCP- participants as well as ImpACT (Verbal and Visual Memory, Visual Motor Speed [VMS], Reaction Time [RT] and Total Symptom Severity [TSS]) as well as SOT (Equilibrium Score [ES] and Somatosensory, Visual and Vestibular sensory ratios) outcome scores. Paired t-tests were used to compare baseline and return-to-play performance for ImpACT and SOT outcome scores. All analyses were performed with $\alpha = 0.05$. **Results:** No statistically significant differences were observed between groups for any baseline or return-to-play ImpACT or SOT outcome scores ($p < 0.05$). Significant

improvements were observed from baseline to return-to-play assessments for the OCP+ group for ImpACT's VMS ($44.2 + 5.66$ to $46.2 + 4.23$ [$t_{(28)} = -2.51, p = 0.02$]), RT ($0.53 + 0.05$ to $0.51 + 0.04$ [$t_{(28)} = 2.98, p = 0.006$]), and TSS ($6.0 + 6.89$ to $0.03 + 1.18$ [$t_{(28)} = 4.209, p < 0.001$]). Significant improvements were observed from the baseline to return-to-play assessments for ES ($83.4 + 3.23$ to $84.3 + 3.37$ [$t_{(28)} = -2.64, p = 0.014$]) and TSS ($3.59 + 7.41$ to $0.41 + 1.05$ [$t_{(28)} = 2.28, p = 0.03$]) for the OCP- group. No statistically significant differences ($t_{(57)} = -0.91, p = 0.37$) were observed for days of recovery between OCP+ ($10.7 + 9.11$) and OCP- ($13.3 + 13.04$) groups (Figure 1). **Conclusions:** Overall, improvements were observed from baseline to return-to-play performance for the ImpACT and the SOT for the OCP+ and OCP- groups, respectively. Our results suggest that OCP use did not shorten the time until asymptomatic of concussed collegiate female athletes, which supports previous research. Although not statistically significant, participants in the OCP+ group recovered approximately 3 days earlier on average than those in the OCP- group.

Figure 1. Days Until Asymptomatic With and Without Hormonal Contraceptive Use



The Influence of Gender Differences on Neck Strength and Head Acceleration During Soccer Heading: A Systematic Review

Carson R, Troy J, Berry DC:
Saginaw Valley State University,
University Center, MI

Context: Soccer players repetitively strike the ball with the head throughout their careers, often with enough subconcussive impact to generate neurological deficits. Women soccer players may be at increased risk due to differences in neck strength and/or head acceleration speeds; therefore, identifying anthropometric differences between genders may help predict risk of injury. This study aimed to systematically review, evaluate, and summarize the literature to determine the influence of gender differences of neck strength and head acceleration in soccer athletes. **Methods:** Databases searched: Pubmed, MEDLINE, and Cumulative Index of Nursing and Allied Health Literature (CINAHL) using the phrases “soccer” AND “neck strength” AND “sex”, (n=47); “soccer” AND “head acceleration” AND “sex”, (n=46) from September 2008-to-September 2018, resulting in 93 articles. Following screening (duplicates=30, title, abstract), 57 articles were reviewed. Five met the inclusion criteria: (1) observational, cross-sectional studies, (2) English-language, (3) available-abstract, (4) interventions applied to athletes 12-28 years old (5) males compared to females (6) outcomes measuring either neck strength and/or head acceleration during head/neck kinematics. Two reviewers independently assessed the studies’ level of evidence (LOE) and quality using the Oxford (2011) and Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) scales, respectively. Data of interest: subjects, interventions (type), and main outcome descriptive and inferential statistics. **Results:** Five studies met the inclusion criteria (LOE=3). STROBE scales ranged

between 20-25 (maximum=32; average=22±1.87). Pooled sample size=192 (M=84; F=110), average age=19.7±1.90 (range=12-24). In one study, gender differences were observed in neck girth ($p<0.001$), flexor ($p=0.012$) and left-lateral flexor strength ($p=0.002$), and rotational velocity at 25 mph ($p=0.024$) and 40 mph ($p=0.048$). Women displayed significantly less flexor strength (women = 23.12 ± 5.38 , men = 34.66 ± 8.60 , $d=1.56$), left-lateral flexor strength (women = 21.66 ± 4.30 , men = 32.36 ± 4.68 , $d=2.38$) and higher head acceleration (25 mph: women = 1038 ± 253.63 , men = 656.56 ± 258.03 , $d=1.49$; 40 mph: women mean = 1416.13 ± 507.63 , men = 774.60 ± 501.13 , $d=1.27$). Head acceleration speeds wearing two-headgear types found women experienced greater peak linear rotation versus men (F=21.5 g vs. M=16.3 g) and (F=21.8 g vs. M=15.2 g), ($p<0.05$). Females (20.2 g) exhibited 10% greater ($p=0.164$) head acceleration under controlled conditions versus men (18.2 g). Women experienced higher peak linear (40.9 ± 13.3 g) and rotational acceleration (3279 ± 1065 rad/s²) compared to males (27.6 ± 8.5 g, 2219 ± 823 rad/s²), ($p<0.001$). No differences in the frequency or severity of head impacts between genders ($p=.290$) were noted. Men’s soccer games resulted in 285% more head impacts than practices ($p<0.001$). **Conclusions:** Results demonstrate moderate-to-strong evidence that females have weaker neck muscle strength and experience greater head acceleration speeds while striking a soccer ball. Athletic trainers might consider: (1) educating female athletes on the dangers of striking a ball with the head, specifically when neck strength deficits are present, (2) neck strength and/or head acceleration assessment could be part of the pre-participation screening, (3) developing conditioning programs for at-risk athletes.

Concussion Prevention Strategies: A Survey of Division I and Division II Female Soccer Teams

Jeffries KK, Girouard TJ, Radzak KN: University of Nevada, Las Vegas, Las Vegas, NV

Context: Female soccer players have over a two times greater risk of concussion incidence compared to their male peers. While much attention has been drawn to identifying ways to decrease concussion rates, it is unknown what strategies are currently being performed. In addition, athletic trainers' knowledge and beliefs on the efficacy of concussion prevention practices for female soccer athletes is unknown. The purpose of this study is to evaluate concussion prevention strategies that are being used in NCAA Division I and Division II schools and characterize the beliefs of Certified Athletic Trainers (ATs) concerning equipment for concussion prevention. **Methods:** Participants included ATs employed at any of the 334 NCAA Division I or 273 Division II universities who provide services to the female soccer teams. A survey instrument of structured questions followed by open-ended follow-up questions was developed to identify if teams were utilizing cervical strengthening programs, headgear, or other techniques specifically for concussion prevention. Questions also address the ATs beliefs on the effectiveness of cervical strengthening, headgear and mouth guards in concussion prevention. Data were collected via questionnaire e-mailed in January 2017 to potential participants through Qualtrics survey software, with two and four-week follow-up e-mails to non-respondents. Responses were received from 222 ATs who work with the female soccer team at their respective university (37.8% response rate). Data were analyzed via descriptive statistics using Qualtrics reports. **Results:** Some form of cervical strengthening or stability for

concussion prevention was performed by 38 teams (17.12%), 177 teams (79.73%) were not, and seven ATs (3.15%) did not know if a program was being implemented. The majority of ATs (69.86%) believe that a cervical strengthening or stability program will aid in the prevention of concussions. The use of equipment for concussion prevention was reported by 36 participants (16.59%). Text responses for equipment included mouthpieces (3 respondents) and headgear (31 respondents). 78 (35.49%) reported having players on their team that wear headgear. 19 ATs (8.76%) believe that soccer headgear prevents concussions. 45 ATs (20.74%) believe that mouth guards prevent concussions. 151 (69.59%) respondents implement proper soccer technique to prevent concussions. 14 (0.06%) respondents cite nutritional strategies for concussion prevention. **Conclusions:** The majority of programs are utilizing technique education for concussion prevention. Although most ATs believe that cervical strengthening could help prevent concussions, very few programs are implementing this strategy. The disconnect between evidence-based concussion prevention practices and the perceptions held by ATs regarding mouth guards and soccer headgear as concussion prevention tools is alarming.

Return-to-Play Protocols Following Sport-Related Concussion in NCAA Gymnastics

Horner A, Root HJ, Valovich McLeod TC: A.T. Still University, Mesa, AZ

Context: Gymnastics requires skills of varying difficulty on multiple apparatuses including a combination of linear and rotational movements with flight elements, which increases the risk of falls and surface contact. This poses a unique threat of sustaining a sport-related concussion (SRC) as well as challenges with returning athletes to sport. Little is known about return-to-play (RTP) protocols following concussion at the collegiate level. The purpose of this study was to determine the current practices of athletic trainers (ATs) regarding concussion management and RTP in collegiate gymnastics. **Methods:** A cross-sectional online survey design was used to assess concussion management practices and return to gymnastics protocols among athletic trainers assigned to NCAA gymnastics programs. The survey was validated by a panel of medical and gymnastics experts for face validity. The survey consisted of 5 sections: institution demographics, athletic training services demographics, concussion demographics, baseline concussion testing practices, and return to gymnastics protocol. Question types included multiple-choice, 4-point Likert scale items, and multi-item questions. The survey took approximately 10 minutes to complete. The survey was sent to ATs with listed affiliation to the gymnastics team(s), but if sport assignment was not included online, emails were sent to the head athletic trainer. Schools were excluded if no contact information was available on the website. Frequencies and percentages were reported. **Results:** Eighty-nine ATs were contacted, 39 ATs (17 male, 16 females, 5 anonymous) completed the survey (response rate= 43.82%), with the majority of those working at the division I level (69.2%, n=27)

and with female teams (69.2%, n=27). Respondents reported 22.3±10.3 (range 10-60) gymnasts participating per team. ATs providing care for female gymnasts reported fifty-one concussions (average=1.7±1.7, range 0-8) during the 2017-18 competition season, with the majority occurring on uneven bars (n=32/51, 54.23%) and floor exercise (n=8/51, 15.68%). ATs providing care for male gymnasts reported 31 concussions (average=3.44±6.63, range 0-12), with high bar (n=16/31, 51.61%) and rings (n=9/31, 29.03%) resulting in the highest number of concussions. Only 46% (n=18/39) of the ATs reported having a gymnastics-specific RTP protocol. One-fifth (n=8/39) indicated they experience challenges with progressing gymnasts through different movement planes, particularly flight and release skills. Of those with gymnastics-specific RTP protocols most described a progression beginning with aerobic exercises, progressing to strength-based skills, simple rotations (without dismounts), complex rotations, and finally dismounts, beginning with landing in the pit to mats, to normal floor.

Conclusions: We found higher reporting number of concussions within NCAA gymnastics programs than had been reported in previous years. Less than half of the respondents reported having gymnastics specific RTP protocol and many faced challenges in knowing how to progress gymnasts. Many reported good collaboration with their directing physician and the coaching staff to help determine the appropriate skill progressions.

Free Communications, Poster Presentations: Cryotherapy and Thermal Modalities

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

The Heating Rates of Intramuscular Tissue Using a Portable Ultrasound Unit: An Exploratory Study

Porter KH, Thrasher AB, Taylor JE: Western Carolina University, Cullowhee, NC

Context: Ultrasound is a widely used therapeutic intervention for deep tissue heating and manufacturers have developed portable ultrasound units. As a convenient and inexpensive alternative to traditional ultrasound units, athletic trainers are using these devices; however, the heating rate and effectiveness is unknown. The purpose of this exploratory study is to examine the rate of intramuscular tissue temperature increase using the portable ultrasound unit with the pre-set manufacturer parameters.

Methods: Eleven healthy adults (6 females; 5 males; age 21.5 ± 1.7 , height: 170.6 ± 9.3 cm, weight: 74.5 ± 14.1 kg) with no lower extremity injuries in the past 6 months or ultrasound contraindications participated in this cross-sectional laboratory study. Number of subjects was chosen based

on a preliminary power analysis and using means and standard deviations of previous research. Two intramuscular temperature probes were inserted into the medial calf to measure the rate of temperature change at 1.5 cm (superficial) and 3 cm (deep) below the apex of the right calf. The tip of the 4 cm thermocouple was in the center of the treatment area. Baseline temperatures were recorded for 10 minutes, then an ultrasound treatment using the US Pro 2000 portable ultrasound unit (Roscoe Medical) was applied. Using the pre-set device parameters, the treatment was delivered on the high intensity setting (Continuous duty cycle, 1 MHz frequency, 1.6 W/cm² intensity) for 15 minutes (maximum treatment time on the device), or until the deep temperature reached vigorous heating of 4° Celsius (C). The transducer was moved at a rate of 4 centimeters per second. The amount of time it took to increase intramuscular temperature was recorded at each depth in one-second intervals until the subject reached vigorous heating, or the completion of the 15-minute treatment. Mean and standard deviation for time to increase

temperature and heating rate were calculated for each degree increase.

Results: Mean baseline temperature was $36.17 \pm 0.44^\circ\text{C}$ and $35.85 \pm 1.7^\circ\text{C}$ for deep and superficial respectively. Mean temperature increase was $2.30 \pm 0.93^\circ\text{C}$ and $3.22 \pm 0.81^\circ\text{C}$ for deep and superficial respectively (Table 1). Rate of temperature change was very inconsistent. For deep tissue, subjects increased from 0-1°C at 0.16°C/min and 1-2 degrees at 0.28°C/min. For superficial tissue, subjects increased from 0-1°C at 0.33°C/min, 1-2°C at 0.20°C/min, and 2-3°C at 0.47°C/min. Only one participant reached vigorous heating levels at the deep tissue within the treatment time, thus rate was not calculated for 3-4°C increase.

Conclusions: Based on pre-set parameters at the highest level, the portable ultrasound unit did not produce vigorous intramuscular heating; however, moderate heating did occur. Rate of temperature change is lower than values determined by Draper et al at similar intensities. This portable ultrasound unit did not produce consistent levels of heating. More research is needed to determine if this is an effective modality.

Table 1: Time required to increase tissue temperature by each degree Celsius at superficial and deep levels (in minutes)

Temperature increase	Mean Time to reach each degree at deep level	Mean Time to reach each degree at superficial level
1 degree C	6.15 ± 3.5	2.95 ± 1.87
2 degrees C	9.68 ± 2.27	7.83 ± 2.92
3 degrees C	$11.15 \pm 2.67^*$	9.95 ± 2.72
4 degrees C	$14.72 \pm 0.0^{**}$	$12:18 \pm 1.87^*$

*Based on only three participants

**Based on only one participant

Effects of Ten Sessions of Strengthening Exercise With or Without the Use of Cryo-Electrotherapy on Quadriceps Function in Individuals With Anterior Knee Pain: A Randomized Clinical Trial

Roh Y, Oh M, Lee J, Kim S, Doo H, Song S, Park J: Kyung Hee University, Yongin, Korea

Context: Therapeutic modalities or strengthening exercises are considered as acceptable treatments for functional restoration and pain reduction in patients with anterior knee pain (AKP). It is uncertain if a combination of two interventions (disinhibitory modality followed by exercise) produces a summative effect. Therefore, we observed changes in quadriceps function, pain perception, and functional outcomes after ten-sessions of daily adjustable progressive resistance exercise (DAPRE) technique-based exercise programme with or without the use of pre-exercise modality (a 30-min cryo-electrotherapy).

Methods: Study design: Randomised clinical trial. Setting: Patient clinic. Patients population: Thirty patients with unilateral AKP (age: 21.2 ± 2.8 years, height: 1.72 ± 0.08 m, mass: 71.8 ± 17.8 kg, male: 19, female: 11, time post pain: 45.5 ± 35.3 months). Intervention: Patients were randomly assigned one of two ten-session treatments (either modality + exercise or exercise only). Patients with the combined condition (modality + exercise) received a 30-min cryotherapy and electrotherapy (TENS) simultaneously, prior to exercise. The exercise programme was consisted of jogging, stretching, strengthening (straight leg raise, knee extension, lunge, and squat), and balance training. The intensity of strengthening exercises was determined by the DAPRE technique. Outcome measures: Bilateral quadriceps strength (maximal voluntary isometric contraction: MVIC) and activation (central activation ratio: CAR), pain perception (visual

analogue scale: VAS), and functional outcome measures (lower-extremity functional scale: LEFS) were recorded before and after ten-session treatment. Statistical analyses: Parametric or a non-parametric tests ($p < 0.05$) with calculations of Cohen's d effect size with 95% confidence intervals were performed. **Results:** Regardless of conditions and legs, quadriceps strength (2.7 to 3.0 N·m/kg in MVIC, 10%, $d = 0.40$; $\chi^2 = 7.97$, $df = 7$, $p = 0.34$) and activation (0.823 to 0.865 in CAR, 5%, $d = 0.41$; time effect: $F_{1,84} = 6.61$, $p = 0.01$) were improved. Regardless of conditions, pain perception (63%, $d = 1.14$, time effect: $F_{1,28} = 22.07$, $p = 0.0001$) and functional outcome measures (13%, $d = 0.60$, time effect: $F_{1,28} = 22.35$, $p = 0.0001$) were improved. The absolute change in the average pain perception from pre- to post-treatment was 2.5 cm (73%, $d = 1.69$) for the combined condition and 1.0 cm (46%, $d = 0.67$) for the condition of exercise only (condition \times time: $F_{1,84} = 3.78$, $p = 0.06$). Similarly, functional outcome measures were absolutely changed 10 points (20%, $d = 0.87$) for the condition with the additional modalities and 4 points (8%, $d = 0.36$) for the condition without the modalities (condition \times time: $F_{1,84} = 3.41$, $p = 0.08$). Conclusions: Our data suggest that (1) ten-sessions of the DAPRE technique-based exercise programme improves quadriceps strength and activation, self-reported pain perception and functional outcome measures, and (2) receiving cryo-electrotherapy prior to the exercises at each session may produce greater effects to reduce pain perception and improve functional outcome measures.

Temperature Effects of a Novel Iceless Cryotherapy/Thermotherapy Device in Humans

Merrick MA, Beauregard TA: Ohio State University, Columbus, OH

Context: The Therm-X is a novel, portable, software-controlled multimodality device providing iceless cryotherapy, thermotherapy, compression, contrast, and DVT prophylaxis. Human in vivo temperatures produced by the device have not been previously documented. Our purpose was to document safety and comparability of the device by describing tissue temperatures produced by the Therm-X using clinically relevant protocols in healthy participants. **Methods:** This was a controlled laboratory study in a research laboratory with ambient temperature of $22.9 \pm 0.3^\circ\text{C}$ during testing using a convenience sample of 17 healthy adults (11 men, 6 women, 21.3 ± 1.6 yrs old). Interventions were the Therm-X's pre-programmed protocols for cryotherapy (1.1°C , 45mmHg, 40 min), thermotherapy (43.3°C , 45mmHg, 40min), and contrast therapy (5 cycles of alternating [10°C , 45mmHg, 10 min] then [43.3°C , 45mmHg, 10min]). Main Outcome Measures were distal vastus medialis skin-interface temperature measured using type-t thermocouples (Physitemp PT-6) and 1cm intramuscular temperature measured using type-t thermocouples (Physitemp IT-23) inserted via a catheter, all interfaced to a portable data-logger (Pico Technologies USB TC-08). Thermocouples were 3 point calibrated for accuracy using a NIST traceable partial immersion thermometer in a water bath prior to use. Participant perception of treatment comfort was measured using a 10cm visual analog scale. Descriptive statistics were calculated for temperature and comfort perception and a one-way ANOVA examined between group differences in comfort perception. **Results:**

The cryotherapy protocol produced a mean minimum skin-interface temperature of $14.7 \pm 1.8^\circ\text{C}$ with a lowest observed temperature of 9.2°C and a mean minimum intramuscular temperature of $27.5 \pm 0.4^\circ\text{C}$ with a lowest observed temperature of 26.3°C . The thermotherapy protocol produced a mean maximum skin temperature of $41.5 \pm 0.2^\circ\text{C}$ with a highest observed temperature of 42.0°C and a mean maximum intramuscular temperature of $36.8 \pm 0.5^\circ\text{C}$ with a highest observed temperature of 38.0°C . The contrast therapy protocol produced a mean end-cold skin-interface temperature of $18.0 \pm 2.5^\circ\text{C}$ with a lowest observed temperature of 13.3°C , a mean end-warm skin-interface temperature of $39.2 \pm 1.7^\circ\text{C}$ with a highest observed temperature of 42.0°C , a mean end-cold intramuscular temperature of $32.0 \pm 0.9^\circ\text{C}$ with a lowest observed temperature of 28.7°C , and a mean end-warm intramuscular temperature of $32.6 \pm 0.9^\circ\text{C}$ with a highest observed temperature of 34.7°C . Treatment protocols were perceived as strongly comfortable for both the thermotherapy ($8.4 \pm 0.8\text{cm}$) and contrast therapy (8.2 ± 0.8) treatments and mildly uncomfortable for the cryotherapy treatment ($4.4 \pm 1.1\text{cm}$). Comfort with the cryotherapy treatment was statistically less than either thermotherapy or contrast treatments ($p < 0.001$).

Conclusions: The Therm-X produces skin and intramuscular temperatures during cryotherapy, thermotherapy, and contrast treatments that are within the generally accepted safe range and that are comparable with temperatures reported for other devices, yet does so without the need to add ice. This may be of benefit in situations where access to ice may be limited or inconvenient, particularly during travel.

Synergistic Effects of Ice and TENS on Knee and Hip Neuromechanics During Painful Running

Kwon S, Morrin S, Hopkins JT, Seeley MK, Bruening DA: The University of Utah, Salt Lake City, UT; SUNY Downstate Medical Center, Brooklyn, NY; Brigham Young University, Provo, UT

Context: Knee pain is a common symptom in knee injury and is associated with altered knee and hip muscle activation and hip joint angles. Relieving pain through therapeutic intervention may help to restore pre-injury neuromuscular function. Cryotherapy and transcutaneous electrical nerve stimulation (TENS) are common and useful treatment modalities to relieve acute pain due to soft-tissue injuries. Because both Ice and TENS have shown individual efficacy, many clinicians suggest ice and TENS combination as an effective therapeutic approach for reducing joint pain. However, the effectiveness of this combination treatment on reducing perceived knee pain or improving lower-extremity neural activation during dynamic athletic movements, such as running, has not been evaluated. The purpose of this study was to examine the effects of simultaneous ice/TENS treatments on perceived anterior knee pain (AKP), hip frontal plane angle, and associated muscle activations, during running, in individuals with experimental knee pain (EKP). **Methods:** We used a laboratory-based, pretest, posttest, crossover design. Nineteen participants (11M, $23.2 \pm 1.9\text{y}$, $176 \pm 11.6\text{ cm}$, $71.5 \pm 16.9\text{ kg}$) completed two experimental sessions (sham; Ice/TENS combination). For both sessions, hypertonic saline was infused into the infrapatellar fat pad for 74 minutes (total 11.1 mL). Measurements were recorded during running at four time points (pre-infusion, post-infusion, post-treatment, and post-interval). Perceived AKP on a 100-mm visual analog scale (VAS), knee and hip muscle peak electromyography (EMG) amplitude, and hip adduction

angles were the main outcome measures. A repeated measures mixed model ANOVA was used to compare subject-perceived knee pain across time. Neuromechanical variables were compared using a 2×3 (treatment \times time) mixed model ANCOVA with repeated measures. **Results:** Hypertonic saline infusion increased perceived AKP in all participants. Average peak perceived knee pain was 28 mm on a 100 mm VAS in EKP application. Increased perceived AKP level stayed consistent across time in the sham session. However, the ice/TENS combination treatment significantly reduced perceived (AKP) by 35% at 6 minutes after the treatment start ($p = 0.049$), and the reduced knee pain lasted for 22 minutes ($p > 0.05$). Peak EMG amplitude of the gluteus medius (GM) was decreased by approximately 14% for the sham and treatment sessions ($p = 0.023$ and 0.013 , respectively). The peak EMG amplitude of the GM was not restored to pain-free level during running after the treatment ($p = 0.026$). No other muscles changed their peak EMG activation due to EKP or treatment. Similarly, hip adduction angles during running were not altered by EKP or treatment ($p > 0.3$). **Conclusions:** EKP increased perceived AKP and decreased peak muscle activation of the GM during running, but did not change running biomechanics. Ice/TENS combination treatment reduced perceived AKP quickly, but did not restore neuromechanics during running.

Free Communications, Poster Presentations: Education

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Differences in Spatial Ability and Mental Effort Among Health Professions Students

Richter SD, Welch Bacon CE, Huxel Bliven KC: A.T. Still University, Mesa, AZ

Context: Spatial ability is one's capability to understand and reason through relationships between objects. Athletic trainers inherently use spatial ability when analyzing human movement or viewing medical images, yet assessment of this skill and the acquisition of it is not well understood. Perception of one's spatial ability has been shown to moderately relate to improved performance on spatial ability tasks, which in turn requires less mental effort. The purposes of this study were to determine whether perceived spatial ability group differences and relationships exist between self-perceived spatial ability, objective spatial ability scores, and self-rated mental effort during spatial ability tasks among health professions students. **Methods:** A cross-sectional study design was used at a graduate health sciences university. Invited participants (n=130) were health professions (ie, athletic training, physical therapy, occupational therapy) students. At the beginning of their curriculum, students completed the Spatial Ability Assessment, which included self-perceived spatial ability on a scale of 0-100%, the validated Mental Rotation Test (MRT) scored from 0-24 points (higher scores relate to better spatial ability), and the validated Pass Scale for self-rated mental effort, from 1 (very, very low) to 9 (very, very high). The independent variable was established using median self-perceived spatial ability (64%) to dichotomize groups as "low" (<65%; n=59) or "high" (≥65%; n=58). Dependent variables included MRT score and self-rated mental effort. Descriptive statistics (mean±sd) were used to

report group scores. Mann-Whitney U tests and Spearman's Rank Correlation Coefficients were used to assess group differences and correlations, respectively, between self-perceived spatial ability, MRT score, and mental effort ($P<.05$). **Results:** 117 of 130 students (90% response rate) completed the Spatial Ability Assessment. The "low" self-perceived spatial ability group scored 11.1 ± 3.6 (95%CI: 10.1, 12.0) on the MRT and reported mental effort as 6.1 ± 1.2 (95%CI: 5.8, 6.4). The "high" group had MRT scores of 11.3 ± 3.5 (95%CI: 10.4, 12.2) and reported mental effort at 6.0 ± 1.2 (95%CI: 5.7, 6.3). No significant group differences were found for MRT score ($P=0.80$) or self-reported mental effort ($P=0.66$). No significant correlations were found between self-perceived spatial ability and MRT scores ($P=0.72$), self-perceived spatial ability and self-reported mental effort ($P=0.21$), or MRT scores and self-reported mental effort ($P=0.55$). **Conclusions:** Results suggest health professions students' self-perceived spatial ability is not different nor related to their actual spatial ability or mental effort required during spatial ability tasks. While objective spatial ability scores in this study were similar to previous reports, the lack of group differences and relationships between perceived spatial ability, objective spatial ability, and self-rated mental effort was unexpected. Further research is needed to determine whether these variables change during normal coursework, or if they require targeted interventions within athletic training curricula to ensure competency in spatial ability for one's clinical practice.

Accuracy of Athletic Training Student Performance Factors for Determining BOC Exam First-Time Pass Outcomes

Hobson ZR, Vairo GL:
The Pennsylvania State University, University Park, PA

Context: The primary aim of this investigation was to assess accuracy of athletic training student performance variables for successfully passing the Board of Certification (BOC) exam on a first attempt. Per prior pilot data, we hypothesized that cumulative grade point average (GPA) upon admission to an athletic training program would be the most accurate criterion. A secondary aim consisted of determining the utility of a unique composite score devised to help guide the admissions process.

Methods: Per receiver operating characteristic (ROC) curve analysis, using the following parameters: single test method; significance level (α) of 0.05; power ($1-\beta$) of 80%; area under the ROC curve of 0.700; allocation ratio of 1, a minimum of 24 students was required to examine accuracy of performance factors, and identify corresponding variable threshold values. Cumulative

GPA upon admission, pre-professional phase course combined GPA, averaged admission interview scores, averaged preceptor evaluation of applicant scores, BOC exam outcomes, and cumulative GPA upon graduation data were collected for a cohort of 26 students. Grade point averages were calculated on a four-point scale, interviews were scored out of ten, evaluation scores were out of one-hundred percent. Excluding GPA upon graduation, these factors were weighted, and compiled to produce a novel composite score targeted to reflect the multifaceted nature of a health care curriculum's holistic admissions process. Board of Certification exam outcomes were tallied on a pass or fail basis. Accuracy of factors was determined by the area under the curve (AUC); furthermore, from the ROC curve data, an optimal threshold value for each variable was computed per the index of union method. **Results:** The AUC for factors (Figure 1) were as follows: cumulative GPA upon admission=0.696; pre-professional phase combined course GPA=0.710; averaged interview scores=0.326; averaged preceptor evaluation of applicant scores=0.471; cumulative GPA upon graduation=0.768; composite score=0.688. Thresholds for factors

were as follows: cumulative GPA=3.31 (sensitivity = 0.348 ; 1-specificity = 0.333); pre-professional phase combined course GPA = 3.58 (sensitivity=0.565; 1-specificity = 0.333); averaged interview scores=8.46 (sensitivity = 0.435; 1-specificity = 0.667); averaged preceptor evaluation of applicant scores = 93% (sensitivity = 0.652; 1-specificity = 0.667); cumulative GPA upon graduation = 3.29 (sensitivity = 0.435; 1-specificity = 0.333); composite score = 8.07 (sensitivity = 0.348; 1-specificity = 0.333). **Conclusions:** Cumulative GPA upon graduation was the most accurate indicator of successfully passing the BOC exam on a first attempt, which may be due to content exposure reflected on the exam. Interview, and preceptor evaluation scores were inaccurate factors. Although not the most accurate of all variables, the composite score may represent an all-inclusive indicator of success. A minimum cumulative GPA upon graduation of 3.29, and composite score of 8.07 are better suited to identify students poised for success. The results of this study may be used by educators to shape their related programmatic operations. Further investigation should focus on identifying the best student performance factors indicative of successful BOC exam outcomes.

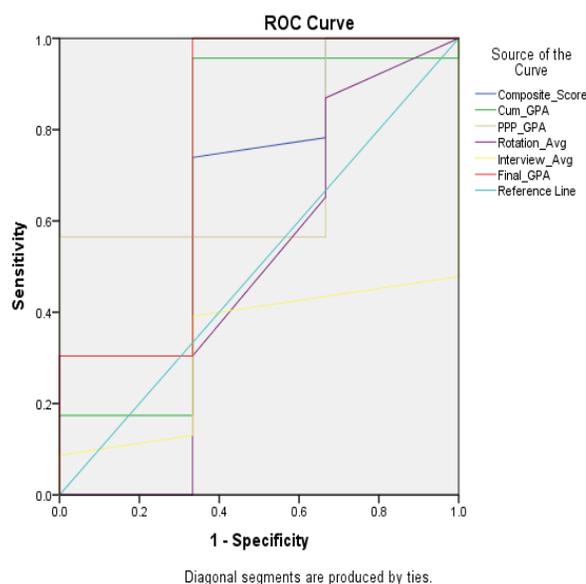


Figure 1. Receiver operating characteristic (ROC) curves for student performance factors indicative of Board of Certification exam success.

Athletic Trainers' Selection Behaviors Related to Multi-Session Continuing Education Conferences

Babiarz AM, Edler JR, Eberman LE: Indiana State University, Terre Haute, IN; Grand View University, Des Moines, IA

Context: Continuing education in athletic training is commonly achieved en masse at conferences and symposia. It is well known that athletic trainers (AT) have many barriers to continuing education, but it is relatively unknown what the planning practices of ATs are when attending these symposia and conferences. The purpose of this study is to explore ATs planning practices at multi-session conferences regarding format types, preferred domains, and the ideal number of concurrent sessions.

Methods: We used a cross-sectional, web-based survey with both quantitative (4 items) and qualitative questions (5 items) regarding the planning practices of ATs at multi-session conferences. We established content and face validity and piloted the tool prior to use. We distributed the survey via email once per week for 6 weeks to a random sample of 8660 ATs. 908 ATs responded to the survey (response rate=10.5%) with 767 ATs previously attending multi-session conferences and included in the analysis. Partial data for all questions were coded and analyzed for frequencies.

Trustworthiness of the coded data was established with multiple-analyst triangulation and external auditing. **Results:** The sample of ATs (age=38±11y; females=367, males=249, missing/prefer not to answer=151; 15±11 years of clinical experience) reported choosing to attend clinical workshops (78%, n=598/767), large group lectures (75.9%, n=582/767), and small group lectures (63.5%, n=487/767) the most as a preferred session formats for CE content. ATs were mostly motivated to select their preferred session formats by their personal learning preferences (38.4%, n=239/623) and interest in the topic or content (37.4%, n=233/623).

Examination, assessment, and diagnosis was the most preferred domain to learn about (80.7%, n=619/767), whereas ATs did not prefer to learn about the healthcare administration and professional responsibility domain (41.9%, n=321/767). The practical application of CE content was the main influencer (53.4%, n=337/631) to attend the session in the ATs preferred domain. ATs felt that 3.40±1.65 was the ideal number of concurrent sessions, which provided them a wide variety to select from (54.6%, n=367/672). 49.7% (n=381/671) of respondents stated that their CE selection behaviors changed dependent on the number of concurrent sessions available. When a scheduling conflict occurred, ATs prioritized their session selection based on interest in the topic or content (31.4%, n=211/671).

Conclusions: Continuing education for ATs at multi-session conferences is vital for the advancement of the profession. Reducing feelings of indecision and ensuring applicable sessions for ATs is important. The planning of multi-session conferences should include concurrent sessions that align with the preferences of the audience including the domains of practice, learning styles, and session formats. However, the professional needs of an AT should not be solely driven by self-perception of the most interesting topic, yet should be influenced by objective measures related to competency.

Cultural Competence of Athletic Training Educators

Grove D, Mansell JL: Temple University, Philadelphia, PA

Context: Professional and governmental agencies support practicing culturally competent care; however, research reveals certified athletic trainers and athletic training students are not culturally competent and do not perform culturally competent behaviors. The objective of the study was to examine athletic training educators' (ATEs) cultural competence (CC) and preparedness to teach CC concepts. **Methods:**

A cross-sectional, web-based survey was used. Target participants were current professional ATEs recruited using convenience and snowball sampling of the CAATE-accredited program director directory. Researchers created a survey to collect demographic information, measure educator's CC, and determine their preparedness to teach CC concepts. The Cultural Competence Assessment (CCA, Doorenbos et al., 2005) was included in the survey and used to assess CC ($r = 0.85$, $\alpha = 0.89$). The CCA has three parts: cultural diversity experience (not scored), cultural awareness and sensitivity (CAS), and cultural competence behaviors (CCB). Preparedness and effectiveness questions were created by the author and content validity was established through pilot subjects. The survey was sent via email using Qualtrics; participation was anonymous. Data were analyzed using SPSS, specifically descriptive statistics as well as a paired-samples t-test. CC of ATEs was the main outcome of the study and measured using the CAS and CCB subscales. The CAS and CCB use Likert scales with values ranging 1 (less CC) to 7 (more CC). Averages for each subscale were calculated to obtain separate CAS and CCB scores. Overall CC scores were calculated by averaging the CAS and CCB scores. Due to sampling procedures, response rate could not be calculated. **Results:** Participants were largely female (n=43/64, 67.2%) and overwhelmingly White (n=63/64,

98.4%) and not Latinx (n=59/64, 92.2%) with an average of 10.88 + 7.07 years of teaching experience. The mean overall cultural competence score was 5.33 ± 0.69, and average CAS and CCB scores were 6.10 ± 0.60 and 4.61 ± 1.03, respectively. Participants scored significantly lower on the CCB subscale than the CAS subscale (t(63) = 11.83, p < .001). Though 78.1% (n=50/64) of participants did not receive cultural competence education during professional training and have not received CC training specific to AT (n=35/64, 54.7%), majority of participants (n=35/64, 54.7%) reported feeling prepared to teach their students about cultural competence concepts and care. **Conclusions:** Athletic training educators exhibit similar cultural competence patterns to athletic training students and certified professionals—higher CAS and lower CCB scores, indicating a greater awareness and sensitivity—or knowledge base—but inability to transfer that knowledge into CCB. More exploration into ATEs cultural competence education and preparation is needed since most report having little training but being prepared to educate students. Further, research investigating barriers to persons of color from entering faculty or teaching positions is warranted due to misrepresentation of educators from diverse backgrounds.

The Prevalence of Vocal Cord Dysfunction Education in Athletic Training Curriculum

Rippon L, Hunt B, John A, Mineo C: Seton Hall University, Nutley, NJ

Context: Athletic trainers have limited knowledge of vocal cord dysfunction exercise-induced laryngeal obstruction (VCD-EILO). Since pediatric athletic populations are at a higher risk of suffering a VCD-EILO attack, athletic trainers have a higher probability of treating patients with VCD-EILO. Patients suffering from VCD-EILO often endure lengthy diagnosis times and are commonly misdiagnosed as having exercise-induced asthma. Interprofessional collaboration, which often includes a Speech Language Pathologist (SLP) can often reduce diagnosis times and costs associated with misdiagnosis. The purpose of this study is to explore the extent to which information of VCD-EILO is taught in athletic training curriculums. **Methods:** An observational study was conducted to explore the prevalence of VCD-EILO education within athletic training curriculums. Programs were selected from the CAATE program directory if they were active/in good standing. A total of 287 CAATE accredited athletic training education programs met inclusion criteria. Program directors email addresses were obtained from the CAATE website. Subjects were sent a brief 10-minute online survey assessing the inclusion of VCD-EILO within their curriculum, mode of education, the courses used for instruction and extent of interprofessional collaboration for instruction. Survey instrument was face and content validated by content experts. Descriptive statistics, frequency data, chi-square and P value < .05 were performed. **Results:** Response rate for the survey was 22.6% (N=65) program directors from all 10 NATA districts. Average age of respondents was 46 (SD=8.5) and average years at their current position was 10 (SD=8.2). Programs were categorized according to the highest professional degree offered.

A bachelors was the highest degree offered in 61% (n=40), 31% (n=20) a professional masters, and 8% (n=5) a post professional masters or higher. VCD-EILO is taught in 47.7% (n=31) of athletic training educational programs. Educational instruction included: signs and symptoms (96.7%; n=30/31), diagnosis (93.5%; n=29/31), and treatment (80.6%; n=25/31). Education on VCD-EILO is most commonly taught in general medicine courses (93.5%; n=29/31). The most common modes of education are lecture (100%; n=31/31) and case scenarios/presentations (52%;n=16/31). Within athletic training curriculums, the most common educators of VCD-EILO include athletic trainers (93.5%; n=29/31), followed by SLPs (22.5%; n=7/31) and General Practitioners (22.5%; n=7/31). There was no statistically significant relationship between professional program type and inclusion of VCD-EILO in athletic training curriculums X² (4, N=65) =3.48, p=0.48. **Conclusions:** The results of this study demonstrate VCD-EILO education and interprofessional collaboration are limited in athletic training curriculums. Athletic training curriculums should include education on VCD-EILO to improve athletic trainers' awareness and knowledge. Athletic trainers should be educated on the evaluation and treatment that SLPs can provide for these patients. Increasing the extent of interprofessional collaboration may lead to increased awareness of VCD-EILO among athletic trainers and contribute to improved patient care.

Debrief Improves Athletic Training Students' Confidence After Multi-Station Objective Structured Clinical Examination

Frye JL, Armstrong KJ, Walker SE: James Madison University, Harrisonburg, VA; Ball State University, Muncie, IN

Context: Objective structured clinical examinations (OSCEs) provide a mechanism to assess multiple learning objectives while simultaneously assessing students' ability to communicate, make decisions, and problem solve during patient encounters. Debriefing after an OSCE includes a planned discussion to provide opportunities for students to self-reflect on their actions, thought processes, and emotions to improve patient outcomes. The purpose of this investigation was to determine the impact of debriefing sessions following two OSCEs on athletic training students' confidence. **Methods:** Self-reported confidence was assessed using a pre-test, post-test survey design. First-year athletic training students participated (n=18, 10 females, 8 males, 20.4 ± 0.71 years old). Participants completed two OSCEs in an athletic training teaching laboratory totaling 6 different

cervical spine SP encounters (OSCE 1 = 3 spine boarding encounters including one equipment laden, OSCE 2 = 1 spine evaluation; 2 equipment removal encounters). Debriefing sessions were held after both OSCEs during the next class session. Standardized open-ended questions were used to facilitate student reflection. Confidence ratings (eg, history taking ability, dealing with difficult patients) were assessed at three points (prior to and immediately following the first OSCE and following debrief of the second OSCE) using a 17-item Likert scale (1 = strongly disagree, 5= strongly agree). Cronbach α determined internal consistency of survey items at 0.971. The debriefing sessions were audio recorded and transcribed. Descriptive statistics were computed for all survey items and Wilcoxon signed-rank tests determined differences in pre-encounter and post-encounter confidence ratings (see Table 1). Qualitative data were analyzed using an interpretative coding method, categorizing individual comments into representative themes. **Results:** Participants reported that both OSCEs improved their confidence on all survey items. Of importance, respondents reported increased confidence when formulating a treatment

plan (3.72 ± 0.46 to 4.22 ± 0.43) and using appropriate verbal communication (4.0 ± 0.69 to 4.44 ± 0.51). Participants reported a significant increase between mean pre-OSCE to mean post-debrief confidence ratings (Z = -3.366, P = .001). Four themes emerged from the debriefing sessions: improved confidence (eg, formulating differential diagnoses, evaluating the patient holistically), improved communication skills (eg, providing patient education, collaborative care), improved clinical decision-making (eg, adapting to patient and situation), and self-reflection (eg, awareness of limitations, areas of improvement). **Conclusions:** The OSCEs provided a real-time patient encounter similar to patient care. Students' confidence improved in all areas related to obtaining a patient history, completing a physical examination, and interpersonal communication as a result of the OSCEs. Debriefing facilitated the student's ability to self-reflect on their actions and clinical decisions during the OSCE. This reflection is important to identify performance gaps, which informs decisions made during future patient encounters. By providing these OSCEs, students become more confident in their athletic training abilities.

Table 1. AT Students Perceived Confidence Per Objective Structured Clinical Examination

Confidence Rating Item (n = 18)	Pre-OSCE <i>M</i> ± <i>SD</i> *	Post-OSCE <i>M</i> ± <i>SD</i> *	Post-Debrief <i>M</i> ± <i>SD</i> *	Z
Identify questions	4.00 ± 0.343	4.27 ± 0.461	4.56 ± 0.511	-2.887†
Generate follow-up questions	4.00 ± 0.594	4.11 ± 0.583	4.44 ± 0.511	-2.138†
Obtained adequate history	3.77 ± 0.646	3.67 ± 0.840	4.22 ± 0.584	-2.828†
Selecting appropriate palpations	3.77 ± 0.646	4.11 ± 0.583	4.33 ± 0.485	-2.486†
Selecting special tests	3.72 ± 0.669	3.83 ± 0.786	4.28 ± 0.575	-2.308†
Interpreting special tests	3.67 ± 0.840	3.78 ± 0.732	4.05 ± 0.539	-1.611
Formulating differentials	3.44 ± 0.511	3.89 ± 0.676	4.05 ± 0.539	-2.804†
Formulating treatment plan	3.72 ± 0.461	4.00 ± 0.594	4.22 ± 0.428	-3.000†
Providing patient education	3.61 ± 0.850	3.94 ± 0.639	4.17 ± 0.514	-2.486†
Dealing with difficult patients	3.76 ± 0.831	4.05 ± 0.539	3.94 ± 0.802	-1.027
Evaluating diverse populations	4.27 ± 0.575	4.22 ± 0.548	4.44 ± 0.511	-1.000
Using verbal communication	4.00 ± 0.686	4.17 ± 0.383	4.44 ± 0.511	-2.126†
Using non-verbal communication	4.06 ± 0.556	4.11 ± 0.583	4.50 ± 0.514	-2.310†
Using professional language	4.27 ± 0.461	4.33 ± 0.485	4.56 ± 0.616	-1.667
Evaluating patients holistically	3.66 ± 0.767	3.83 ± 0.618	4.11 ± 0.538	-1.999†
Knowing limitations	4.00 ± 0.485	4.22 ± 0.647	4.39 ± 0.502	-2.333†
Abilities as an athletic trainer	3.89 ± 0.583	3.94 ± 0.539	4.11 ± 0.323	-1.414
Mean	3.86 ± 0.370	4.03 ± 0.396	4.28 ± 0.333	-3.3366

*1 = Strongly Disagree; 5 = Strongly Agree

†Wilcoxon Signed Rank Pre-OSCE x Post-Debrief, p < .05

Free Communications, Poster Presentations: Education and Research

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Examining Historical Research Trends Within the *Journal of Athletic Training* Using Text Mining

Farnsworth JL, Kuo M, Kang M:
Texas State University, San Marcos, TX; The University of Mississippi, University, MS

Context: Seven years after the formation of the National Athletic Trainers' Association, the first issue of the *Journal of Athletic Training (JAT)* was published in September of 1956. The goal was to create a platform for the dissemination of information and sharing of ideas and techniques among professionals. Examination of trends in published research can help to demonstrate the success and growth of a profession. To date, no studies have examined research trends within the *JAT*. Therefore, the purpose of this project was to explore research trends in the *JAT* by analyzing the titles of research using text mining techniques. **Methods:** The titles of 2,776 articles published between 1956 and June 2018 were obtained from the *JAT* archives. Data analysis was conducted using KH Coder, a quantitative content analysis software. Trends were evaluated based on three methods: 1) frequency analysis of words appearing each decade; 2) chi-square goodness of fit test on research by each of five domains of clinical practice (injury prevention & wellness promotion; examination, assessment, & diagnosis; immediate & emergency care; therapeutic intervention; and healthcare administration & professional responsibility); and 3) visual inspection of graphs to identify trends in research within each domain. **Results:** A total of 3,813 unique words were identified. Examination of words specific to body-region indicated that ankle appeared most frequently (n=253) followed by knee (n=162), shoulder (n=90), and hip (n=48). Chi-square goodness of fit tests indicated

that the proportion of words identified over each decade were not significantly different for the domains: injury prevention & wellness promotion ($X^2_6 = 6.58$; $p = .36$) and immediate & emergency care ($X^2_6 = 8.52$; $p = .15$); however, differences were observed for examination, assessment & diagnosis ($X^2_6 = 44.21$; $p < .01$); therapeutic intervention ($X^2_6 = 21.20$; $p < .01$); and health care administration & professional responsibility ($X^2_6 = 23.39$; $p < .01$) domains. Additionally, the number of publications increased significantly each decade ($X^2_6 = 1,465.74$; $p < .01$). Excluding incomplete decades, the largest increase in publications occurred during the 1980s with a 79% increase in publications from the previous decade (186 to 333). Visual analysis of trends indicated a significant increase in relative percentage of publications related to examination, assessment & diagnosis; therapeutic interventions; and health care administration & professional responsibility. **Conclusions:** The increasing number of publications each decade suggests significant growth and expands on ideas, techniques, and information within the profession. Trend analysis indicates that the proportion of publications related to injury prevention & wellness promotion and immediate & emergency care have remained relatively consistent; while the publication rates for studies related to examination, assessment & diagnosis; therapeutic interventions; and healthcare administration & professional responsibility have increased considerably over the decades.

Differences Among Post-Professional Athletic Training Students' Knowledge and Confidence of Evidence-Based Practice

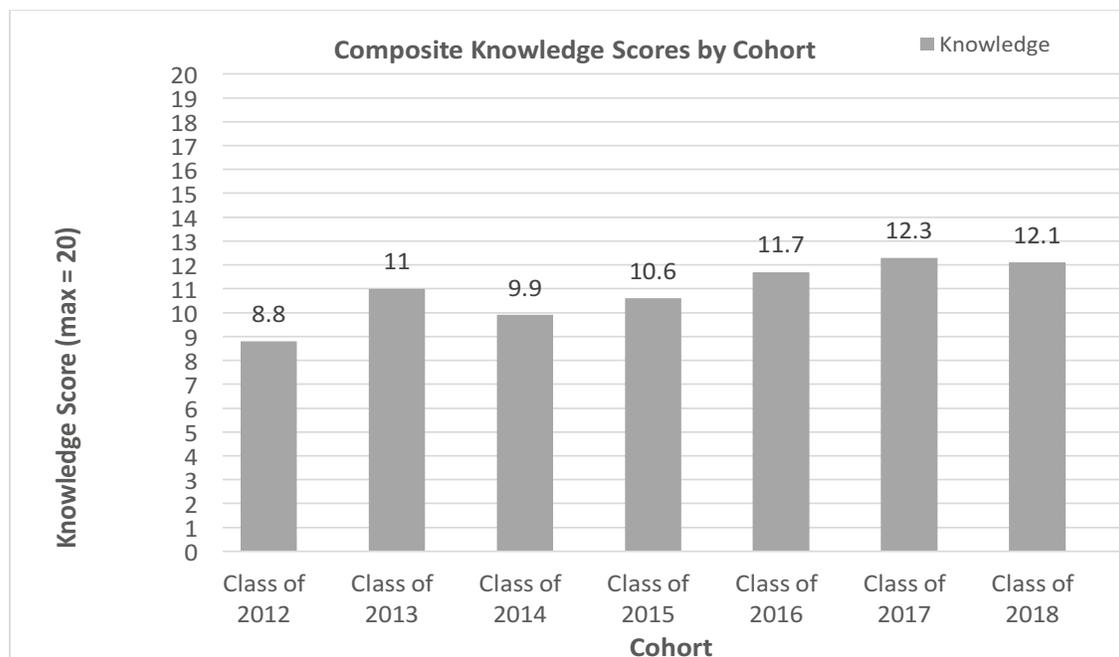
Reimann RM, Abner TN, Valovich McLeod TC, Welch Bacon CE: A.T. Still University, Mesa, AZ

Context: Previously, evidence-based practice (EBP) had not been an integral part of professional level athletic training programs. Due to the more recent addition of EBP and the core competencies in the athletic training profession, not all athletic trainers may have a good understanding of EBP and many may lack the knowledge and confidence to implement EBP. The purpose of this study was to compare differences of post-professional athletic training students' knowledge and confidence of EBP from cohorts that matriculated between 2012-2018. **Methods:** Upon matriculation in a CAATE-accredited post-professional athletic training program, 71 students voluntarily completed an online EBP survey (19 males, 52 females, age=22.9±1.5). With permission, the survey consisted of multiple sections from previously validated

surveys relating to different topics within EBP, including accessibility to resources, knowledge, confidence, and attitudes and beliefs. For the purpose of this study, we analyzed 20 multiple-choice knowledge questions regarding EBP and 20 4-point Likert-scale items assessing participants' confidence in knowledge of the multiple-choice questions. Each correct answer was awarded 1 point. The Likert-scale items ranged from 1 (not confident at all) to 4 (extremely confident). The Likert-scale items regarding confidence were summed and divided by 4 to obtain an average score. The closer a score was to 4, the more confident a participant was in their knowledge of EBP. Descriptive statistics (mean±SD) were computed and Kruskal Wallis H and Mann Whitney U tests were used to assess group differences ($P < .05$). **Results:** The overall composite knowledge score among all participants was 54.5% (10.9/20±2.5) and participants reported they were minimally confident in their knowledge (2.4/4.0±0.4). Composite knowledge scores by cohort are displayed in Figure 1. Composite knowledge scores differed among classes ($P = .013$), although confidence scores did not ($P = .45$). Class2012 scored significantly lower on the knowledge assessment

than Class2016 ($P = .007$), Class2017 ($P = .003$), and Class2018 ($P = .002$). Class2014 also scored significantly lower on the knowledge assessment than Class2016 ($P = .037$), Class2017 ($P = .016$), and Class2018 ($P = .019$). No other significant differences were found between cohorts. **Conclusions:** These findings suggest participants' knowledge regarding the concepts of EBP can be improved. With an average score of slightly over 50%, it is unsurprising participants were only minimally confident in their knowledge. However, the most recent three years of cohorts had significantly greater knowledge scores than prior cohorts, perhaps suggesting a shift to a greater emphasis on EBP concepts in professional programs. The additional emphasis on EBP in the CAATE 2020 Standards for Accreditation of Professional Athletic Training Programs should help to improve knowledge and confidence among students. Professional, post-professional degree and post-professional residency programs should continue to reinforce EBP concepts in both didactic and clinical education to further improve knowledge and build confidence in athletic trainers regarding EBP concepts that can improve patient care.

Figure 1. Composite Knowledge Scores by Cohort



A Comparison of Post-Professional Athletic Training Students' Accessibility to Resources and Perceived Challenges of Implementing Concepts of Evidence-Based Practice in Clinical Practice

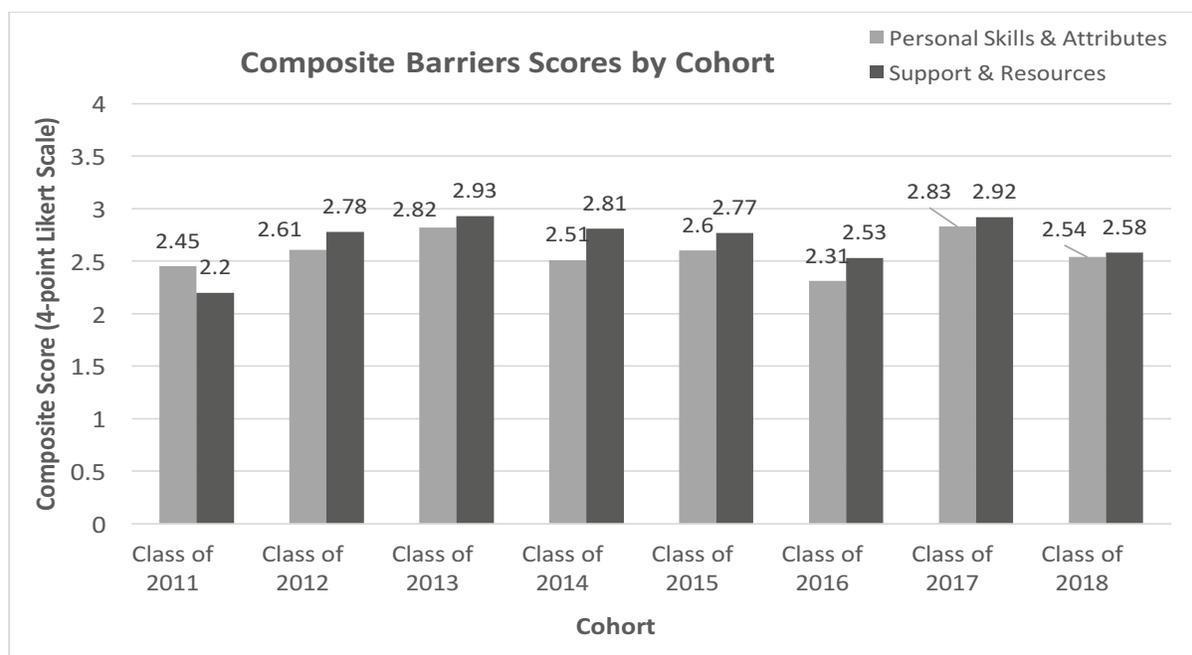
Iaiennaro B, Abner TN, Reimann RM, Valovich McLeod TC, Welch Bacon CE: A.T. Still University, Mesa, AZ

Context: Two key uncertainties in terms of evidence-based practice (EBP) are access to resources and barriers to implementation of EBP. With the integration of EBP into professional and post-professional education over the past several years, access to resources should ideally increase whereas perceived barriers should decrease. The purpose of this study was to compare differences regarding perceptions of access to EBP resources and perceived barriers among post professional athletic training students that matriculated between 2011-2018. **Methods:** Upon matriculation into a CAATE-accredited post-professional athletic training program, 89 students (age=23±1.7yrs) voluntarily completed an online survey. With permission, the survey

consisted of several sections from previously validated EBP surveys. The accessibility section included questions focused on participants' access to 10 commonly used resources for seeking evidence, and how often they accessed those resources. The survey also consisted of 16 4-point Likert-scale items to assess participants' perceptions of potential barriers in relation to EBP. The barriers items were further subdivided into two categories: personal skills and attributes and supports and accessibility of resources. Composite scores for each barriers subcategory were summed and then averaged back to the Likert scale (total divided by 4). The independent variable was cohort (class2011, class2012, class2013, class2014, class2015, class2016, class2017, class2018) while the dependent variables were participants' responses to the survey items. Descriptive statistics (means±SD, frequencies) were calculated and significant differences ($P<.05$) were assessed using Kruskal Wallis H and Mann Whitney U tests. **Results:** Overall, participants wavered between disagree and agree regarding personal skills and attributes (2.5/4.0±0.49) as well as support and accessibility to resources (2.6/4.0±0.49) as barriers to EBP implementation. While differences were found among cohorts for support and accessibility to resources barriers

($P=.003$), no significant differences were found regarding personal skills and attributes barriers ($P=.20$). While class2011 disagreed that support and accessibility to resource barriers existed, class2012 ($P=.001$), class2013 ($P=.002$), class2014 ($P=.007$), class2015 ($P=.004$), class2017 ($P<.001$), and class2018 ($P=.043$) disagreed to agreed that there were support and accessibility to resources barriers. Composite barriers scores by cohort are displayed in Figure 1. With respect to accessibility to resources, 44% of participants ($n=39/89$) reported they were unfamiliar with clinical prediction rules and 48% ($n=48/89$) were unfamiliar with the Cochrane database. **Conclusions:** Our findings produced mixed results regarding access to resources and perceived barriers. Most post-professional athletic training students in this study still perceive support and accessibility to resources as barriers toward implementing EBP in clinical practice. However, it is uncertain whether participants' perceived accessibility of resources as a barrier is due to true lack of access or unfamiliarity with the resources available. Further education is needed to help athletic trainers identify available resources to seek evidence that is easily translatable to inform clinical decisions during patient care.

Figure 1. Composite Barriers Scores by Cohort



Post-Professional Athletic Training Students' Attitudes and Beliefs Regarding Evidence-Based Practice

Abner TN, Reimann RM, Valovich McLeod TC, Welch Bacon CE: A.T. Still University, Mesa, AZ

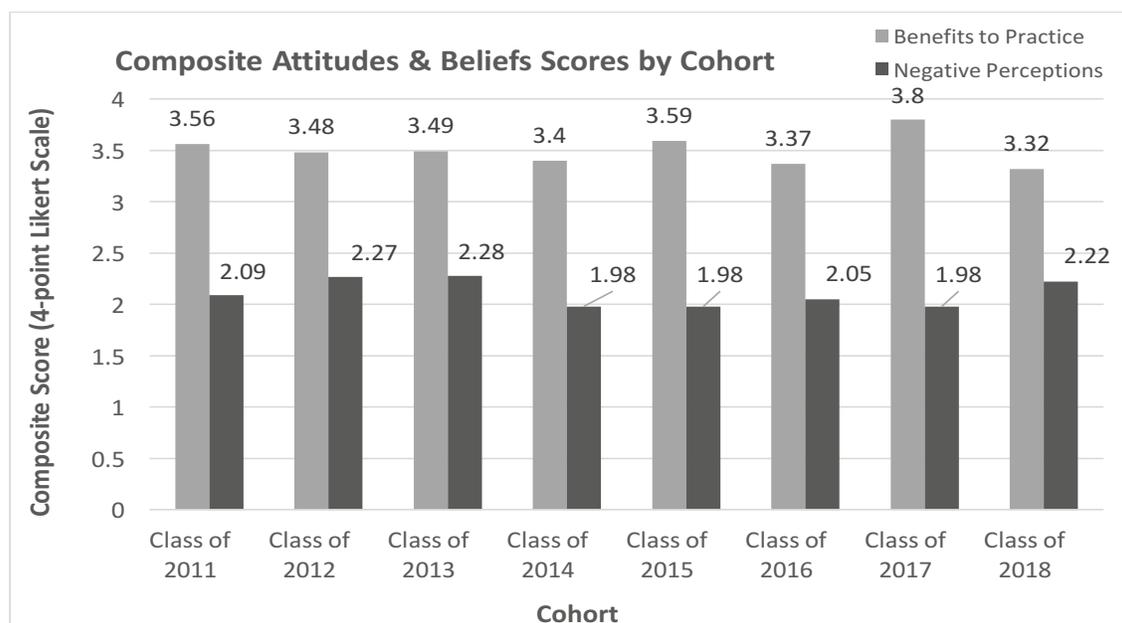
Context: Since 2011, concepts related to evidence-based practice (EBP) have been integrated into the athletic training profession, with the inclusion of an EBP category for maintenance of certification and within professional and post-professional educational programs. However, there has been mixed findings regarding knowledge, attitudes and beliefs, and use of EBP concepts in clinical practice. While EBP has been heavily emphasized throughout the profession, it is unclear whether attitudes and beliefs towards EBP have altered over time. The purpose of this study was to compare differences regarding attitudes and beliefs of EBP among post-professional athletic training students (PPATS) between 2011-2018. **Methods:** Eighty-nine PPATS (age=23±1.7yrs; 27 males, 62 females) voluntarily completed an online survey upon matriculation into one CAATE-accredited post-professional

athletic training program between 2011-2018. With permission, the survey included 5 sections from previously validated surveys, including importance, knowledge and confidence, attitudes and beliefs, challenges, and accessibility. The attitudes and beliefs section included 15 4-point Likert scale items to assess participants' perceptions of EBP regarding benefits to practice as well as negative perceptions. Composite attitudes and beliefs scores were summed and then averaged back to the Likert scale (total divided by 4). The independent variable in this study was cohort (class2011, class2012, class2013, class2014, class2015, class2016, class2017, class2018). The dependent variables were participants' responses to the survey items. Descriptive statistics (mean±SD, frequencies) were calculated and significant group differences ($P < .05$) were calculated using Kruskal-Wallis H and Mann-Whitney U tests.

Results: Composite attitudes and beliefs scores by cohort are displayed in Figure 1. Overall, participants agreed that EBP had numerous benefits to clinical practice (3.5/4.0±0.34), and agreed (3.4/4.0±0.56) that they need to increase the use of evidence in their daily practice. However,

participants disagreed that there were negative perceptions associated with EBP (2.1/4.0±0.39). Benefits to practice scores differed among cohorts ($P=.036$); while class2011 ($P=.035$), class2013 ($P=.015$), class2014 ($P=.004$), class2016 ($P=.032$), and class2018 ($P=.001$) agreed EBP had benefits to clinical practice, class2017 strongly agreed. No significant differences were found regarding negative perceptions ($P=.39$). **Conclusions:** These findings suggest that PPATS believe EBP has benefits to practice and their negative perceptions of EBP were minimal. Interestingly there was no trend over time that would be indicative of more recent cohorts having better attitudes or beliefs regarding EBP. Concerted effort to shift from a "cookie cutter" approach to more individual data-driven, clinically relevant research treatments is needed. This shift in thinking will have a dramatic impact on future care given to patients. With the emphasis on data-driven care being exhibited in clinical practice this allows our profession to grow. This provides a more valuable opportunity of mentor support available for upcoming athletic students allowing the athletic training profession to reach its full potential.

Figure 1. Composite Attitudes and Beliefs Scores by Cohort



The Role of Curricular Content and Influential Factors on the Interest of Professional Post-Baccalaureate Athletic Training Students' in a Doctor of Athletic Training Degree

Hoffman E, Paladin S, Medina R, Clines S, Welch Bacon CE, Eberman LE, Cavallario J, Van Lunen BL: Old Dominion University, Norfolk, VA; Sacred Heart University, Fairfield, CT; A.T. Still University, Mesa, AZ; Indiana State University, Terre Haute, IN

Context: As post-baccalaureate athletic training students complete their degrees, they will have the opportunity to examine additional pathways within post-professional education. The doctor of athletic training (DAT) degree is one of several educational options, yet we know very little about content areas individuals may be interested in and what factors may be influential in the decision to attend such programs. Therefore, we examined interest in didactic content areas and influential factors for entering a DAT degree program of currently enrolled post-baccalaureate athletic training students. **Methods:** Students from 15 of 51 programs that met the inclusion criteria (no additional IRB, in good standing with the accreditation agency, had student enrollment) participated in this cross-sectional study. 287 of 335 eligible students (91 males, 193 females) participated (85.7% completion rate). Participants completed a paper survey consisting of demographics and 6 themes which included accrual of academic debt, professional goals, curricular content, interest, and post-graduate employment opportunities, and benefits to the profession. Questions were asked in select one, open-ended, and 4-point Likert scale formats with responses associated with importance, interest, agreement, and likelihood. Prior to distribution, the survey was assessed for face and content validity by a panel of experts. The main outcome measures for this part of the larger scale survey were curricular

content areas of interest and influencing factors (18 items) for completing a DAT degree. Descriptive statistics (percentages, frequencies) were calculated to describe overall characteristics related to interest and influential factors.

Results: Participants reported moderate to extreme interest in DAT degree content areas of advanced rehabilitation skills (85.4%, n=244), orthopaedics (84%, n=240), urgent and emergent care (82.9%, n=237), performance enhancement (76.6%, n=219), prevention and wellness (75.5%, n=216), behavioral/mental health (67.2%, n=192), primary care (65.7%, n=188), leadership (61.5%, n=173), education (49.3%, n=141), pediatrics (48.8%, n=111), business (35%, n=100), and research techniques (20.3%, n=58). The top three factors listed as a lead factor to influence the desire to attend a DAT program were the additional cost of completing the DAT degree (22%, n=63), debt accumulated upon completion of the post-baccalaureate degree (14.3%, n=41), and the ability to maintain employment while completing the DAT degree (14.3%, n=41). Participants reported factors which were moderately to extremely important in the decision to pursue the DAT degree and all 18 influential factors assessed were reported as moderately/extremely important (60.5-95.8%). **Conclusions:** Athletic training students enrolled in a post-baccalaureate program are interested in a variety of curricular content areas if they pursued a DAT degree. Although several influential factors are important when considering entering a DAT, it appears that factors related to debt accumulation remain at the forefront. Further research should investigate current curricular focus areas within DAT programs and the associated debt accumulation related to attending these programs.

Free Communications, Poster Presentations: Epidemiology and Injury Risk

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Gender-Specific Differences in Upper Quarter Closed Kinetic Chain Performance After Return to Play in Overhead Athletes

Kim Y, Rosen AB: Utah State University, Logan, UT; University of Nebraska at Omaha, Omaha, NE

Context: The shoulder joint is a complex mechanical system, and proper joint stability is important for efficient overhead sports performance. Previous research has found a relationship with upper quarter dynamic balance and several shoulder injuries. However, proper dynamic assessment and multi-planar movement measures have yet to be assessed in overhead athletes after return to play and little is known about the influence of gender in these populations. Therefore, the purpose of this study was to evaluate the effects of a previous shoulder injury on upper quarter closed kinetic chain performance in male and female collegiate overhead athletes.

Methods: This case control study was conducted in an athletic training clinic. Thirty-five male (age: 20.3 ± 1.2 years, mass: 84.0 ± 9.2 kg, height: 183.6 ± 6.3 , upper limb length: 93.8 ± 3.3 cm) and 25 female (age: 19.6 ± 0.8 years, mass: 70.8 ± 10.9 kg, height: 176.0 ± 10.0 , upper limb length: 88.9 ± 5.0 cm) overhead athletes in NCAA Division I baseball, softball, volleyball, or tennis were recruited and assigned to either the injury history group or the healthy group. All subjects were fully participating in athletics without any injuries or neuromuscular dysfunctions. The subjects in the injury history group had a previous medical history of shoulder injury. The upper quarter closed kinetic chain performance was evaluated via Upper Quarter-Y Balance Test (UQYBT) for the dominant limb in three directions: medial, superolateral, and inferolateral. The furthest distance (cm) in each direction was recorded and normalized by upper limb length.

A two (group) by two (gender) ANOVA was used to evaluate the long-term effects of shoulder injuries on UQYBT scores in each gender. Cohen's d effect sizes were calculated to evaluate the magnitude of differences. **Results:** In females, the mean score in the superolateral direction was lower in the injury history group versus healthy group (55.1 ± 14.4 cm vs. 66.9 ± 5.4 cm, $p = .02$, $d = 0.95$), whereas no group differences were identified in males ($p > .05$). Male overhead athletes showed greater mean scores in the medial direction compared to female overhead athletes (118.6 ± 6.0 cm vs. 113.5 ± 5.8 cm, $p = .01$, $d = 0.80$). **Conclusions:** Female overhead athletes with a history of shoulder injury had worse upper quarter closed kinetic chain performance in the superolateral direction versus those without an injury history after return to play. However, in females the stability in the medial and inferolateral directions as well as all three directions in males demonstrated comparable levels, despite a history of shoulder injuries. Therefore, the results of the study suggest that shoulder injuries may have longer-term negative effects on upper quarter dynamic stability in female overhead athletes compared to male athletes. Proper gender-specific management plans may be useful for preventing second shoulder injuries and improving overhead performance after return to play.

Functional Movement Pattern Proficiency Is Similar Across Stroke Type Dominance in Collegiate Swimmers

Pokryfke J, Leon A, Mokha M:
Nova Southeastern University,
Davie, FL

Context: The freestyle, breaststroke, backstroke and butterfly strokes are different biomechanically and necessitate stroke specific strength and conditioning programs for injury prevention and performance enhancement. Differences may also exist in functional movement pattern proficiency between swimmers of different strokes. The Functional Movement Screen (FMS) identifies dysfunctional movement patterns and consists of seven tests (deep squat,

hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability). Results may guide stroke specific corrective exercise programs that could be implemented into team-based strength and conditioning sessions. Therefore, the aim of this study was to examine differences in functional movement pattern performance between stroke dominance in NCAA Division II swimmers. **Methods:** Fifty-seven asymptomatic (31 females, 26 males) NCAA Division II swimmers (age, 19.7 ± 1.4 yrs; height, 174.8 ± 8.5 cm; mass 72.4 ± 10.2 kg) categorized as freestyle (n=21), breaststroke (n=14), backstroke (n=12), butterfly (n=5) or individual medley (n=5) underwent the FMS during their pre-participation examination by FMS-certified staff. Individual tests and

composite FMS scores were compared across five stroke groups using Kruskal-Wallis H Test, p<0.05. **Results:** Table 1 depicts mean (+SD) scores for all of the FMS tests across five strokes. There were no significant differences between stroke groups in the deep squat ($\chi^2=4.17$, p=0.38, df=4), hurdle step ($\chi^2=9.03$, p=0.06, df=4), inline lunge ($\chi^2=7.86$, p=0.10, df=4), shoulder mobility ($\chi^2=5.03$, p=0.28, df=4), active straight leg raise ($\chi^2=1.03$, p=0.91, df=4), trunk stability push-up ($\chi^2=5.17$, p=0.27, df=4), and rotary stability ($\chi^2=7.06$, p=0.13, df=4). **Conclusions:** Functional movement pattern proficiency is similar across stroke types in collegiate swimmers. Therefore, team-based corrective exercise programs based on FMS performance do not need to be stroke specific in swimmers.

Table 1. Mean (+SD) FMS individual and composite scores by swimming stroke.

	Freestyle (n=21)	Breaststroke (n=14)	Backstroke (n=12)	Butterfly (n=5)	Individual Medley (n=5)
Deep squat	1.9±0.7	2.1±0.6	2.0±0.7	2.3±0.6	1.6±0.5
Hurdle step	1.8±0.5	2.3±0.5	2.2±0.4	1.8±0.6	2.0±0.0
Inline lunge	2.2±0.6	2.0±0.7	2.6±0.5	2.2±0.7	2.8±0.4
Shoulder mobility	2.3±1.1	2.6±0.6	2.8±0.4	2.0±1.0	1.8±1.3
Active straight leg raise	2.3±0.8	2.6±0.5	2.4±0.9	2.3±0.7	2.4±0.7
Trunk stability push- up	1.9±0.9	2.1±1.2	2.4±0.9	2.3±1.0	1.2±1.3
Rotary stability	2.0±0.0	2.0±0.0	2.0±0.0	1.8±0.6	1.6±0.9
Total	13.6±4.0	15.3±1.9	16.4±2.5	14.7±1.9	13.4±3.0

Epidemiology of Sport-Related Knee Injuries Reporting to U.S. Emergency Departments From 2008-2017.

Thornton EP, Bay RC, Marshall AN, Lam KC: A.T. Still University, Mesa, AZ; High Point University, High Point, NC

Context: Sport-related knee injuries are common in the adolescent population. Little is known about current epidemiological trends related to patients reporting to emergency departments (EDs) with a sport-related knee injury. The purpose of this study was to describe the rates and patterns associated with sport-related knee injuries reporting to EDs from 2008-2017 for adolescent-aged individuals. **Methods:** De-identified data were extracted from the U.S. Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS) in October 2018. The NEISS database consists of patient data collected from a probability sample of 100 EDs selected from a pool of over 6000 hospitals in the U.S. and its territories. The hospitals are located across the country in varying communities (eg, urban, suburban, rural), and of varying socio-economic statuses to provide a nationally representative sample. Data were extracted for a ten-year period (2008-2017). Variables included injury year (2008-2017), sex (male, female), age (13-18 years), body part (knee), sport (baseball, basketball, cheerleading, field hockey, football, ice hockey, lacrosse, skiing, soccer, track and field, softball, wrestling, volleyball), diagnosis (contusion/abrasion, dislocation, fracture, laceration, strain/sprain), and disposition (treated and released, admitted). We limited the dataset to include sports and diagnoses reported in previous epidemiological studies on injuries during interscholastic and intercollegiate sports. Each patient case was associated with a weight to provide national estimates. Descriptive statistics (frequencies, percentages) were used to summarize variables across patient cases between 2008-2017. For

incidence rate calculations, we extracted U.S. population estimates for 13-18 year olds from 2008-2017 from the U.S. Census Bureau. Incidence rates were calculated as the number of cases per 10,000 person-years. **Results:** A total of 17,566 patient cases (male=70.2%, n=12,325; female=29.8%, n=5,241; age=15.3±1.6 years) were captured for this study. Most of the knee injuries occurred during participation in basketball (33.1%, n=5,810), football (30.2%, n=5,298), and soccer (18.3%, n=3,213). The most common diagnoses were sprain/strain (66.5%, n=11,687), contusion/abrasion (17.4%, n=3,064), and dislocation (10.7%, n=1,879). Nearly all patients were treated and released (99.0%, n=17,385), with a small percentage of patients being admitted for their injury (0.7%, n=120). These data yielded population-weighted estimates of 589,643 knee injuries for the study period. The highest incidence rates by sex and sport were male football (13.4 per 10,000), male basketball (9.7), female basketball (4.8), female soccer (4.4), and male soccer (4.0). **Conclusions:** Our results are in agreement with previous epidemiological findings on knee injuries during interscholastic and intercollegiate sport participation including similar ranking of sports, diagnoses, and incidence rates. Nearly all patients who reported to the ED with a knee injury were treated and released. Future investigations should aim to better understand the role athletic trainers may play in managing these patient cases to help address global healthcare concerns such as overall demands and costs.

The Effect of Previous Medical History on Student-Athlete Quality of Life

Watkins RW, Bowman TG, Bradney DA, Register-Mihalik JK: University of Lynchburg, Lynchburg, VA; University of North Carolina, Chapel Hill, NC

Context: Health-Related Quality of Life (HRQL) assessments can provide Athletic Trainers with valuable information about student-athletes overall well-being and health. There is little data to aid clinicians in evaluating how previous medical conditions and family history of medical conditions may impact student-athlete HRQL. The objective of this study was to examine the association between personal and family reports of medical history and HRQL in collegiate student-athletes during a pre-season baseline assessment. **Methods:** We recruited 271 student-athletes for our cross-sectional study (age = 19.00 ± 1.15 years, height = 175.18 ± 4.29 cm, mass = 72.29 ± 12.03 kg). All participants were National Collegiate Athletic Association Division III soccer, field hockey, basketball, or lacrosse athletes who completed a comprehensive pre-season assessment including completion of the Patient-Reported Outcomes Measurement Information System® (PROMIS-29), the Quality of Life in Neurological Disorders scale (Neuro-QOL), and a detailed past medical history. The independent variables included the presence of any family (parents, siblings, grandparents) or any personal history of health impairments (balance disorder, psychological disorder, memory disorder or history of headaches). The 9 subsets of HRQL (anxiety, depression, fatigue, pain interference, pain intensity, physical function, sleep disturbance, social roles) and the 2 subsets of Neuro-QOL (fatigue SF, Cognitive Function SF) served as the dependent variables. We ran a separate stepwise linear regression equation for each of the 9 subsets of HRQL and each of the 2 subsets of Neuro-QOL against the 4 independent variables.

Results: Participants reported personal (N=131), parent (N=55), sibling (N=21) and grandparent (N=59) previous history of medical conditions. Sibling health history (without=19.88±.63, with=19.31±2.21; P<.001) and grandparent health history (without=19.98±.14, with=19.81±.89; P=.049) were associated with worse physical function scores ($F_{2,243}=8.891$, P<.001). Sibling health history (without=4.92±1.61, with=4.43±1.20; P=.044) was associated with pain interference ($F_{1,242}=4.110$, P=.044). Sibling health history (without=1.85±1.99, with=1.12±1.43; P=.038) was also associated with worse pain intensity ($F_{1,241}=4.342$, P=.038). Patient health history (without=10.98±3.93, with=10.16±3.43; P=.013) was associated with worse fatigue SF scores ($F_{1,252}=6.229$, P=.013). Family and patient medical history had no effect on anxiety, depression, sleep disturbance, social roles and activities, cognitive function or difficulty with daily activities (P>.05). **Conclusions:** Family and patient past medical history were associated with four categories of HRQL (physical function, pain interference, pain intensity, and fatigue SF). Sibling health history seemed to predict categories of pain while patient health history predicted fatigue ratings. It is important to be informed that past medical history may impact HRQL as this may provide insight into student-athlete well-being. Further research is necessary to determine if other predictions can be made from past family and medical history. Word Count: 410 words.

Quantifying External Load Among Collegiate Men's Lacrosse Players: Implications for Position Specific Injury Risk

Sullivan BS, Myers AF, Trigsted SM, Harrell SF, Taylor JB, Hegedus EJ, Nguyen A: High Point University, High Point, NC; University of Wisconsin, Madison, WI

Context: Participation in men's lacrosse continues to grow, leading to the increased likelihood of sport-specific injury. Injury epidemiological data specific to men's lacrosse suggests a pattern of greater injury rates in midfield players, followed by offensive players, then defensive players. Differences in external load has been suggested to contribute to injury, however, external load has not been quantified in collegiate men's lacrosse players specific to position. Identifying the position specific differences in external loads will help us understand the role of external load as a risk factor for injury. Therefore, the purpose of this study was to examine the differences in external load between men's lacrosse player positions over a competitive season. **Methods:** A descriptive laboratory study design was used, during a season long field-based assessment, to measure external load on 20 male division-1 collegiate men's lacrosse players (20.1±1.5yrs, 84.0±8.2kg, 182.8±5.4cm). External loads were collected using a wearable global positioning system unit during 13 weeks of practice over the course of a season. The weekly cumulative distance, high intensity (>16 km/h) distance, number of high-intensity accelerations (>3.25 m/s²), and number of high-intensity decelerations (<3.25 m/s²) were computed. Mean weekly values for midfield (n=8), offense (n=5), defense (n=4), faceoff (n=3) positions were used for analyses. One-way ANOVA models were used to determine differences (P<0.05) in external loads between player positions. **Results:** There were no significant differences in weekly cumulative distance between player positions (P=0.213). Weekly

cumulative high-intensity distance was greater in midfield (2220±306m) compared to offense (1335±456m, P=0.003). Weekly cumulative number of high-intensity accelerations was greater in defense (272±47) compared to midfield (213±48), offense (155±33) and faceoff (180±33), and midfield was greater than offense (P=0.006). Weekly cumulative number of high-intensity decelerations were greater in midfield (89±18) and defense (90±16) compared to offense (65±10) and faceoff (59±17, P=0.017). **Conclusions:** Weekly cumulative external loads are different between men's lacrosse positions and vary dependent on the variable used to quantify external load. While high-intensity distance and number of high-intensity decelerations may partially explain the disparity in injury rates observed in mid-field players, other external load variables would suggest increased injury risk in defensive players. Future work is needed to prospectively examine which external load variable, or combination of variables, contribute to increased risk of injury. Understanding the role of external load as a risk factor for injury will help clinicians develop strategies toward reducing injury risk in men's lacrosse athletes.

External Loads in Collegiate Women's Lacrosse Players Differ Throughout a Season and Between Event Types: Implications for Increased Injury Risk

Myers AF, Sullivan BS, Trigsted SM, Yakel KM, Taylor JB, Hegedus EJ, Nguyen A: High Point University, High Point, NC; University of Wisconsin, Madison, WI

Context: Injury epidemiological data specific to women's lacrosse has identified a pattern of the greatest number of injuries occurring in the pre-season (PRE), followed by in-season (IN), then post-season (POST), and greater injury rates during competition (GAME) compared to practice (PRAC). Differences in external load may contribute to the injury pattern, however, external load has not been quantified in collegiate women's lacrosse players. Quantification of external loads relative to event type and phase of competitive season is needed to understand the role of external load during the times when athletes may be at greatest risk of injury. Therefore, the purpose of this study was to examine differences in external load during the phases of a competitive season and between event types in collegiate women's lacrosse players. **Methods:** A descriptive laboratory study design was used, during a season long field-based assessment, to measure external load on 23 female division-1 collegiate women's lacrosse players (21.1±1.1yrs, 63.3±4.6kg, 167.0±4.3cm). External loads were collected using a wearable global positioning system unit during 17 weeks of a competitive season. Daily total distance, high intensity (>16 km/h) distance, number of high-intensity accelerations (>3.25 m/s²), and number of high-intensity decelerations (<3.25 m/s²) were computed. Mean cumulative weekly values during PRE, IN, and POST were used to examine differences between phases of the season. Mean daily values during GAME and PRAC were used to examine differences between event types. Only

athletes that participated in at least 75% of the season's games (n=17) were included when examining differences in event type. Separate repeated measures ANOVAs were used to determine differences (P<0.05) in external loads across a competitive season. Post hoc consisted of simple main effects testing. **Results:** Differences between phase of season were observed where mean cumulative weekly distance was greater in PRE (29258±5502m) and IN (27334±5313m) compared to POST (23586±6171m, P<0.001). Mean cumulative weekly high-intensity distance was greater in PRE (3838±1176m) compared to IN (3147±879m), which was greater than POST (2461±238m, P=0.001). Mean cumulative weekly number of high-intensity accelerations was greater in PRE (539±150) and IN (528±172) compared to POST (394±169, P<0.001). Mean cumulative weekly number of high-intensity decelerations was greater in PRE (211±55) and IN (207±60) was greater than POST (164±63, P=0.001). Differences between event type (GAME vs. PRAC) were observed with GAME greater than PRAC in mean distance (8025±2030m vs. 5401±570m, P<0.001), high-intensity distance (814±255m vs. 621±145m, P=0.005), number of high-intensity accelerations (154±33 vs. 115±18, P<0.001), and number of high-intensity decelerations (51±21 vs. 41±9, P=0.020). **Conclusions:** Differences in external loads across a competitive season and between event types are consistent with previously reported differences injury rates in collegiate women's lacrosse players. Prospective studies are needed to confirm whether differences in external load contribute increased risk of injury.

Rib Stress Injuries Among Female NCAA Collegiate Rowers: A Prospective Epidemiological Pilot Study

Madison CA, Harter RA, Housman JM, Pickerill ML: Children's Hospital, Seattle, WA; Texas State University, San Marcos, TX; Colorado State University, Pueblo, CO

Context: Rib stress injuries are among the most debilitating injuries that rowers sustain during their careers, with reports of average time loss due to rib injuries ranging from 48 to 60 days per year. Few studies have been conducted regarding rib stress injuries among collegiate rowing athletes, and those that have been published are case studies or case series. The purpose of this study was to document the frequency and severity of rib stress injuries sustained by a cohort of female rowers during a single NCAA rowing season and to evaluate potential risk factors associated with injury. **Methods:** We used a mixed methods approach, combining prospective quantitative (epidemiological) and qualitative (descriptive) experimental designs. An athletic trainer from each participating institution acted as the liaison between the study participants and the principal investigator to obtain the student-athletes' email addresses. Thirty-one NCAA Division I and III female rowers (age, 19.3 ± 1.8 yrs; hgt, 171.6 ± 6.3 cm; mass, 75.8 ± 9.3 kg) agreed to participate in this 14-week study. We collected our patient-reported data online; specifically, a completed demographics questionnaire and 14 weekly "e-diaries" from each participant. Our outcome measures included physical training program characteristics, frequency of rib stress injuries, nutritional supplement use, menstrual status, and contraceptive use. Statistical analyses included measures of central tendency (frequency, mean +SD), paired t-tests, and qualitative theme analysis. **Results:** Twenty-seven of the 31 participants (87%) completed all aspects of this 14-week study. A total of

3,407 hours of physical training, on-water practices and competitions were reported by the 27 participants across one NCAA rowing season. Rowers at the NCAA Division I program trained an average of 18.4 hours/week compared with 13.8 hours/week at the Division III school ($p = 0.004$, Cohen's $d = 0.97$). Seven of 27 participants (26%) reported a rib cage injury, of which 4 injuries were further identified as rib stress injuries. Eighteen of the 27 (67%) female rowers reported that they did not row before college, while 52% (14 of 27) indicated that they had been competing as an NCAA rower for less than 1 year. Twenty-three participants (85%) reported that they were not taking any nutritional supplements during this study; 8 participants (30%) indicated they were using a hormonal contraceptive. Self-reported menstrual activity categorized 4 individuals (15%) as oligomenorrheic with the remaining 23 (85%) classified as eumenorrheic. **Conclusions:** In our pilot study, rib stress injuries affected nearly 15% of the NCAA female rowing population sampled, the majority of whom could be classified as novice rowers. These findings suggest that larger scale epidemiological studies should be conducted to determine the incidence, severity, and subsequent clinical outcomes of rib stress injuries among female intercollegiate rowers.

Video Analysis of the Injury Mechanism of Athletes at the 2017 Muju World Taekwondo Championship

Jeong HS, Park GS, O'Sullivan DM, Jeong DH, Lee SY: Yonsei University, Seoul, South Korea; Pusan National University, Busan, South Korea; Southern Illinois University School of Medicine, Springfield, Illinois

Context: Since rules and technical scoring equipment for competitions promoted by World Taekwondo have changed, there is a shortage of epidemiology studies reporting how these changes have affected injury profiles and mechanisms. The purposes of this study are first, to analyze the injury incidence and profiles in the World Taekwondo Championships (WTC) and second, to analyze the injury mechanism by the video review of Taekwondo games. **Methods:** This study design was a descriptive epidemiological study with video analysis. A total of 971 athletes (male 593, female 378, age = 22.9 ± 4.2) who participated in the 2017 Muju WTC were enrolled. All injuries were recorded prospectively in the web-based injury surveillance system developed by the International Olympic Committee. Each injury was recorded retrospectively by three cameras surrounding each court. Injury profiles and mechanisms were calculated as; percent injury rate, injury rate/1000 athlete-exposures (AEs; one athlete participating in one match), injury rate/1000 minute-exposures (MEs; one athlete participating in a match for a duration of 1 min), injury location, type, and mechanism (Injury situation, attacker situation, receiver situation, blocking skill, foot position, attack technique) via the injury surveillance system and video analysis. **Results:** There were 74 injuries, which corresponded to an overall incidence of 10.2 injuries (95% confidence interval [CI]: 11.2–15.8) per 100 athletes and the estimated injury rate per 1,000AEs was 59.0 and per 1,000MEs 21.1 for a seven-day period.

The face (27.0%), knee (19.8%), ankle (9.2%), fingers (6.1%), and hand (5.3%) were most frequently injured parts. Contusions (37.8%), fracture (20.3) and ligament sprains (20.3%) were the most frequently injury types. The main mechanism for contact injury is while attacking with the roundhouse kick (53.5%), and the foot hits against the opponent (37.2%) or when the defender fails to block (83.7%). The attacker was injured when the position of the attacker's leg was in front of the kicking leg (69.8%), and the defender was injured when the defender's blocking or avoiding leg was located in front (58.1%). Among the non-contact injuries [7(9.5%)], the athletes got injured during attacking (66.6%) or when they were kicking (70.5%). In addition, they got injured when they were avoiding (66.6%), or when their supporting leg was in front during attack (70.8%), or supporting leg was in back during defense (65.0%). **Conclusions:** The incidence of injuries to the face, knee, and ankle was relatively high. To prevent contact injuries, protective headgear and better shin guards and hand protectors need to be developed. In addition, practicing defense techniques from the roundhouse kick should be focused on preventing contact injuries. As for the non-contact injuries, we recommend hamstring strengthening exercises, and neuromuscular training to strengthen the tendons and ligaments protecting the ankle and knee joints.

Free Communications, Poster Presentations: Factors Influencing Biomechanics During Functional Tasks

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Athletic Surface Type Does Not Affect Landing Error Scoring System (LESS) Scores

Burbulysa ER; Pryor JL;
California State University,
Fresno, CA

Context: Athletic surface type influences the incidence of certain lower extremity injuries in soccer and American football players. Whether athletic surface type affects movement technique, a causal factor for lower extremity injury, is unclear. The purpose of this study is to evaluate whether common athletic surface types (grass, rubber pellet turf, hardwood, and cement) influence movement technique during jump-landing tests. **Methods:** Using a randomized crossover design, 38 recreationally active men and women (age: 22.4 ± 2.1 y, height: 1.69 ± 0.11 m, mass: 68.9 ± 13.6 kg, body fat: 23.3 ± 7.4 %) completed jump-landing tests to evaluate movement technique on each athletic surface type. Participants completed two test sessions one week apart. During Session 1, participants completed jump-landing testing on concrete and hardwood floors (lab setting) and during Session 2 participants were tested on grass and rubber pellet turf (field setting). Because fatigue and muscle soreness may influence movement technique, we measured perceptual fatigue (0-10; 1.0 unit increments), perceptual muscle soreness (100 cm VAS), and maximal vertical jump height before both test sessions. Participants wore their own sneakers and avoided physical activity 24 hours prior to testing. The Landing Error Scoring System (LESS) was used to assess movement technique. Dependent t-tests assessed differences in perceptual fatigue, perceptual muscle soreness, and vertical

jump height. A one-way ANCOVA, controlling for sex, evaluated changes in total LESS scores across athletic surface types. We used a LESS score of ≥ 5 as a clinically meaningful threshold for “at injury risk” (ROC = 5.0, sensitivity = 86% [95%CI (42, 99)], specificity = 64% [95%CI (62, 67)]) (Padua et al., J Athl Train 2015). Then, we evaluated whether athletic surface type affected the proportion of subjects defined as “at injury risk” using logistic regression while controlling for sex. Alpha level was set at 0.05. Data are reported as mean \pm standard deviation. **Results:** Perceptual fatigue was 0.4/10 units higher before Session 1 versus Session 2 ($p = 0.038$). Vertical jump (Session 1: 43.7 ± 8.4 ; Session 2: 43.7 ± 8.1) and muscle soreness (Session 1: 5 ± 6 ; Session 2: 5 ± 6) measurements were not different between sessions ($p > 0.05$). Total LESS scores were not different across concrete (5.6 ± 2.2), hardwood (5.7 ± 2.1), rubber pellet turf (5.4 ± 2.3), and grass surfaces (5.4 ± 2.3) ($p > 0.93$). After adjusting for sex, athletic surface type was not predictive for determining “at injury risk” status defined as a LESS score ≥ 5 units ($\chi^2 = 2.1$; $p = 0.38$, Nagelkerke $r^2 = 0.02$). **Conclusions:** After controlling for sex, fatigue, and muscle soreness, the athletic surface types used in this study did not influence movement technique during a jump-landing task. Our sample population could benefit from participating in an ongoing preventative training program to enhance movement technique.

Validity of a Real-Time Clinical Checklist to Assess Jump-Landing Biomechanics of the Single Leg Hop for Distance

Herron AA, Grooms DR, Yom J,
Simon JE: Ohio University, Athens,
OH

Context: The single-leg hop for distance (SLHOP) is a common clinical assessment of lower extremity function to inform clinical decision making for return to play and injury risk. However, the SLHOP is based solely on performance (distance jumped) with no measure of movement quality. Therefore, the purpose of this study was to create and validate an observational checklist based on biomechanical errors assessed during the SLHOP to provide an assessment of movement quality. **Methods:** This study took place in a gymnasium setting using a cross-sectional design. Fifty-nine high school athletes volunteered (15.2 ± 1.1 years, 165.8 ± 9.2 cm, and 61.5 ± 13.9 kg, 51 females and 8 males). Participants were free from lower extremity injury and were cleared for participation for their respective sport. Each participant performed three trials of the single-leg hop for distance on their dominant leg. A three-dimensional inertial measurement system (Noraxon, Scottsdale, AZ) was used to capture knee joint kinematics to validate the developed checklist. A single-leg hop for distance checklist was developed to score biomechanical errors based on lower extremity injury risk factors seen in real time. Four criteria were developed for the checklist based on prior literature related to injury risk 1: knee valgus, 2: foot rotation, 3: lateral trunk flexion, and 4: erect posture. Based on the checklist individuals were grouped into low, medium or high-risk groups. The between groups

subject factors: low injury risk group (no errors or erect posture only), medium injury risk groups (foot rotation or lateral trunk flexion) and high injury risk groups (three errors or more). A multivariate ANOVA was conducted for the independent variable group and for two dependent variables (knee flexion and abduction displacement). Follow-up univariate testing was completed if the overall multivariate ANOVA was significant with alpha set at 0.05 a priori. **Results:** Based on the single-leg hop for distance checklist, group frequencies were low-risk n=12, medium risk n=22, and high-risk n=25. Knee abduction displacement was statistically significant between groups $p < 0.001$, but knee flexion displacement was not significant between groups ($p > 0.05$). Knee abduction displacement was statistically significant between low and high-risk groups (mean difference: 9.16°), and medium and high-risk groups (mean difference: 7.53°). **Conclusions:** Knee abduction is notably a common risk factor for injuries sustained at the knee and this injury-screening checklist was able to distinguish between low, medium, and high-risk individuals for knee abduction displacement in real time. Therefore, the results of this study could be directly transferred to clinical practice, providing a real time movement quality assessment.

The Relationship Between Knee Joint Biomechanics and Single Leg Hop Performance in High School Athletes

Thompson K, Simon JE, Grooms DR, Yom J: Ohio University, Athens, OH

Context: The single-leg hop for distance (SLHOP) is a typical measure of functional performance to assess return to sport readiness and identify lower extremity deficits. However, examinations of joint kinematics in the field during this clinical test have not been examined to determine if a relationship exists between knee joint control and functional performance (hop distance). The purpose of this study was to determine if a relationship exists between SLHOP distance and knee joint kinematics. **Methods:** This study was a cross-sectional study that enrolled 40 high school athletes (12 male, 28 female, 15.9 ± 1.8 years, 171.6 ± 12.9 cm, 63.6 ± 15.9 kg). Participants must have been free from lower extremity injury within the last thirty days that may have caused them to miss participation in their sport. The participants must have had no injury to the lower extremity that required surgery within the last six months. Participants performed the SLHOP test on both right and left legs in a high school gymnasium. Each participant performed three trials of the SLHOP test on both right and left legs. The SLHOP was completed by fixing a tape measure to the ground and instructing the participant to hop on one leg as far as possible. Participants were instructed to “stick the landing” and a successful trial required the participant to remain stable upon landing for 2 seconds and the non-test leg not making contact with the ground. The average of three trials for each leg was calculated for analysis. Three-dimensional inertial measurement units (Noraxon, Scottsdale, AZ) were attached to the participants’ tibia and femur to measure frontal and sagittal plane knee joint kinematics. Knee flexion and abduction displacement were calculated from

initial ground contact to peak angle during each landing. Pearson correlations were used to determine the relationship between SLHOP performance and knee flexion and abduction displacements. Alpha level was set at 0.05 a priori. **Results:** The average SLHOP distance was: 137.04 ± 25.03 cm, knee flexion displacement: $40.92 \pm 8.20^\circ$ and abduction displacement: $6.93 \pm 6.05^\circ$. Knee flexion joint displacement was determined to correlate with hop distance for the right ($r = .35$; $p = .03$) and left ($r = .53$; $p < .01$) legs. Knee abduction displacement was not correlated with hop distance for the right ($r = -.16$; $p = .33$) or left ($r = -.09$; $p = .60$) legs. **Conclusions:** A relationship exists between SLHOP performance (distance hopped) and knee flexion joint displacement indicating that those participants who had increased hop distance also demonstrated increased knee flexion. Single leg hop distances did not demonstrate a relationship with knee abduction joint displacement. The lack of a relationship between SLHOP distance and knee abduction displacement may indicate compensations in knee frontal plane control that should be considered in addition to performance as hop distance is not an indicator of frontal plane knee control.

The Influence of Fatigue on Sauté Jump Kinematics and Kinetics in Dancers

Tuesta E, Jarvis DN: California State University, Northridge, CA

Context: Injuries in dancers are extremely common, and dancers frequently perform repeated jumping and leaping tasks. Fatigue is thought to be related to an increased risk of injury due to altered movement patterns, but little research has examined the effects of fatigue on dance performance. The purpose of this study was to determine the effects of a dance-specific fatigue protocol on performance of a sauté jump. It was hypothesized that ankle dorsiflexion would decrease, ankle plantar flexion would increase, and ground reaction forces would increase when dancers are in a fatigued state. **Methods:** Seventeen healthy, experienced dancers (mean age 24.9 ± 5.5 years, mass 57.7 ± 4.5 kg, height 1.6 ± 0.05 m) with 20.1 ± 5.7 years of dance training participated in this study after providing informed consent. Dancers performed 10 sauté jumps before and after a dance-specific fatigue protocol designed to mimic a ballet class or rehearsal; the protocol was approximately one minute long and included a combination of jumps, leaps, and turns. Fatigue was defined as dancers reaching a self-reported fatigue state of greater than or equal to 17 on the Borg rating of perceived exertion scale. A 12-camera motion capture system and force plates were used to collect three-dimensional kinematic and kinetic data during dance performance. Vertical ground reaction force data were normalized to body weight. Peak ankle dorsiflexion, peak ankle plantarflexion, and peak vertical ground reaction force data were extracted for further analyses. Variables were compared between the sauté jumps before and after fatigue using paired t-tests ($p=0.05$). **Results:** Dancers performed the choreography sequence an average of 4.8 ± 1.9 times in order to reach their fatigued state. Contrary to our hypothesis, ankle dorsiflexion increased ($28.88 \pm 3.98^\circ$ pre-fatigue, $30.32 \pm 4.98^\circ$

post-fatigue, p **Conclusions:** In a fatigued state, dancers demonstrated lower peak vertical ground reaction forces, increased ankle dorsiflexion in landing, and decreased ankle plantar flexion during flight. The decreased ankle plantar flexion indicates that dancers are not able to maintain the same aesthetic proficiency when fatigued, as a pointed foot and ankle complex during the flight phase is desirable. The increased ankle dorsiflexion likely created longer contact time with the floor during the jump and allowed for the decreased ground reaction forces, but this increased ankle dorsiflexion may also indicate a reduction in eccentric lower extremity musculature control. Eccentric strengthening may help to counteract the increase in dorsiflexion when fatigued to reduce the possible risk of sustaining an injury during multiple jumping and leaping tasks during classes, rehearsals, or live performances.

Influence of Anticipation and Dual-Tasking on Cutting Biomechanics in Healthy Males

Norte GE, Frendt T, Murray AM, Armstrong CW, McLoughlin TJ, Donovan LT: The University of Toledo, Toledo, OH; University of North Carolina, Charlotte, NC

Context: Biomechanical analyses of cutting tasks have demonstrated kinematic differences associated with noncontact knee injury risk when the direction of movement is unanticipated. Cognitive-motor tasks requiring dual-tasking in a changing athletic environment may contribute to injury risk by further altering biomechanics. Therefore, our objective was to investigate the effect of anticipation and dual-tasking on cutting biomechanics. **Methods:** This cross-sectional study enrolled thirty-two recreationally active males (age: 23.1 ± 3.6 years, height: 180.0 ± 7.0 cm, mass: 81.3 ± 17.3 kg, Tegner activity level: 6.8 ± 1.0), who regularly participated in a cutting sport (e.g. football, soccer, basketball, rugby, lacrosse, or ultimate frisbee) at least one time per week. Independent variables included anticipation (anticipated [A], unanticipated [U]) and dual-task (no ball throw, ball fake, ball throw). Dependent variables included three-dimensional trunk, hip, and knee joint angles in the sagittal, frontal, and transverse planes. Participants performed a 45-degree sidestep cutting task on the dominant limb during a random order of testing conditions (Figure 1). Ensemble averages with 95% confidence intervals were used to compare mean joint angles over the stance phase, from initial contact to toe-off (0-100%). Regions of non-overlapping confidence intervals were considered significant. The region of identified differences, mean differences in joint angles (95% CI), and Cohen's d effect sizes (95% CI) are presented. **Results:** No differences in hip or knee joint angles were observed. Similar differences in trunk angles were observed between dual-task conditions regardless of anticipation. The trunk

was more extended (A: 0-85%, 3.7° [3.0-4.4°], $d = 2.7$ [2.0-3.4]; U: 8-72%, 2.9° [2.5-3.3°], $d = 3.6$ [2.8-4.4]), laterally flexed (A: 0-100%, 5.5° [4.7-6.3°], $d = 3.3$ [2.5-4.0]; U: 0-38%, 5.7° [5.1-6.3°], $d = 4.7$ [3.8-5.7]), and rotated (A: 25-100%, 8.7° [5.9-11.4°], $d = 1.6$ [1.0-2.1]; U: 0-100%, 9.7° [5.3-14.0°], $d = 1.1$ [0.6-1.6]) away from the cutting direction during the ball throw condition compared to no ball throw. Greater trunk rotation was observed during the ball throw condition compared to ball fake (A: 28-100%, 6.3° [3.8-8.8°], $d = 1.3$ [0.7-1.8]; U: 13-100%, 6.2° [2.8-9.7°], $d = 0.9$ [0.4-1.4]). When considering the interaction between anticipation and dual-tasking, several differences in trunk angles were observed. The trunk was more extended (7-59%, 4.2° [3.9-4.4°], $d = 8.4$ [6.9-9.9]) and rotated (24-100%, 9.7° [6.7-12.7°], $d = 1.6$ [1.1-2.2]) away from the cutting direction during the unanticipated ball throw condition compared to anticipated no ball throw. **Conclusions:** Dual-tasking and its interaction with anticipation promote a more upright, neutral trunk position during sidestep cutting, which has been associated with risk for noncontact knee injury. Current recommendations for injury prevention do not consider anticipation or dual-tasking. By promoting task complexity during end stage rehabilitation and injury prevention programming, physically active individuals may become better prepared to succeed when performing high-risk athletic maneuvers.

Does Restricting Anterior Movement of the Knees During a Barbell Back Squat Alter Lower Extremity Biomechanics?

Koshewa L, Ebersole K, Huddleston W, Earl-Boehm J: University of Wisconsin, Milwaukee, WI

Context: The strengthening benefits of the barbell back squat make it ideal for use across a variety training and rehabilitation programs that athletic trainers might implement. Slight changes in knee position relative to the toes are thought to influence joint loading. Restricted squats (knees behind the toes) reduce knee joint loading, but may increase loading elsewhere. Unrestricted squats better represent natural movement, but may increase knee joint loading. The focus of previous research has been on elite male weightlifters, however there is significant growth in the number of females engaging in barbell lifting. The purpose of this study is to determine how restricting the anterior movement of the knees during barbell back squats affects joint mechanics of the lower extremities in female recreational weightlifters. **Methods:** 16 healthy, female, recreationally-active, weightlifters (age= 25.6±4.2 yrs; height= 170.4±8.3cm; weight= 63.8±8.3 kg) participated in this study. 3-D biomechanical analysis of joint angles and moments were performed using a motion capture system and standard procedures. Participants performed 5 squats for each of the three squat conditions; natural (NS), knee over toe (KOT), and restricted (RS), using the middle three squats for data processing. Hip, knee, and ankle sagittal plane angles and moments were extracted at peak knee flexion. A repeated measures ANOVA compared the angles, internal joint moments, and the net support moment between the three squat types. The relative contribution of the individual joint moments to the net support moment were expressed as a percentage. A Bonferroni correction was used

to adjust the alpha value to $\alpha < .004$, and Tukey's post hoc test was used to identify significant differences among the squat conditions. **Results:** Knee angle and flexion moment were smaller in the RS condition and larger in the NS condition $F(2,30)=35.3, p<.0001$, $F(2,30)=18.8, p<.0001$. Hip extension moment was smallest in KOT and larger in the RS and NS conditions $F(2,30)=18.2, p<.0001$. Dorsiflexion was the smallest in RS and NS conditions and largest in the KOT condition $F(2,30)=75.8, p<.0001$. Trunk angle was largest in the RS condition $F(2,30)=42.5, p<.0001$. The net support moment was largest in the NS condition $F(2,30)=7.9, p=.002$. **Conclusions:** The primary findings of this study supported initial hypotheses that anterior restriction of the knees during a back squat affects lower extremity biomechanics, particularly in increased trunk lean. Clear differences in sagittal plane joint angles and joint moments were seen across the all three conditions. Within a healthy, recreationally-active, population, mechanics of the natural squat show slight anterior movement of the knees past the toes with an erect trunk. It is possible that the three squat conditions could all be appropriate ways to squat, depending on the goals of the lifter, yet increased training may help to reduce compensations to allow lifters to squat in safer patterns.

Relationship Between Mechanics on Single Limb Stepdown and During Running Gait

Schreiber C, Becker J: Montana State University, Bozeman, MT

Context: The single-leg step-down (SLSD) is a movement screen commonly used by clinicians to assess the strength and neuromuscular control of the lower extremity. Poor performance on the SLSD is marked by medial collapse of the support limb. Similar kinematics have been reported in injured runners suggesting the SLSD may be a good screening tool to identify runners at heightened risk of injury due to poor mechanics. However, to date a direct comparison between kinematics during SLSD and during running has not been performed. Therefore, the purpose of this study was to determine if there is a relationship between kinematics on SLSD and kinematic during running gait. **Methods:** 50 runners (sex: 24 F,

26 M; age: 28.4 ± 9.2 years; weekly mileage: 44.2 ± 18.7 miles) participated in this cross-sectional study. Inclusion criteria included running a minimum of 20 miles per week and no lower extremity injuries within the preceding three months. For the SLSD, the participant was instructed to stand on top of a 30-centimeter box, slowly lower themselves until the heel of the non-support limb touched the ground and return to standing. Ten continuous trials were performed. Running gait was evaluated while participants ran overground in the laboratory. Whole body kinematics during both SLSD and running gait were recorded using a 10-camera motion capture system. For both activities, peak contralateral pelvic drop, hip adduction, hip internal rotation, knee valgus, and rearfoot eversion were calculated. Total medial collapse was also calculated by adding the pelvic drop, hip adduction, knee valgus, and rearfoot eversion values. Linear regressions were used to evaluate relationships

between SLSD measures and running mechanics. **Results:** Mean values for kinematic during SLSD and running are shown in Table 1. Performance on SLSD was a significant predictor of hip adduction, hip internal rotation, knee valgus, rearfoot eversion, and total medial collapse during running, accounting for between 12.7% and 35.4% of the variance in these variables (Table 1). **Conclusions:** There are strong relationships between kinematics on the SLSD and during running gait, supporting the use of SLSD as a screening tool for poor running mechanics. SLSD could be especially useful when a full 3D running gait analysis is not available. It should be noted that all participants in the current study were healthy. Further research is required to determine whether similar relationships are observed in injured runners or whether SLSD mechanics predict internal tissue loading or other variables more directly related to the development of running injuries.

Table 1. Mean values (\pm standard deviation), and regression results for peak contralateral pelvic drop (CPD), hip adduction (HADD), hip internal rotation (HIR), knee valgus (KV), rearfoot eversion (EVER), and total medial collapse (TMC).

Variable	SLSD value	Running value	Regression R^2	Regression p	Regression β	95% CI
CPD ($^\circ$)	3.25 (\pm 2.14)	3.93 (\pm 2.07)	0.001	0.740	0.032	-0.226 – 0.162
HADD ($^\circ$)	16.00 (\pm 4.58)	13.04 (\pm 3.49)	0.103	0.001	0.245	0.101 – 0.389
HIR ($^\circ$)	11.32 (\pm 7.17)	9.18 (\pm 6.36)	0.312	< 0.001	0.499	0.352 – 0.646
KV ($^\circ$)	7.44 (\pm 5.98)	5.04 (\pm 3.90)	0.354	< 0.001	0.388	0.283 – 0.492
EVER ($^\circ$)	8.92 (\pm 4.20)	9.08 (\pm 5.17)	0.181	< 0.001	0.523	0.301 – 0.747
TMC ($^\circ$)	35.26 (\pm 8.71)	31.06 (\pm 8.02)	0.127	< 0.001	0.331	0.159 – 0.503

The Effects of a Fatiguing Run on Dynamic Balance

Tom JC, Radzak KN: University of Nevada, Las Vegas, NV

Context: Fatigue has been reported to increase injury risk due to impaired joint proprioception and kinematics. While studies have examined the effects of localized muscular fatigue on dynamic balance tasks, the effects of generalized aerobic fatigue is relatively unknown. The current study aims to biomechanically examine the effects of an aerobically fatiguing run on dynamic balance tasks. **Methods:** A pretest-posttest experimental design was performed in a laboratory setting. Ten healthy, active adult males (age:33.5±5.8 years, height:175.5±9.9 cm, mass:77.8±10.7 kg) were recruited. Participants complete Anterior, Posteromedial, and Posterolateral reach directions of the Star Excursion Balance Test. Measures were taken prior to (Pre), and following (Post) a fatigue protocol. Participants were allowed up to four practice trials, per direction and limb, prior to data collection. Participants completed three successful trials on the dominant leg (8 right, 2 left), followed by three non-dominant leg trials. The

fatiguing protocol consisted of a modified Åstrand graded exercise test and exhaustive run at 80% VO₂max until the participant reported fatigue. Fatigue was quantified as a rate of perceived exertion ≥17/20 and/or a fatigue visual analog scale score of ≥7/10. Post trials were repeated using identical methodology as Pre. Variables of interest included maximal reach distance (normalized to stance leg length) and sagittal plane ankle, knee, and hip angles at the point of maximal reach. The mean of three trials was used for analysis. A 2x2 (Limb x Condition) repeated measures ANOVA was utilized to examine the effects of fatigue on variables of interest. **Results:** Descriptive statistics of variables of interest are reported in Table 1. Interaction effect for Limb and Condition, and main effect for Limb were not significant (p>0.05) for any of the reported variables. Main effect for Condition was significant for variables of ankle dorsiflexion, knee flexion, and reach distance. The following variables significantly increased from pre- to post-fatigue: ankle dorsiflexion angle in all three directions [mean (confidence interval): Anterior: Pre = 22.61° (18.78-26.43), Post = 24.95° (20.98-28.91), p≤0.001; Posteromedial:

Pre = 17.23°(14.40-20.05), Post = 19.38° (16.62-22.14), p = 0.001; Posterolateral: Pre = 17.97° (14.97-20.97), Post = 21.55° (17.85-25.26), p = 0.001], knee flexion angle in the Posterolateral direction [Pre = 49.04° (40.49-57.59), Post = 53.22° (43.45-63.00), p = 0.025], and reach distance in the Anterior [Pre = 58.99% (55.53-62.46), Post = 60.78% (56.94-64.62), p = 0.004] and Posterolateral [Pre = 83.54% (76.91-90.17), Post = 87.16% (80.04-94.28), p = 0.029] directions. There were no differences in hip flexion angles from pre- to post-fatigue. **Conclusions:** Previous research has shown dorsiflexion motion and velocity to increase following fatiguing exercise in both landing and running tasks, respectively. A prolonged, fatiguing run was found to increase dorsiflexion during a dynamic balance task in the current study. Increased tibial advancement during the reaching task may be due to the eccentric demands placed upon the fatigued ankle plantarflexors. The differing effects of fatigue on knee flexion angle dependent on reach direction may indicate that unique movement strategies are employed for each reach direction.

	Anterior		Posteromedial		Posterolateral	
	Dominant	Non-Dominant	Dominant	Non-Dominant	Dominant	Non-Dominant
Ankle Dorsiflexion (°)						
Pre-fatigue	21.20 ± 6.34	24.01 ± 9.61	16.39 ± 5.90	18.06 ± 6.13	17.06 ± 5.41	18.88 ± 7.24
Post-fatigue	24.30 ± 7.17	25.60 ± 9.54	19.42 ± 5.85	19.34 ± 5.90	21.36 ± 7.37	21.55 ± 7.67
Knee Flexion (°)						
Pre-fatigue	44.60 ± 14.84	49.35 ± 19.12	34.82 ± 13.07	36.09 ± 15.75	47.81 ± 16.94	50.27 ± 19.37
Post-fatigue	46.43 ± 15.57	48.45 ± 19.72	35.32 ± 12.96	37.59 ± 15.09	53.07 ± 19.63	53.37 ± 21.93
Hip Flexion (°)						
Pre-fatigue	13.37 ± 12.66	12.58 ± 12.18	48.17 ± 14.26	48.33 ± 16.94	51.40 ± 17.64	51.90 ± 19.34
Post-fatigue	13.44 ± 13.78	12.42 ± 13.99	48.51 ± 14.56	47.48 ± 18.28	55.92 ± 18.59	54.01 ± 22.65
Reach Distance (% leg length)						
Pre-fatigue	57.06 ± 7.12	60.93 ± 7.62	68.56 ± 15.49	71.91 ± 15.09	82.54 ± 14.40	84.54 ± 13.82
Post-fatigue	59.30 ± 7.70	62.25 ± 8.62	70.15 ± 17.24	73.34 ± 16.92	85.40 ± 15.14	88.93 ± 15.18

Relationship Between Functional Hop Performance and ACL-Injury Related Knee Biomechanics in the Sagittal Plane During a Single-Leg Jump Cut

Mulligan CMS, Chang E, Huang YL, Johnson ST, Norcross MF: Oregon State University, Corvallis, OR; Inha University, Incheon, South Korea

Context: Following anterior cruciate ligament reconstruction (ACLR), an estimated 1 in 4 will sustain a recurrent injury. Given the high incidence of re-injury is partially attributed to asymmetries in strength and function, functional hop testing and quantification of limb symmetry index (LSI) is commonly used. Unfortunately, clinically acceptable LSIs (> 90%) for return-to-play can be achieved while absolute deficits in strength and function persist. Quantifying absolute performance (AP) could provide additional insight into the recovery of strength and function. However, it is unknown if AP is associated with landing biomechanics linked to lesser ACL injury risk. Therefore, the purpose of this study was to determine

the relationship between single-leg (SLTH) and cross-over (COTH) triple hop performance and sagittal plane knee biomechanics during a single-leg jump cut (SLJC) in participants who achieve > 90% LSI. **Methods:** Fifteen physically active females who have undergone ACLR (Age: 19.7 ± 1.0 years, Height: 165.3 ± 6.8 cm, Mass: 62.8 ± 11.7 kg) who surpassed 90% LSI in SLTH and COTH were included in this analysis. AP was also calculated during SLTH and COTH tasks and normalized to body height. Kinematics and kinetics of the ACLR limb were assessed during three SLJCs using an optical motion capture system interfaced with one force plate. Knee flexion (KF) at initial contact (IC) and peak KF angles; KF angular displacement; and peak knee extension (pKEM) moment were identified during the stance phase of SLJCs. Relationships between AP and means for each SLJC biomechanical variable were assessed via Pearson or Spearman rank correlation coefficients ($\alpha \leq 0.05$). **Results:** Mean LSI values for SLTH and COTHs exceeded 95% (SLTH: 95.63 ± 5.40%; COTH: 97.85 ± 4.48%), while AP was highly variable (SLTH: 2.51 ± 0.45, 1.62-3.29 body heights;

COTH: 2.34 ± 0.41, 1.55-2.97 body heights). Lesser KF at IC in SLJCs was associated with greater AP in SLTH and COTH tasks. Furthermore, SLTH and COTH AP was associated with greater KF displacement during SLJCs. No significant correlation was found between SLTH or COTH AP and peak KF during SLJCs (Table 1). **Conclusions:** Even with LSIs > 90% in both SLTH and COTH, ranges in AP up to 1.5 body heights were identified. While greater AP in each task was associated with lesser KF at IC during SLJCs, greater AP was also associated with greater KF displacement, but not pKEM. These findings suggest that greater AP may not be associated with greater ACL loading during SLJCs despite the use of a more extended IC knee position. Instead, it appears that AP can provide insight into sagittal plane biomechanics linked to lesser ACL injury risk even after LSI is restored. Clinicians should consider including AP in ACLR return-to-play decision-making. Future research should look to identify optimal AP and evaluate LSI/AP and knee biomechanics measured during the same functional hop tasks.

Table 1. Correlations for Single-Leg and Cross-Over Triple Hop Performance and Sagittal Plane Landing Biomechanics of a Single-Leg Jump Cut

Criterion Variable	Mean±SD	Single-Leg Triple Hop		Crossover Triple Hop	
		r / ρ	p-value	r / ρ	p-value
Knee Flexion at Initial Contact	22.95±6.53°	r = -0.658	0.007 ^a	r = -0.689	0.004 ^a
Peak Knee Flexion	60.50±4.95°	r = 0.348	0.203	r = 0.351	0.200
Knee Flexion Displacement	37.55±7.49°	r = 0.804	<0.001 ^a	r = 0.833	<0.001 ^a
Peak Knee Extension Moment	-0.12±0.04 N·m	ρ = -0.314	0.254	ρ = -0.371	0.174

^a significant correlation ($\alpha \leq 0.05$).
Knee extension moment is negative by convention

Acute and Delayed Effects of Fatigue on Biomechanical Risk Factors for ACL Injury

Padua DA, Frank BS, Hawley VS, White JL: University of North Carolina at Chapel Hill, Chapel Hill, NC

Context: Fatigue has been shown to immediately alter lower extremity kinematics associated with ACL injury. However, it is unknown if negative alterations in lower extremity kinematics persist after a period of recovery. Therefore, the purpose of this study was to examine the acute and delayed effects of a lower extremity fatigue protocol on frontal and sagittal plane knee and hip kinematics during a jump-landing task. **Methods:** Healthy, physically active females (n=28, age=22.0±1.8 years; height=164.1±7.6 cm; mass=66.3±6.4 kg) participated in the study. All participants underwent a fatigue protocol that consisted of completing five cycles of 5-minute treadmill running at a speed coincident with 115-120% ventilatory threshold, followed by 10 jump-landings from a 30 cm box and 10 split-squats. Once completing the five cycles, the participants then completed

two cycles of 10 jump-landings and 20 split-squats. In total, participants completed 25 minutes of treadmill running, 70 jump-landing repetitions, and 90 split-squat repetitions. An electromagnetic tracking system was used to measure sagittal and frontal plane hip and knee joint angles at initial contact (vertical ground reaction force > 10N), peak (maximum angle during stance phase), and displacement (peak angle - initial contact angle) during three jump-landing trials. Jump-landing kinematics were assessed across three time points: pre-fatigue, immediately post-fatigue (acute-fatigue), and 24-hours post-fatigue (delayed-fatigue). Repeated measures ANOVA with time as the within-subject factor (pre-fatigue, acute-fatigue, delayed-fatigue) were performed for all dependent variables ($\alpha < 0.05$). Post hoc testing was conducted using paired t-tests with Bonferroni correction. **Results:** Significant main effects for time were observed for knee ($F_{(2,54)} = 11.23, p < 0.001$) and hip ($F_{(2,54)} = 4.80, p = 0.012$) flexion at initial contact, knee valgus peak ($F_{(2,54)} = 4.65, p = 0.014$), and hip adduction displacement ($F_{(2,54)} = 4.51, p = 0.015$). Post hoc analyses demonstrated acute-fatigue changes compared

to pre-fatigue for knee flexion at initial contact (decreased from pre-fatigue), knee valgus peak (increased from pre-fatigue), and hip adduction displacement (increased from pre-fatigue) (Table 1). Delayed-fatigue knee and hip flexion at initial contact values were decreased compared to pre-fatigue (Table 1). Delayed-fatigue knee valgus peak and hip adduction displacement values were no longer different from pre-fatigue levels (Table 1). No other significant differences were observed for all other variables ($p > 0.05$).

Conclusions: Knee flexion, knee valgus and hip adduction demonstrated acute-fatigue alterations compared to pre-fatigue. However, only knee flexion alterations displayed delayed-fatigue alterations by maintaining differences from pre-fatigue as knee valgus and hip adduction returned to pre-fatigue levels after 24-hours. Hip flexion did not demonstrate acute-fatigue alterations, but did display delayed-fatigue alterations compared to pre-fatigue. Both acute and delayed fatigue alterations occur following a lower extremity fatigue protocol. The relationship between delayed-fatigue reductions in knee and hip flexion with injury risk requires further study.

Acute and delayed fatigue alterations in lower extremity kinematics (degrees)

		Pre-Fatigue		Acute-Fatigue		Delayed-Fatigue	
		Mean	SD	Mean	SD	Mean	SD
Knee Flexion	Initial Contact	23.8	5.5	19.1*	6.2	20.2*†	5.9
	Peak	97.0	18.2	93.2	16.2	92.7	17.9
	Displacement	73.1	3.1	74.0	2.9	72.5	3.3
Hip Flexion	Initial Contact	-34.7	8.0	-33.8	8.8	-30.3*	8.2
	Peak	-82.6	21.0	-79.7	10.0	-78.4	19.8
	Displacement	47.9	20.6	45.9	18.5	48.1	20.3
Knee Valgus	Initial Contact	2.2	3.5	0.2	2.8	2.2	6.5
	Peak	-6.2	6.0	10.0*	6.4	-5.4†	10.0
	Displacement	8.4	1.0	10.2	1.2	7.1	1.1
Hip Adduction	Initial Contact	9.7	5.6	-9.7	5.2	-10.7	8.4
	Peak	-7.2	7.0	-6.1	5.8	8.6	9.4
	Displacement	-2.5	0.5	-3.6*	0.7	-2.1†	0.5

*significantly different from Pre-Fatigue

†significantly different from Acute-Fatigue

Different Quadriceps Strength Characteristics Predict Sagittal Plane Movement during Activities of Daily Living and Sport Specific Movements

Lisee C, Birchmeier T, Yan A, Kuenze C: Michigan State University, East Lansing, MI

Context: Maximal quadriceps strength is commonly used to assess patient progress and has been consistently associated with sagittal plane movement of sport specific activities after ACL reconstruction (ACLR). However, it is unclear if other characteristics of quadriceps function are associated with sagittal plane movement during less demanding tasks of daily living. **Methods:** The purpose of this cross-sectional laboratory study was to assess the ability of involved limb maximal voluntary isometric knee extension contraction torque (MVIC) and rate of torque development (RTD) to predict lower extremity sagittal plane kinematics and kinetics during single leg step down (SLSD) and single leg crossover hop (SLC) tasks in individuals with ACLR. A total of 52 participants with unilateral ACLR (17 men/35 women, mass=73.5±11.9 kg, height=1.7±0.1 m, age=22.6±4.4 years, time since surgery=37.8±23.8 mo.) were included in this study. Participants completed three trials of SLSD and SLC tasks. Lower extremity sagittal plane joint excursions and peak moments were collected via motion capture and force plate and sampled at 240 and 1200 Hz, respectively. Participants performed three isometric knee extension contractions on an isokinetic dynamometer with visual feedback. MVIC was defined as peak torque produced during the contraction. RTD outcomes were defined as the change in torque over change in time between the onset of muscle contraction and peak torque. RTD was calculated between the first 20-80% of the muscle contraction. RTD100 and RTD200 were calculated during the first 100ms

and 100-200ms of muscle contraction, respectively. Separate multiple linear regressions with forward entry were performed to assess the predictive relationship between quadriceps strength characteristics and involved limb lower extremity sagittal plane joint excursions and peak moments during both tasks. **Results:** During the SLSD task, RTD explained 16.1% of the variance in trunk flexion excursion ($p=0.009$) and RTD200 explained 12.4% of the variance in knee extension moment ($p=0.03$). During the SLC task, MVIC and RTD100 explained 54% of the variance in knee flexion excursion ($p<0.001$), MVIC explained 14.5% of the variance in hip flexion excursion ($p=0.01$), and RTD and MVIC explained 17.5% of the variance in trunk flexion excursion ($p=0.01$). MVIC also explained 36.6% of the variance in knee extension moment ($p<0.001$) and RTD100 explained 27.9% of the variance in hip extension moment ($p<0.001$) during the SLC task. **Conclusions:** MVIC does not predict sagittal plane movement during less demanding tasks of daily living, but predicts sagittal plane lower extremity joint excursions and moments during sport specific tasks. RTD outcome deficits should be addressed during rehabilitation to improve sagittal plane joint excursions and moments during both types of activities. Maximal quadriceps strength has greater association with sport specific movements, but not ADL. Clinicians should also consider aggressive incorporation of eccentric exercise and disinhibitory modalities to promote maximal quadriceps strength and address high-risk sagittal plane lower extremity biomechanics of sport specific activities.

Factors Contributing to Lower Limb Asymmetry in Healthy Adults Performing Unilateral Hopping Tests

Booth RL, Volz JD, Madsen LP, Docherty CL: Indiana University, Bloomington, IN

Context: Patients often return to sport following a lower extremity injury when their injured limb performs similarly on unilateral hopping tests compared to the uninjured limb. However, the exact target symmetry value for a safe return to sport remains arbitrary. The objective of this study was to identify variables that can better predict patients' personal lower limb symmetry values (LLSVs) for six unilateral hopping tests. **Methods:** The study design was cross-sectional. Two hundred seventy-five healthy, physically active adults comprised of recreational athletes (n=198), NCAA Division I student-athletes (n=56), and Army ROTC cadets (n=21) volunteered to participate. This included 143 males and 132 females (age = 20.16 ± 2.19 years, height = 172.66 ± 10.22 cm, weight = 72.64 ± 14.29 kg). Each

participant completed three speed (side hop, 6-meter crossover hop, figure-8 hop measured in seconds) and three distance (lateral hop, medial hop, triple crossover hop measured in centimeters) functional performance tests (FPT) on both limbs. Mean performance of the dominant and non-dominant limbs were used to calculate LLSVs. LLSVs for the speed FPTs were calculated by dividing the value of the fastest performing limb mean by the slowest performing limb mean and multiplying by 100. LLSVs for the distance FPTs were calculated by dividing the value of the shortest performing limb mean by the farthest performing limb mean and multiplying by 100. Two multiple regression models were then used to find variables that may help to predict a participant's LLSV for each FPT. All prediction models included the independent variables of gender, body mass index, and minutes of physical activity per week. One prediction model for each FPT included the previous listed variables as well as the performance of the dominant limb, whereas the second prediction model used performance of the non-dominant limb. **Results:** The mean LLSV was above

90% for all FPTs (Side hop=94.1±5.5; Figure-8=96.1±3.7; 6-meter=91.9±7.2; Triple Crossover=93.4±6.5; Lateral hop=93.8±5.2; Medial hop=93.8±6.5). Ten of the 12 regression models were statistically significant (p>0.05), with the triple crossover hop (F(4,269)=1.59, p=.176) and lateral hop (F(4,269)=1.55, p=.189) dominant limb models not reaching significance. The side hop regression models produced the highest Pearson R values at 0.38 for the dominant limb model and 0.47 for the non-dominant limb model. The other 8 statistically significant regression models had R values between .20 and .30 indicating a small to medium linear association. Table 1 shows the regression equations obtained for each FPT along with statistically significant variables. **Conclusions:** We found significant predictor variables that clinicians may use in the absence of baseline testing to formulate target LLSVs that are specific to their patient. Individualizing return to play decisions in this way may help to minimize subjectivity in the return to play decision making process, and help to ensure a safe and timely return to competition.

Table 1. Regression equations for each FPT. All equations include the unstandardized coefficients for each variable in the equation.

Functional Performance Test	Multiple Regression Equation using Age, BMI, Minutes of Physical Activity, and Dominant Limb Performance Coefficients	Multiple Regression Equation using Age, BMI, Minutes of Physical Activity, and Non-Dominant Limb Performance Coefficients
Side Hop	LLSV = 91.67 + (.70 x Gender*) + (-.06 x BMI) + (-.19 x MPA) + (.01 x DomPerf*)	LLSV = 98.68 + (2.11 x Gender*) + (.16 x BMI) + (-.49 x MPA) + (-.89 x NonDomPerf*)
Figure-8 Hop	LLSV = 103.2 + (.05 x Gender) + (-.15 x BMI*) + (-.16 x MPA) + (-.26 x DomPerf*)	LLSV = 104.05 + (.41 x Gender) + (-.13 x BMI*) + (-.19 x MPA) + (-.39 x NonDomPerf*)
6-meter Crossover Hop	LLSV = 96.32 + (.28 x Gender) + (.01 x BMI) + (-.33 x MPA) + (-1.4 x DomPerf*)	LLSV = 97.17 + (.60 x Gender) + (.02 x BMI) + (-.36 x MPA) + (-1.79 x NonDomPerf*)
Triple Crossover Hop	LLSV = 91.67 + (.70 x Gender) + (-.06 x BMI) + (-.19 x MPA) + (.01 x DomPerf*)	LLSV = 88.05 + (1.62 x Gender) + (-.02 x BMI) + (-.31 x MPA) + (.02 x NonDomPerf*)
Lateral Hop	LLSV = 86.59 + (1.16 x Gender*) + (.13 x BMI) + (-.06 x MPA) + (.01 x DomPerf*)	LLSV = 83.13 + (2.11 x Gender*) + (.15 x BMI) + (-.18 x MPA) + (.02 x NonDomPerf*)
Medial Hop	LLSV = 92.64 + (-.40 x Gender) + (-.04 x BMI) + (-.28 x MPA) + (-.01 x DomPerf*)	LLSV = 93.78 + (-.69 x Gender) + (-.05 x BMI) + (-.23 x MPA) + (.007 x NonDomPerf)

Note: * shows the variables in each equation with a statistically significant slope coefficient. BMI = Body Mass Index; MPA = Minutes of physical activity; DomPerf = Mean performance on the test using dominant limb; NonDomPerf = Mean Performance on the test using non-dominant limb.

Free Communications, Poster Presentations: Foot and Ankle Pathology Interventions

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;

Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

A Novel Technique for Improving Tibial Internal Rotation Range of Motion (ROM)

Stanek JM, Brown BJ, Barrack JS, Parish JG: Illinois State University, Normal, IL

Context: Despite tibial rotation ROM being difficult to measure, this motion is essential for ankle and knee function. Previous research has demonstrated tibial internal rotation (IR) increases with knee flexion angles. During closed-chain activities such as squatting, the tibia must internally rotate to allow ankle dorsiflexion and pronation to occur. Lost ankle dorsiflexion is common following ankle injury and is implicated with a number of lower extremity pathologies. Anecdotally, clinicians have been performing techniques to restore tibial IR to improve ankle dorsiflexion, however, no evidence exists to support their efficacy. Therefore, the two objectives were to: 1) Determine the effectiveness of a technique for improving tibial internal rotation ROM and 2) Examine the relationship between dorsiflexion and tibial IR ROM. **Methods:** Study Design and Setting: Cohort; AT clinic. Patients or Other Participants: Twenty-four participants (age: 20.1 ± 1.2 years, 68.9 ± 13.5 kg, 171.3 ± 10.4 cm) qualified based on one or both limbs having $<12^\circ$ of tibial IR. In instances when both limbs qualified, both limbs were assigned to the same group. In all, 21 limbs were allocated into each of the control and experimental groups. Interventions: Participants' closed chain ankle dorsiflexion and tibial IR were assessed at baseline and immediately post-treatment. Control group participants sat quietly for 5 minutes. The experimental group performed 3 sets of 15 repetitions of a mobilization with movement technique. An elastic band was wrapped around the tibia with the participant in a lunge position with the test limb forward. To the beat

of a metronome, the participant lunged forward into ankle dorsiflexion while the examiner simultaneously passively moved the tibia into IR. Returning to the starting position completed one repetition. Main Outcome Measures: Closed chain dorsiflexion was assessed with a digital inclinometer in standing and kneeling. Active tibial IR was assessed in sitting using a smartphone compass secured to the anterior tibia. Change scores were calculated for each participant and independent samples t-tests were used to compare groups. Pearson correlations were used to determine relationships between tibial IR and dorsiflexion. **Results:** A significant difference in change scores was found between groups for tibial IR ($p=0.001$, effect size 1.09, 95%CI: 0.44-1.74) but not for standing ($p=0.97$) or kneeling ($p=0.42$) dorsiflexion ROM. Participants in the intervention group (2.03 ± 2.24) increased tibial IR compared to the control group (-0.62 ± 2.60). A weak, non-significant correlation was found between tibial IR and both standing ($r=0.20$, $p=0.15$) and kneeling dorsiflexion ($r=0.02$, $p=0.87$). **Conclusions:** A single mobilization with movement treatment is effective for improving tibial IR ROM. However, active tibial IR and end-range dorsiflexion range of motion do not appear to be correlated based on these methods. Future research should examine normative values of tibial internal rotation occurring concurrently during closed chain dorsiflexion and examine the correlation.

Validity of a Novel Cross-Line Laser for Predicting Lateral Plantar Pressure in Individuals With Chronic Ankle Instability

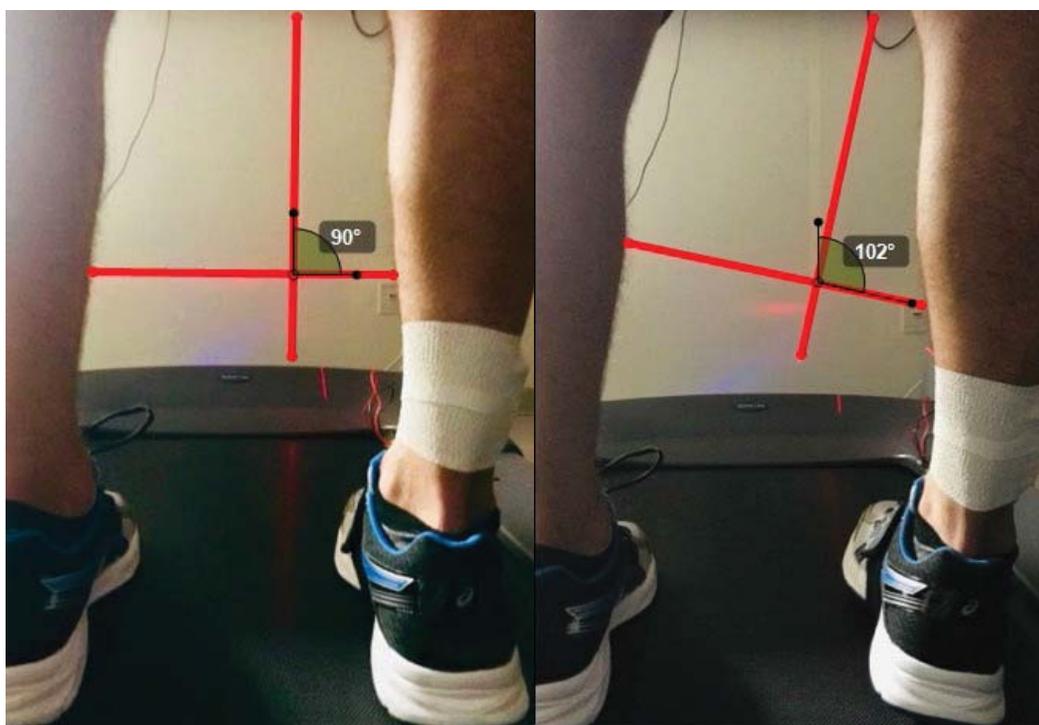
Torp DM, Thomas AC, Donovan L: University of North Carolina at Charlotte, Charlotte, NC

Context: Increased plantar pressure within the lateral midfoot and lateral forefoot is thought to contribute to repetitive ankle sprains and the development of ankle osteoarthritis in patients with CAI. Presently, there is no valid low-cost clinical tool that can predict lateral plantar pressure in patients with CAI. The objective of this study was to determine the validity of a cross-line laser for predicting lateral midfoot and forefoot peak plantar pressure in patients with CAI during treadmill walking. **Methods:** Twenty-five participants with CAI (20.8 ± 2.3 years, 170.4 ± 10.4 cm, 78.9 ± 22.4 kg) were fitted with standard athletic shoes and plantar pressure insoles. A cross-line laser was fixed to the dorsum of the involved foot using a strap. Next, the participant stood on the treadmill in a

neutral position so that the vertical line of the laser was perpendicular to the floor (90°) while the horizontal line was parallel (0°) when projected on the wall (Figure 1). During walking, rotation of the laser cross-line signified that the foot was no longer in a neutral position. A video camera mounted to the treadmill was used to record laser motion during walking at 60 frames-per-second. Following set-up, participants walked on the treadmill for 30s at a self-selected pace while plantar pressure and video of the laser projection were simultaneously recorded. Using the plantar pressure software, peak pressure (kilopascals) of the lateral midfoot and forefoot was obtained and averaged across the middle 10-consecutive steps. Peak rotation (degrees) of the laser cross-line was measured and averaged across the middle 3-consecutive steps using a free virtual goniometer. Separate linear regression analyses using the enter method was conducted to predict peak plantar pressure of the lateral midfoot and forefoot from the peak rotation values of the laser cross-line. The peak rotation values were entered into the two regression equations produced to

calculate the estimated peak pressures of the lateral midfoot and forefoot. The absolute agreement between both the actual peak pressure of the lateral midfoot and forefoot and the corresponding estimated peak pressure using the laser rotation value were assessed using interclass correlations coefficients (ICC2,1). **Results:** The peak rotation of the laser during walking explained 57% of variance in peak plantar pressure of the lateral midfoot ($R^2=0.57$; $p<0.001$) and 64% within the lateral forefoot ($R^2=0.64$; $p<0.001$). Furthermore, good absolute agreement existed between the actual peak pressure value and the estimated peak pressure via the laser rotation value of both the lateral midfoot (ICC=0.74; $p<0.001$) and lateral forefoot (ICC=0.79; $p<0.001$). **Conclusions:** The cross-line laser is a valid tool that can estimate peak plantar pressure within the lateral midfoot and lateral forefoot in patients with CAI during treadmill walking. The cross-line laser may provide clinicians a low-cost method to assess gait in patients with CAI.

Figure 1. Example of neutral and rotated positions of cross-line laser.



Normative Data on Ankle Dorsiflexion Range of Motion Measured Using the Weight-Bearing Lunge Test

Loutsch RA, Moss DP, Richard LM, Riddle ZL: Northwestern College, Orange City, IA

Context: The weight-bearing lunge test is a simple clinical evaluation method used to measure ankle dorsiflexion range of motion and has been shown to have good inter-rater and intra-rater reliability; however, there is a lack of research reporting normative values for the weight-bearing lunge test. Therefore, the purpose of this study is to identify normative data on the weight-bearing lunge test in collegiate athletes. **Methods:** Prior to the start of the fall sport season, ankle dorsiflexion range of motion (ROM) was recorded using the weight-bearing lunge test on 148 healthy collegiate athletes (104 males, 44 females; age range = 17-23 years). Participants volunteering for this cross-sectional study participated in football (N = 70), women's soccer (N = 27), men's soccer (N = 27) and women's volleyball (N = 17). The Clinometer smartphone application (Plaincode™) was used to measure tibial angle during the weight-bearing lunge test. Participants performed the weight-bearing lunge test three times on each leg and the mean angle of the three trials was used for data analysis. Prior to the start of the study all researchers involved with data collection performed reliability testing on the weight-bearing lunge test. The results of the reliability testing suggest that both intra-rater (ICC = .712-.973; $p = .036 < .001$) and inter-rater (ICC = .987; $p < .001$) reliability was good among all researchers. Normative values for ankle dorsiflexion ROM measured using the weight-bearing lunge test was analyzed using SPSS (version 25, IBM Corp, Armonk, NY). **Results:** Mean ankle dorsiflexion ROM among all participants was $41.7^\circ \pm 6.7^\circ$ ($23.8^\circ - 61.2^\circ$). There was no statistically significant difference ($p = .078$) between males ($41.1^\circ \pm 6.9^\circ$) and

females ($43.2^\circ \pm 6.0^\circ$). Difference between right and left ankle dorsiflexion ROM was also analyzed and there was a significant difference ($p = .002$) between males ($2.1^\circ \pm 1.6^\circ$) and females ($3.1^\circ \pm 2.2^\circ$). **Conclusions:** This study provides normative data of ankle dorsiflexion ROM using the weight-bearing lunge test. Limited ankle dorsiflexion has been associated with an increased risk of lower extremity injuries, therefore, the results of this study provide normative data in healthy collegiate athletes that may be used to identify patients who may have limited ankle dorsiflexion ROM. Further research needs to be done in order to identify if limited dorsiflexion ROM measured using the weight-bearing lunge test is associated with a greater risk of lower extremity injuries.

The Effect of the Figure-Eight on Sagittal Plane ROM During Prophylactic Ankle Taping of NCAA Division I Athletes

Hollien AM, Bremner CB, Samson CO, Spencer RB: Southern Utah University, Cedar City, UT

Context: Prophylactic ankle taping is widely used to limit ankle ROM. The figure-eight component is thought to limit ankle ROM in the sagittal plane, especially plantarflexion, but it is unclear if sagittal plane ROM differs as a result of including this component. Therefore, our objective was to analyze ankle taping that included two figure-eights and compare sagittal plane closed-chain ROM with ankle taping where the figure-eights were excluded. We hypothesized that the figure-eights would provide greater ROM limitations. **Methods:** This cross-over study was conducted in a university Athletic Training facility. Healthy NCAA Division I athletes were recruited through convenience sampling ($n=7$; 4 female, 3 male; height= 172.72 ± 14.2 cm; mass= 71.0 ± 17.7 kg; age= 21.3 ± 2.1 yrs). Participants completed two sessions separated by a minimum of 24 hours. During the first session, baseline ROM measurements were obtained following a standardized warm-up, and a randomly assigned ankle (non-dominant vs. dominant) was taped using one of two randomly assigned conditions (figure-eight or no-figure-eight). ROM measurements were again taken following the taping condition. During the second session participants were taped using the other condition and ROM measurements were repeated. Ankle taping was applied to each participant by the same examiner to prevent inter-examiner variations. Dorsiflexion and plantarflexion ROM were measured by marking the fibular head, lateral malleolus, and styloid process of the fifth metatarsal. Participants were video recorded while performing closed-chain dorsiflexion and plantarflexion, and end ROM for each motion was obtained with video analysis software. During

each condition (baseline, figure-eight, no figure-eight) three repetitions of each motion were performed and the mean of these values was used to represent available dorsiflexion and plantarflexion ROM. A repeated measures ANOVA was used to examine the differences between conditions for closed chain dorsiflexion ROM, and pairwise comparisons with a Bonferroni correction were used to examine the condition main effect. A Friedman's ANOVA was used to examine the differences between conditions for closed chain plantarflexion ROM because the assumption of normality was violated. **Results:** There was a significant main effect for condition with respect to closed-chain dorsiflexion ROM ($F_{2,12}=12.618$, $P=0.001$). Pairwise comparisons revealed that relative to the baseline condition ($103.24\pm 2.09^\circ$) significantly less closed chain dorsiflexion ROM occurred under the figure-eight condition ($P=0.014$; $111.67\pm 2.37^\circ$) and under the no figure-eight condition ($P=0.043$; $108.95\pm 1.69^\circ$). However, there were no significant differences between the two taping conditions ($P=0.367$). There was no significant main effect with respect to closed-chain plantarflexion ROM ($X^2_2=2.889$, $P=0.236$; baseline = $165.03 \pm 2.32^\circ$, with figure-eight= $161.05\pm 1.43^\circ$, no figure-eight= $162.24\pm 1.15^\circ$). **Conclusions:** Closed-chain dorsiflexion ROM was limited by the ankle tape, irrespective of the taping method used, but the taping conditions did not significantly limit closed chain plantarflexion. This was unexpected, as the figure-eight component is commonly used to limit plantarflexion rather than dorsiflexion. Additional research on this topic is warranted.

Ankle Bracing as a Mediator of the Influence of Attentional Foci on Landing Mechanics in Healthy Females

Haines M, Murray AM, Glaviano NR, Gokeler A, Norte GE: The University of Toledo, Toledo, OH; Paderborn University, Paderborn, Germany

Context: Decreased ankle dorsiflexion is associated with high-risk knee biomechanics, and identified as a predictor for noncontact ACL injury. Use of prophylactic ankle bracing is common, yet this practice has been linked with similar high-risk knee biomechanics, and may mimic a pathological restriction in ROM. Current evidence suggests that motor learning can be leveraged to optimize landing biomechanics associated with ACL injury by emphasizing an external focus of attention. However, it is unknown whether these benefits are negated in the presence of a mechanically restricted joint. Therefore, our purpose was to determine if ankle bracing mediates the effects of attentional foci on landing biomechanics. **Methods:** This crossover study was conducted in a university laboratory. Nineteen healthy

females (age: 21.4±2.0 years, height: 169.6±8.9 cm, mass: 72.2±11.8 kg, Tegner activity scale: 6.5±1.7) participated. Independent variables included bracing (brace, no brace) and attentional foci (neutral, internal focus [IF], external focus [EF]) conditions. Dependent variables included three-dimensional hip, knee, and ankle kinematics and kinetics in the sagittal and frontal planes. Participants completed 6 blocks of drop vertical jumps from a 30-cm box onto two force platforms. Instructions specific to each mode of attentional foci were repeated during 3 practice trials, immediately prior to completing 5 test trials using self-controlled feedback only (Table 1). The order of testing conditions was randomized and data from the dominant limb were analyzed. Peak joint angles (°) and knee moments (Nm/kg) were compared between testing conditions using separate 2x3 ANOVA with repeated measures. Mean differences with 95% confidence intervals (CI) are reported below. **Results:** Greater hip flexion and abduction occurred during EF compared to IF (flexion: 3.2° [0.1-6.6°], P=.050; abduction: 3.0° [1.7-4.3°], P<.001) and neutral (flexion: 4.9° [2.5-7.3°], P<.001; abduction: 3.1° [1.8-4.3°], P<.001) conditions regardless of

bracing. Greater knee flexion occurred when braced compared to not braced regardless of attentional foci (2.0° [0.1-4.0°], P=.044). Lesser knee abduction occurred during EF compared to IF (1.0° [0.2-1.8°], P=.018) and neutral (1.0° [0.5-1.5°], P<.001) conditions regardless of bracing. Lesser knee flexion moment occurred when braced compared to not braced (0.5 Nm/kg [0.4-0.6 Nm/kg], P<.001), and during EF (0.7 Nm/kg [0.5-0.8 Nm/kg], P<.001) and IF (0.8 Nm/kg [0.5-1.1 Nm/kg], P<.001) compared to neutral conditions. Lesser knee abduction moment occurred during EF compared to IF (0.04 Nm/kg [0.01-0.07 Nm/kg], P=.008) and neutral (0.04 Nm/kg [0.02-0.06 Nm/kg], P=.002) conditions regardless of bracing. Lesser ankle dorsiflexion occurred when braced compared to not braced regardless of attentional foci (5.8° [4.1-7.6°], P<.001). **Conclusions:** An external focus of attention optimized hip and knee landing mechanics in healthy females similarly when ankle ROM was mechanically restricted or not. Clinicians may consider providing athletes with instructions that promote an external focus of attention during landing maneuvers when prescribing ankle braces.

Table 1. Instructions provided to participants for each mode of attentional foci

Neutral	This is a drop vertical jump task. The goal of this task is to jump as high as you possibly can after you have landed on the force plates. When you do this, I want you to jump off the box with both feet at the same time, jump forward to reach the force plates, land with your entire foot in each force plate, and complete the task in a fluid motion.
Internal Focus	This time, complete the same task, but I only want you to focus on: <ol style="list-style-type: none"> 1. Keeping your knees over your toes. 2. Extending your knees as rapidly as possible after you have landed on the force plates.
External Focus	This time, complete the same task, but I only want you to focus on: <ol style="list-style-type: none"> 1. Pointing your knees toward the poles. 2. Pushing yourself off the ground as hard as possible.

Individuals With Plantar Heel Pain Demonstrate Altered Foot Posture, Plantar Fascia Thickness, and Plantar Cutaneous Sensation

Hogan KK, Prince JA, Hoch MC: Old Dominion University, Norfolk, VA; University of Kentucky, Lexington, KY

Context: Plantar heel pain (PHP) is a common injury in physically active individuals that decreases the ability to participate in physical activity and negatively impacts quality of life. Although there has been consistent evidence regarding the symptoms of plantar fasciitis, there has been inconsistent evidence to explain the multifaceted etiology of this condition.¹ The purpose of the study was to compare foot posture, plantar sensation, plantar fascia thickness and abductor hallucis morphology in individuals with and without PHP.

Methods: Sixteen individuals with PHP (females = 13, males = 3; age = 25.0 ± 8.8 yrs; height = 1.65 ± 0.07 m; weight = 66.71 ± 11.03kg; pain duration = 35.0 ± 30.50mo) and sixteen matched healthy participants (females = 13, males = 3; age = 26.06 ± 6.92 yrs; height = 1.67 ± 0.06 m; weight = 67.14 ± 11.16 kg) volunteered to participate. Participants with PHP presented with heel pain, pain upon palpation of the plantar aspect of the heel, and a history of morning plantar heel pain which decreased after walking, and/or increased after exercise within the past month. Participants reported to the laboratory for a single testing session in which foot posture, plantar sensation, plantar fascia thickness, and abductor hallucis cross-sectional area (CSA) were evaluated. Foot posture was assessed with the Foot Posture Index-6 (FPI-6) which grades six criteria on a 5-point Likert-scale ranging from -2 to 2 which were summed for a total score ranging from -12 (highly supinated) to 12 (highly pronated). Plantar fascia thickness and abductor hallucis CSA were measured utilizing

MHz linear array transducer probe. Abductor hallucis CSA was measured anterior to the medial malleolus while the individual was asked to perform a short foot exercise in a bi-pedal stance. Plantar fascia thickness was measured at three sites (proximal insertion, navicular, second metatarsal head) from the medial calcaneal tubercle to the second toe.² Plantar foot sensation was assessed using Semmes-Weinstein Monofilaments with 4 - 2 - 1 stepping algorithm. Sensation thresholds were tested at the head of the first metatarsal and 50% of the medial longitudinal arch.³ Between group differences were evaluated using independent t-tests for all outcome measures ($\alpha \leq 0.05$).

Results: Individuals with PHP exhibited a more pronated foot posture (PHP=6.7±3.4; healthy=3.0±3.6, p=0.01) and displayed greater plantar fascia thickness at the proximal insertion (PHP=0.32±0.09cm; healthy=0.25±0.04cm, p=0.02) compared to healthy controls. Plantar sensation thresholds were higher in the PHP group compared to healthy controls at the head of the first metatarsal (PHP=3.85±0.72; healthy=3.22±0.39, p=0.01) and medial longitudinal arch (PHP=3.91±0.42; healthy=3.62±0.38, p=0.04). There was no difference in abductor hallucis CSA between groups (PHP=2.15±0.53; healthy=1.99±0.57, p=0.41). **Conclusions:** Individuals with PHP exhibited a more pronated foot posture, thicker plantar fascia, and diminished plantar tactile sensation. Cumulatively, these findings provide evidence that PHP is associated with both mechanical and sensorimotor deficits in the foot. Future research should examine how these impairments contribute to alterations in gait and postural control in patients with PHP.

Optimal Therapeutic Interventions Administered by Athletic Trainers in the Management of Pain and Function From Plantar Fasciitis: A Systematic Review

Liedel BM, Bogner LR, Berry DC: Saginaw Valley State University, University Center, MI

Context: Plantar fasciitis (PF) is a common source of heel pain, triggered by standing, walking, and running, among others. Noninvasive interventions include plantar fascia-specific stretching, calf-stretching, custom-made orthotics and dorsiflexion night splints. The objective is to systematically review, evaluate, and summarize the literature related to plantar fasciitis interventions from randomized controlled trials (RCT) to determine optimal intervention strategies for use by athletic trainers (ATs) to manage pain. **Methods:** Databases searched included: CINAHL, PubMed, and MEDLINE using the phrases (1) (“plantar fasciitis” AND treatment), (2) (“plantar fasciitis” AND myofascial release), (3) (“plantar fasciitis” AND Graston), (4) (“plantar fasciitis” AND physical therapy) from January 1996-to-October 2018, resulting in 121 articles. Following initial screening (duplicates=71, title, abstract), thirteen articles were reviewed; nine met the inclusion criteria: (1) peer-reviewed, RCTs, (2) interventions applied to 15-75-year-old participants with confirmed PF, (3) English-language, (4) available abstract, (5) interventions within an AT’s scope of practice defined by the NATA Athletic Training Educational Competencies, 5th Edition and Board of Certification’s Practice Analysis 7th Edition, and (6) outcomes measuring pain. Two reviewers independently assessed studies’ level of evidence (LOE), quality via the Oxford Center for Evidence-Based Medicine (2011) and Physiotherapy Evidence Database (PEDro) instruments, respectively. Data of interest: subjects, interventions (type, length), descriptive/inferential data and mean differences (MD) and effect sizes (d) of outcomes.

Results: Nine studies (LOE=2) met

inclusion criteria, all full-reports. PEDro scores ranged from 5-9 (maximum=10, average=6.61±0.96). Pooled sample size=333, average age=47±16.59. Three studies found myofascial release (MFR) with conventional physical therapy (MD-VAS=4.20±0.94) superior to Cyriax massage technique (MD-VAS=3.26±1.22, $p=0.026$, $d=0.86$), MFR with conventional exercise (MD-VAS=2.01) superior to therapeutic ultrasound (MD-VAS=1.58, $p=0.023$), and MFR (VAS=1.69±1.03) superior to static stretching (VAS=3.52±1.07, $p=0.039$, $d=1.74$) to decrease pain. Low-dye taping significantly decreased pain compared to calcaneal glide mobilization ($p=0.040$). Low-level laser therapy (VAS=2.93±1.84, $p=0.006$, $d=0.395$) and shockwave therapy (VAS= 2.81±1.27, $p=0.012$, $d=0.503$) decreased pain significantly more compared to ultrasound (VAS=3.77±2.38). There was no significant difference in pain between (1) MFR (VAS=13.13±11.45) and iontophoresis (VAS=11.86±11.32, $p=0.763$, $d=0.112$), (2) chiropractic foot mobilizations with Achilles stretching ($p=0.08$) to orthotics ($p=0.235$); (3) ankle and midfoot mobilizations (NRS=5.6±3.3) to therapeutic ultrasound (NRS=5.28±2.88, $p=0.637$, $d=0.19$); and (4) dry cupping (VAS=29.80±9.65) to electrical stimulation (VAS=28.0±8.75, $p=0.697$, $d=.20$). **Conclusions:** There is little evidence to support a “gold standard” in the management of plantar fasciitis pain by ATs. Despite a “gold standard”, MFR appears to be most effective (weak-to-moderate recommendation) when factoring in variables like the ease of access and cost-effectiveness. Interventional strategies should be based on thorough patient assessment and understanding of patient expectations. Further research should differentiate between intervention effects to establish a gold standard intervention for PF and examine the interrelationship between pain and function.

Plantar Pressure Analysis In Walking Orthoses After 1st Metatarsophalangeal Joint Arthrodesis

Johnson D, Corbett RO, Vela LI, Cooper MT, Hertel J: University of Virginia, Charlottesville, VA

Context: When the 1st metatarsophalangeal joint (MTPJ) is compromised due to arthritis, malalignment, or persistent pain, arthrodesis of the 1st MTPJ may be indicated. There is currently no gold standard for prescribing a specific orthosis to patients after 1st MTPJ arthrodesis. Our purpose was to measure plantar pressure under the 1st MTPJ during walking and assess patient perceptions of comfort, stability, and preference in 4 orthosis conditions in patients who had previously undergone 1st MTPJ arthrodesis. **Methods:** A laboratory study utilizing a crossover design was performed. Eleven participants (8 females, 3 females; age=59.4±9.1 years; time since surgery=21.9±17.5 months) volunteered. Participants had undergone unilateral 1st MTPJ arthrodesis greater than 6 months before participation. Four orthosis

conditions were evaluated: no orthosis, carbon fiber insert (DynaFlex Carbon Graphite Plate, Wrymark Inc., St. Louis, MO), Darco wedge (OrthoWedge™, Darco International, Huntington, WV), and walking boot (Post Operation Shoe Square Toe, Breg Inc., Carlsbad, CA). The first two conditions were performed in participants' own casual athletic shoes. Instrumented insoles (Pedar, Novel Inc., Munich, Germany) assessed peak plantar pressure and pressure-time integral measured under the 1st MTPJ during 10 walking steps in each condition. Participants subjectively rated each condition for comfort and stability on 10cm visual analogue scales (VAS) (extremely uncomfortable/unstable=0cm, extremely comfortable/stable=10cm), and rank ordered the 4 conditions for preference to wear during walking. For the plantar pressure and VAS measures, one factor repeated measures ANOVAs assessed the effect of the orthosis conditions. For the preferred rank measure, Friedman's ANOVA compared the preference rankings across the 4 conditions. **Results:** Significant main effects for orthosis condition were identified for the plantar pressure measures (p<0.001, see Table). The Darco wedge

yielded significantly lower 1st MTPJ peak pressure than the other three conditions (p<0.05), and the carbon fiber insert yielded significantly higher 1st MTPJ peak pressure than the other three conditions (p<0.05). The pressure-time integral for the Darco wedge was significantly less than the carbon fiber insert and walking boot (p<0.05). There were significant differences across the orthosis conditions for the comfort, stability, and preference measures (p<.02, see Table). Participants rated the Darco wedge as less comfortable than no orthosis and walking boot (p<.03), and the carbon fiber insert to be less comfortable than no orthosis (p=.05). Participants also rated the Darco wedge and walking boot as less stable than no orthosis (p<.04). Participants rank ordered their preferred conditions as: 1) no orthosis, 2) carbon fiber insert, 3) walking boot, and 4) Darco wedge (p=.003). **Conclusions:** The Darco wedge best protected the 1st MTPJ based on the plantar pressure measures, yet was subjectively ranked by participants as the least preferred orthosis. Clinicians must weigh these conflicting findings when prescribing orthoses to patients after 1stMTPJ arthrodesis.

Table. Means and standard deviations of outcome measures.

	No Orthosis	Walking Boot	Carbon Fiber Insert	Darco Wedge
1st MTPJ Peak Pressure (kPa)	228.0±95.0*^	207.3±122.3*^	284.4±98.6*	142.9±73.4^
1st MTPJ Pressure-Time Integral (kPa * sec)	59.3±40.8^	82.3±41.4*^	98.8±50.6*	64.0±37.0^
Stability VAS (cm)	8.6±1.9*	5.7±3.0#	6.7±2.6	6.3±3.2#
Comfort VAS (cm)	8.7±1.6*	7.8±2.2*	6.7±2.5#	5.8±3.3#
Preference Rank	1.4±0.5\$	2.8±1.0#\$	2.5±1.2#\$	3.4±0.7#

VAS = visual analog scale
 *Significantly greater than Darco Wedge (p<0.05)
 ^Significantly less than Carbon Fiber Insert (p<0.05)
 #Significantly less than No Orthosis (p<0.05)
 \$\$Significantly less than Darco Wedge ((p<0.05)

Opioid and Non-Opioid Prescribing Rates for Ankle Sprains in Emergency Departments Across the United States Between 2006 and 2015

Kosik KB, Bain KA, Villasante Tezanos AG, Hoch MC, Gribble PA: University of Kentucky, Lexington, KY

Context: An ankle sprain is a minor joint injury that can be managed effectively with conservative treatment. However, one out of five adults diagnosed with an ankle sprain filled a prescription for a 3-day supply of opioids and <7% of patients received formalized rehabilitation to alleviate their symptoms in 2015. Managing ankle sprains with opioids rather than physical rehabilitation is a significant healthcare concern given the well-known consequences associated with opioid use. An aspect that remains unknown is the impact age has on prescribing scheduled and non-controlled substances among patients diagnosed with an ankle sprain. Understanding the prescribing habits among different age cohorts is important because the

majority of patients that sprain their ankle are in adolescent and young-adult populations who at the greatest risk of abusing opioids. Therefore, the purpose of this study was to describe the percentage of patients presenting to an Emergency Department (ED) with an ankle sprain prescribed scheduled and non-controlled analgesics along with the distribution of those prescriptions among different age cohorts. **Methods:** This was a secondary analysis of the publicly available data collected through the annual National Hospital Ambulatory Medical Care Survey from 2006 to 2015. Data were analyzed using the sampled visit weight, yielding an unbiased national estimate of ED percentages. Because of the complex sample design, sampling errors were determined using SAS software, Version 9.4. **Results:** Between 2006 and 2015, an estimated 9,052,678 patients in United States EDs received an isolated diagnosis of an acute ankle sprain. Across all years, 75.5% of patients presenting with an ankle sprain received medication during their visit to the ED. Non-controlled substances were the most common medications prescribed (68.5%) with the majority of these

administered to patients between 15-24(29.3%) and 25-44(31.2%) years old (Table 1). However, 20.9% and 6.4% of patients were prescribed a schedule III or a schedule II drug, respectively. Schedule III drugs were most often prescribed to patients 25-44(48.8%) and 15-24(30.7%) years old (Table 1). Likewise, patients 25-44(50.6%) and 15-24(25.2%) years old received a majority of the prescribed schedule II drugs (Table 1). **Conclusions:** A majority of patients presenting to ED in the United States and diagnosed with an ankle sprain were prescribed an analgesic. While a large proportion of patients received a non-controlled substance, 1 out of 4 patients received a schedule II or II substance with the majority of these prescribed to those between 15-44 years of age. This is concerning because this is an age group that is at the highest risk of abusing opioids. To prevent patients from being introduced to substances that are known to be addictive, future research should focus on implementing non-pharmacological interventions to manage pain and facilitate access to physical rehabilitation specialists to restore proper function.

Table 1. Percentage of Scheduled and Non-Controlled Analgesics by Age Category that were Prescribed to Patients Diagnosed with an Ankle Sprain in the Emergency Departments Across the United States Between 2006 and 2015

	<15 years	15-24 years	25-44 years	45-64 years	65-74 years	>75 years
Schedule II	3.03	12.72	38.07	31.16	7.35	7.64
Schedule III	5.10	18.83	39.59	25.62	5.63	5.19
Schedule IV	3.03	13.74	38.18	30.07	6.59	8.36
Schedule V	9.56	15.00	36.41	26.25	7.5	5.25
Multiple Schedules	28.27	19.28	26.54	17.05	4.83	4.00
Non-Controlled	20.68	15.44	27.50	21.21	6.46	8.67

Predicting Responders Following a 4-Week Multimodal Intervention in Patients With Chronic Ankle Instability

Powden CJ, Hoch JM, Hoch MC: Indiana State University, Terre Haute, IN; University of Kentucky, Lexington, KY

Context: Patients with chronic ankle instability (CAI) suffer from a range of impairments such as range of motion, balance, strength, and self-reported function. Rehabilitation interventions have been developed to improve many of these areas of impairment. Despite the general success of these interventions, some patients fail to experience meaningful improvements. Identifying characteristics of CAI patients that predict a positive response to rehabilitation would enhance clinical decision making for these individuals. Therefore, the purpose of this study was to identify characteristics of CAI patients which predict which individuals will most likely demonstrate a positive response to a 4-week multimodal intervention. **Methods:** Twenty patients (15 females, 5 males; age=24.4±7.0yrs; height=169.29±10.1cm; weight=70.6±12.9kg) with self-reported CAI participated in this prospective, repeated measures study. Inclusion criteria included ≥1 previous ankle sprains, ≥2 episodes of giving way in the previous three months, answering “yes” to ≥5 questions on the Ankle Instability Instrument, and ≤24 on the Cumberland Ankle Instability Tool. Patients participated in 12 supervised intervention sessions that included progressive balance training, ankle strengthening, and talocrural joint mobilizations and daily home ankle strengthening and gastroc-soleus complex stretching throughout the 4-weeks. All outcomes were measured before (pre-intervention) and after (post-intervention) the 4-week intervention. The weight-bearing lunge test (WBLT) assessed ankle ROM. A hand-held dynamometer assessed isometric ankle and hip strength. The anterior, posteromedial, and posterolateral

directions of the Y-Balance test assessed dynamic postural control. The average of 3 trials was used for analysis for each outcome. Self-reported function was assessed using the Foot and Ankle Ability Measure (FAAM) ADL and FAAM-Sport, Disablement in the Physically Active Scale, and Fear-Avoidance Belief Questionnaire. Responders were defined as individuals who improved beyond the minimal detectable change on ≥3 of 5 outcome measures (WBLT, posteromedial Y-Balance test, eversion ankle strength, abduction hip strength, FAAM-ADL). Independent t-tests compared baseline differences in all dependent and demographic variables between responders and non-responders. Variables with a significance level of $p < 0.10$ were retained as potential prediction variables. Logistic regression was used to identify the strongest variables to predict intervention responders. Receiver Operator Characteristic (ROC) Curves determined cutoff values and diagnostic accuracy of the variables in the final logistic regression model. Alpha was set at $p \leq 0.05$. **Results:** Twelve patients (60.00%) were categorized as responders. Eversion ankle strength (Responder=3.36±0.85N/kg, Non-Responder=4.11±0.5N/kg, $p=0.03$) and weight (Responder=66.76±10.28kg, Non-Responders=76.32±14.93kg, $p=0.10$) were identified as potential predictor variables. Logistic regression indicated eversion strength and weight predicted 85% of group membership (Nagelkerke R-Square=0.566, $p < 0.01$). The cutoff point for eversion strength was 4.11N/kg (sensitivity = 0.917, specificity = 0.625) while the cutoff point for weight was 73.30kg (sensitivity = 0.833, specificity = 0.625). **Conclusions:** Patients with CAI that have decreased eversion strength and lower body weight may have a higher likelihood of experiencing meaningful improvements in multiple impairments following a 4-week multimodal intervention.

Free Communications, Poster Presentations: Functional Movement Screening and Whole Body Assessment Techniques

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Movement Strategies Change Y Balance Test Performance Variability

Chen YR, Munger LR, Hooper T, James CR: Texas Tech University Health Sciences Center, Lubbock, TX

Context: The Y Balance Test (YBT) outcome measurement is a composite score (CS) based on the maximum reach distances of three trials in each of three testing directions: anterior (ANT), posterior-medial (PM), and posterior-lateral (PL). However, performance variability of the three testing trials may also provide different clinical information about individual movement control during YBT. Movement strategy, with and without specific movement cues, may alter within trial reach distance performance variability. The purposes of this study were to 1) highlight the potential value of performance variability analysis and 2) determine whether movement strategy impacted CS and performance variability in YBT. **Methods:** This research included two controlled laboratory studies. Both

studies were conducted at Texas Tech University Health Sciences Center, Lubbock, Texas. In an initial study, fourteen subjects (eight males and six females) completed YBT on their dominate kick leg (DK). The ANT, PM, and PL reach directions were randomized during nine reaching trials. Descriptive analysis was used to investigate the range of reach distances normalized to the subject's leg length. In a second study, another sixteen subjects (eight males and eight females) were randomly assigned to two groups. Each group performed YBT on the dominate support (DS) and DK legs by using personal (P) and specific (S) strategies in different orders (P-S, S-P). Performance variability of reach distance in each direction was defined by measuring absolute error ($AE = \frac{\sum_{i=1}^3 |x_i - \bar{x}|}{3}$). Two-way mixed ANOVAs, strategy(2) x order(2), were used in a preliminary analysis to rule out an order effect in CS. Two-way repeated ANOVAs, strategy (2) x reach direction (3), were used to determine whether these independent variables affected performance variability. **Results:** The initial

descriptive analysis revealed the range of reach distances in each direction: ANT 64-69%, PM 106-112%, and PL 102-108% (Figure). For CS, there was no main order effect ($p > .05$). However, there was a significant strategy effect for both legs ($p < .001$; DS: $P = 90.01 \pm 6.98\%$, $S = 82.92 \pm 5.97\%$; DK: $P = 89.53 \pm 7.93\%$, $S = 82.82 \pm 7.80\%$). For AE in DS, there was no significant strategy effect, but there was a main direction effect ($p = .001$, $n_p^2 = .376$, Power = .953; ANT = $3.48 \pm 2.02\%$, PM = $5.18 \pm 4.15\%$, PL = $6.05 \pm 4.12\%$). For AE in DK, there was a significant strategy by direction interaction ($p = .044$, $n_p^2 = .189$, Power = .606). Post-Hoc tests revealed a significant strategy effect ($p < .05$) for PL only ($P = 4.78 \pm 3.10$, $S = 7.33 \pm 5.15$). **Conclusions:** 1) Besides CS, athletic trainers may consider analyzing performance variability while using YBT to monitor movement control ability. 2) The movement strategy used impacted CS. However, AE was only altered in the PL direction in DK. The YBT, a closed chain dynamic balance test, may be a novel task for assessing DK leg performance variability.

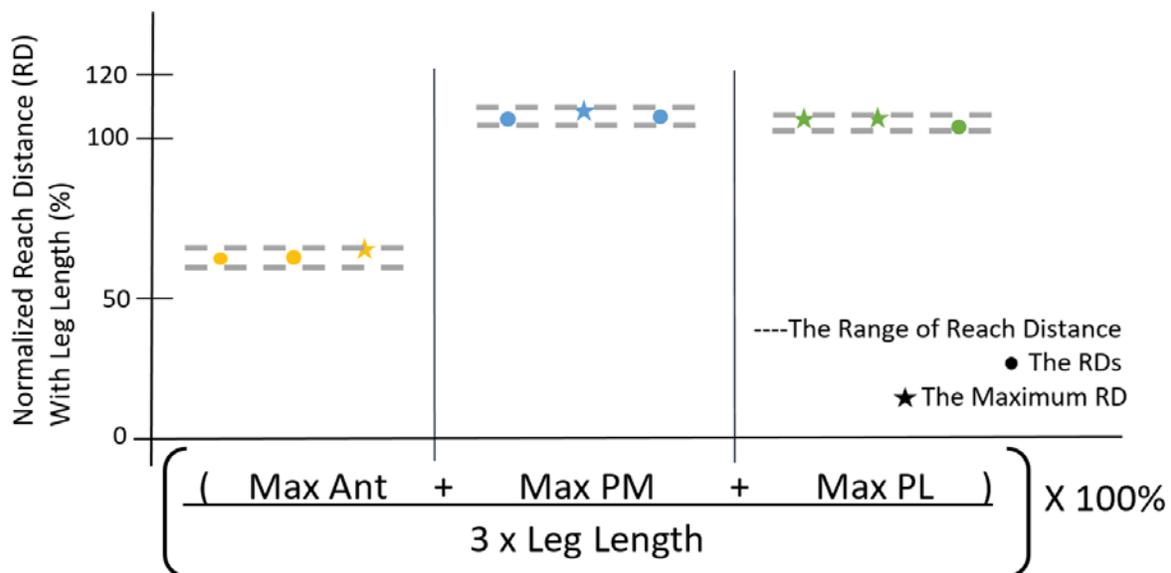


Figure to demonstrate the RD % in each testing direction (ANT, PM, PL) for the initial study

A Comparison of Balance, Postural Sway, Jump-Landing Mechanics, Reaction Time, and Visual Motor Processing Speed in NCAA Division II Athletes With and Without History of Concussion

Anderson HJ, Lundin MJ, Morrison KE, Baer DJ, Cattano NM: West Chester University of Pennsylvania, West Chester, PA

Context: A positive association between concussion and subsequent lower extremity injury has been identified yet it remains unknown as to why this elevated risk exists and how long it may exist for. Further investigating impairments associated with concussion can enhance rehabilitation and decrease risk of subsequent injury. Therefore, the purpose of this study was to compare the results of the Balance Error Scoring System (BESS), Landing Error Scoring System Real-Time (LESS-RT), Ruler Drop, and King-Devick in participants 0 to 1 year post-concussion (0-1yr), 1 to 2 years post-concussion (1-2yr), and those with no prior history of concussion (NoHx). **Methods:**

This was a cross sectional cohort study. Subjects were comprised of males (n = 23) and females (n = 22) who were NCAA Division II student-athletes at a university. Forty-five subjects were split into three different groups. Fifteen participants with history of concussion 0 to 1 year ago (age: 20.07 ± 0.88 years, height: 1.75 ± 0.11 meters, weight: 77.81 ± 20.48 kg), fifteen participants with history of concussion 1 to 2 years ago (age: 20.67 ± 0.90 years, height: 1.75 ± 0.12 meters, weight: 78.83 ± 18.89 kg), and fifteen participants with no history of concussion (age: 19.87 ± 1.36 years, height: 1.74 ± 0.13 meters, weight: 79.32 ± 26.90 kg). Participants reported one time for data collection and completed the BESS, LESS-RT, Ruler Drop, and King-Devick tests. Inferential statistics were analyzed using one-way ANOVA, Tukey Post-Hoc, and Pearson’s Correlations. **Results:** Significant group differences were found in BESS single-leg firm left-right excursion (NoHx: 4.81 ± 1.38, 0-1yr: 5.48 ± 3.65, 1-2yr: 10.08 ± 8.05; P = 0.02). Significant group differences were found in single-leg foam variability (NoHx: 0.79 ± 0.44, 0-1yr: 0.50 ± 0.22, 1-2yr: 0.55 ± 0.24; P = 0.04).

There were many significant moderate and strong positive correlations between BESS and postural sway. There were no statistically significant differences in LESS-RT or King-Devick scores between groups (Table 1). Although not statistically significant, mean differences in reaction time existed between groups (NoHx: 0.16 ± 0.03, 0-1yr: 0.17 ± 0.03, 1-2yr: 0.17 ± 0.02). **Conclusions:** This was the first research study to investigate this battery of tests in athletes 0 to 1 year post-concussion, 1 to 2 years post-concussion, and those with no prior history of concussion. Participants with history of concussion 1 to 2 years ago had poorer postural sway than healthy controls. The BESS had many moderate and strong positive correlations with the postural sway variables. Mean differences existed in reaction time between groups. Clinicians should assess athletes with history of concussion to discover poor performing athletes. Those who suffer a concussion or who may be at risk from a previous concussion could benefit from targeted preventative exercises.

Table 1. Differences between Groups

	NoHx	0-1yr	1-2yr	F	P
	Mean ± SD	Mean ± SD	Mean ± SD		
Average LESS-RT	5.42 ± 1.797	5.62 ± 2.383	6.24 ± 2.311	0.581	0.564
Total BESS Firm	3.60 ± 3.066	2.07 ± 2.738	3.93 ± 3.058	1.699	0.195
Total BESS Foam	12.33 ± 5.024	11.47 ± 4.824	12.40 ± 4.120	0.186	0.831
Total BESS	15.93 ± 7.343	13.53 ± 6.927	16.33 ± 5.996	0.749	0.479
KD Total Time (s)	42.88 ± 8.013	42.32 ± 5.612	40.60 ± 4.337	0.556	0.578
Ruler Drop Average (cm)	12.84 ± 5.068	14.70 ± 5.304	14.19 ± 3.537	0.622	0.542
Reaction Time (s)	0.16 ± 0.0316	0.17 ± 0.030	0.17 ± 0.021	0.888	0.419

Note. NoHx = No history of concussion. 0-1yr = 0 to 1 year post-concussion. 1-2yr = 1 to 2 years post-concussion. SD = Standard deviation. LESS-RT = Landing Error Scoring System-Real Time. BESS = Balance Error Scoring System. KD = King-Devick.

Risk Classification of Army Reserve Officer Training Corps Cadets Based on FMS and Y-Balance Performance Testing

Earl-Boehm JE, Reckelberg RM, Ericksen HM: University of Wisconsin, Milwaukee, WI

Context: Musculoskeletal injuries are a major source of lost time and health care expense in military populations. Athletic trainers are increasing health-care services for the military, including research on injury risk factor identification. The Reserve Officer Training Corps (ROTC) is program designed to prepare college students for careers as military officers. Cadets undergo rigorous physical and tactical training during their college years and are susceptible to musculoskeletal injuries. However, little research has focused on this population. The purpose of this study was to identify the proportion of ROTC cadets who may have elevated injury risk based on risk factors of dynamic balance, core stability, flexibility and strength. **Methods:** We used a cohort design to evaluate 52 ROTC cadets (34 males, 18 females; 19.9 ± 2.3 years; 171.8 ± 10.4 cm; 71.6 ± 13.2 kg). Participants were included if cleared to participate in physical training sessions. The Y-Balance Test (YBT) was used to measure dynamic balance, and the Functional Movement Screen (FMS) was used to measure core stability, flexibility and strength. These tests are known to be reliable and valid for use in military populations, and trained raters used standard procedures for all tests. Scores were classified as “low risk” or “high risk” based on previously established cutoffs from athletic and military populations. For FMS, the composite score of ≤ 14 was high risk, and > 14 was low risk. For the YBT three values known to predict injury risk were used: anterior reach difference > 4 cm was high risk (YBT-Adiff), composite reach difference ≥ 12 cm was high risk (YBT-compdiff), and composite reach percentage $\leq 94\%$ was high risk (YBT-comp%). Chi Square was used to examine FMS and YBT score

classification to high/low risk groups. P-value was set at $p \leq 0.05$. **Results:** The distribution of FMS scores into risk categories was not different than expected ($\chi^2(1, N=52) = 1.528, p = .216$). The average FMS composite score was 15.6 ± 1.77 . For the YBT-comp%, there were significantly more than expected cadets in the high risk group ($\chi^2(1, N = 52) = 11.792, p = .001$). The average YBT-comp% was $89.9 \pm 6.6\%$. Both of the YBT scores that demonstrate a side-to-side difference in reach distance had significantly more than expected cadets in the low risk group: YBT-Adiff ($\chi^2(1, N = 52) = 23.113, p < .0005$); YBT-compdiff ($\chi^2(1, N = 52) = 49.075, p < .0005$). Average score for YBT-Adiff was 1.2 ± 1.8 cm, YBT-compdiff was 2.9 ± 1.9 cm. **Conclusions:** Based on these data, there was a significantly greater than expected number of ROTC cadets who demonstrated poor dynamic balance scores (YBT-comp%) that placed them into a high injury risk category (73% of cadets). While overall dynamic balance was poor, there were not more cadets with side-to-side reach imbalances. Average scores for both the FMS and YBT tests fell into the range of normative data for basic training military recruits. Next, studies/programs could focus on improving overall dynamic balance by implementing basic balance exercises into the ROTC physical training routine.

Functional Movement Screen Improvement Over a 3 Month Period in Army Reserve Officer Training Corps

Atkielski SJ, Earl-Boehm J, Reckelberg RM, Ericksen HM: University of Wisconsin, Milwaukee, WI

Context: The Army Reserve Officer Training Corps (ROTC) is designed to increase the number of commissioned officers by preparing them physically and tactically during their collegiate years. Injuries experienced during ROTC can be detrimental to the cadets' future career in the armed forces. It is known that certain aspects of physical performance, such as dynamic balance, jump landing biomechanics, and functional movement, are related to elevated injury risk in military and athletic populations. Despite this, the typical physical training plan for an ROTC unit includes activities mostly geared toward improving the cadets physical fitness, with little attention paid to injury risk. It is unknown if a typical Army ROTC training routine has an effect on the previously

stated aspects of physical performance. The purpose of this study was to investigate the Functional Movement Screen (FMS), Landing Error Scoring System (LESS) and Y-Balance (Y-Bal) in a group of Army ROTC cadets over one semester of regular physical training. **Methods:** Cohort design with repeated measures over two time points. Twenty-five healthy ROTC cadets (18 males; 7 females; 20.76±2.76yrs; 1.74±0.78m; 74.02±13.97kg) cleared for participation in physical training completed this study. As part of a combined testing session, FMS, Y-Bal and LESS baseline data were collected in September and post-test data were collected in December. During the semester, cadets participated in usual competitions and regular physical training activities 4-5 days per week for at least 1 hour per session. FMS total score, LESS score and Y-Bal right side composite were calculated and used for statistical analysis. A repeated measures ANOVA was used to evaluate differences in dependent variables over time. P-value was set at p≤0.05. **Results:** Total FMS score significantly improved from September to December ($F_{(1,24)}=7.132, p=0.013$).

There was no significant change in the LESS ($F_{(1,24)}=0.009, p=0.924$) or Y-Bal ($F_{(1,24)}=1.047, p=0.316$) over the semester. Means and standard deviations are presented in Table 1. **Conclusions:** Over one semester of regular physical training, ROTC cadets demonstrated a significant improvement in their functional movement (FMS total score), but did not improve in their dynamic balance (YBal) or landing biomechanics (LESS). The improvement in FMS score could be attributed to their physical training regimen, which includes flexibility exercises. It should be noted that no specific exercises for improving balance or landing biomechanics was implemented as part of their regular training. Regular physical fitness training may not be enough to see improvements in these functional measures that have been correlated to injury risk in other populations. Future research should aim to further understand the functional impairments that may be present in the ROTC population, and to modify current physical training practices to include activities specific to improving balance and landing biomechanics.

Table 1	Pre-test September (mean±SD)	Post-test December (mean±SD)
LESS Score	6.6±1.78	6.64±1.70
FMS Total Score	13.68±1.91	14.52±2.40
Y-Bal Right Composite	90.22±5.81	91.02±6.69

Examining the Functional Movement Screen (FMS) and Y Balance Test (YBT) Scores in a Cohort of Intercollegiate Athletes Before and After a Training Intervention

Liljeberg JE, Wisthoff BA, Glutting JJ, Buckley TA, Kaminski TW: Sacred Heart University, Fairfield, CT; University of Delaware, Newark, DE

Context: The number of lower extremity (LE) injuries in Division-I collegiate student-athletes has consistently increased over the past 10 years. Even though research surrounding the FMS and YBT have been mixed, very few studies have looked at the effect of these test scores over time and relative to strength performance measures. The primary purpose of this study was to compare both YBT symmetry and FMS scores in NCAA Division-I student-athletes before and after a supervised strength and conditioning-based intervention. It was

hypothesized that athletes' test scores would increase over time following the intervention. **Methods:** This prospective cohort study, conducted in a university Athletic Training Research Laboratory, had 122 participants (42 males, 80 females) (age=19.6 ± 1.1 yrs., height=174.3 ± 8.2 cm, mass=70.4 ± 9.4 kg). Each participant completed the FMS, YBT, squat max, and bench press max testing at three separate time periods over a 17-month span. Of the 122 student-athletes participating, those that obtained a LE injury, 50 were classified as LE injured while 72 were classified as healthy. Our dependent measures were FMS scores including component (deep squat, hurdle step-over, in-line lunge) and composite and YBT difference (diff) scores for each direction (anterior-ANT, posteromedial-PM, and posterolateral-PL). The difference scores for each direction were calculated by subtracting the reach distance for each limb. The independent variable was time (before, during, and after the intervention). A one-way analysis of variance was used to compare

scores between the two screening tools (FMS and YBT). **Results:** The following variables showed a significant difference over time: ANT Diff (p<0.004), PM Diff (p<0.011), PL Diff (p<0.035), YBT composite score difference (COMP Diff) (p<0.001), deep squat (p<0.025), and in-line lunge (p<0.001) (Table 1). **Conclusions:** The symmetry or difference between the limbs in each reach direction in the YBT improved following the 17-month strength and conditioning intervention. As expected, the FMS components deep squat and in-line lunge improved over time as both the squat and lunge exercises were included in the strength and conditioning program. Certified athletic trainers and strength and conditioning specialists should consider using the YBT as a pre-participation screening tool and resultant symmetry measures to determine where improvements could be made in sport performance balance characteristics. However, it is important to note that when utilizing the FMS and YBT, strength gains over time may influence these test scores.

Table 1. Descriptive Statistics Across Time for FMS & YBT Scores

Variable	Time 1	Time 2	Time 3	Significance
	M ± SD	M ± SD	M ± SD	
ANT Diff (cm)	3.4 ± 2.6	2.7 ± 2.2	2.8 ± 2.5	0.004*
PM Diff (cm)	4.9 ± 4.2	4.2 ± 2.9	3.9 ± 2.9	0.011*
PL Diff (cm)	4.9 ± 4.0	4.2 ± 3.4	4.1 ± 3.4	0.035*
YBT COMP Diff (%)	3.6 ± 3.3	2.6 ± 2.3	2.0 ± 2.3	<0.001*
Deep Squat	2.0 ± 0.7	2.0 ± 0.7	1.8 ± 0.7	0.025*
Hurdle Step-Over	2.0 ± 0.5	2.0 ± 0.7	2.1 ± 0.4	0.315
In-Line Lunge	2.0 ± 0.6	2.0 ± 0.7	2.3 ± 0.6	<0.001*
FMS COMP	15.5 ± 1.9	15.2 ± 2.5	16.0 ± 8.0	0.211

N, Number of subjects; M, Mean; SD, Standard Deviation; ANT, Anterior; Diff, Difference, PM, Posteromedial; PL, Posterolateral; COMP, Composite. * indicates statistically significant variables (p<0.05).

Whole-Body Reactive Agility Asymmetries Among Athletes With Concussion History Are Modifiable

Wilkerson GB, Nabhan DC, Crane RT, Leshner GM, Perry EJ: University of Tennessee, Chattanooga, TN; United States Olympic Committee, Colorado Springs, CO; United States Coalition for the Prevention of Illness and Injury in Sport, Colorado Springs, CO

Context: This study assessed adaptations in whole-body reactive agility produced by upper extremity training that imposed simultaneous cognitive and visuomotor demands. **Methods:** A cohort study of 20 elite athletes representing 6 different Olympic sports (12 males: 25.1 ± 5.5 years; 8 females: 27.0 ± 4.0 years) performed an upper extremity test of choice reaction time, along with 2 tests of whole-body reactive agility that provided measures of reaction time, speed, acceleration, and deceleration. The upper extremity test used an Eriksen flanker display (10 congruent and 10 incongruent 5-arrow sets) to designate correct responses for manual deactivation of illuminated buttons located on opposite sides of the board. Whole-body tests required lateral movement responses to 20 left or right visual targets and diagonal movement responses to 16 visual targets presented in right/left and forward/back combinations. One-minute training sessions were completed 2 or 3 times per week over a 3-week period, which involved upper extremity button deactivations and verbal responses to indicate center arrow direction for 20 5-arrow displays. Post-training assessment included the same tests prior to training. **Results:** At least 6 training sessions (7.7 ± 0.6) were completed by each of the athletes. Concussion history was reported by 10 athletes (5.6 ± 5.2 years prior to testing; range 0.3 – 16.5 years), which was significantly associated (1-Sided $P < 0.5$) with pre-training measures of whole-body reactive agility asymmetries for backward diagonal

deceleration $\geq .24$ (OR=14.3 [estimated by adding 0.5 to each cell]; PPV=100%; NPV=63%), lateral acceleration $\geq .12$ (OR=5.4; PPV=70%; NPV=70%), backward diagonal acceleration $\geq .10$ (OR=6.0; PPV=67%; NPV=75%), and lateral reaction time $\geq .16$ (OR=13.5; PPV=69%; NPV=86%). Among the 12 athletes with self-reported concussion history, the pre- to post-training standardized response mean values for the 4 whole-body reactive agility asymmetries were .22, .45, .32, and .52, respectively. Visuomotor correct choice reaction time average difference between incongruent and congruent responses improved from 114 ± 46 ms to 59 ± 80 ms (standardized response mean=.54). **Conclusions:** Asymmetry in reactive responses could be a manifestation of dysfunctional interhemispheric brain connectivity. Our findings suggest that asymmetries can be reduced through dual-task cognitive-visuomotor training.

Free Communications, Poster Presentations: Gen Med Case Studies

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;

Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Arteriovenous Malformation in a Collegiate Athlete: A Case Study

Moore KA, Lyon AM, Mokris RL:
Gannon University, Erie, PA

Background: Arteriovenous malformation (AVM) is a rare, abnormal connection of arteries and veins which results in bypassing the capillary system. This condition is unusual and most commonly occurs in the brain and spinal cord, however, they can occur anywhere in the body. AVMs only comprise eight percent of all vascular anomalies with cases of the bladder being exceptionally rare. Less than 20 cases of diagnosed AVM in the bladder have been reported in the literature. Bladder vascular malformations are located roughly 50% of the time at the base of the bladder with 25% of these lesions involving the bladder neck. This condition is considered a congenital disorder in which signs and symptoms may arise at any time throughout life. The typical signs and symptoms vary depending on the location and include: bleeding, seizures, headaches, paralysis loss of speech, loss of memory, and loss of vision. Based on the few cases reported in the literature regarding AVM in the bladder, common signs and symptoms experienced were polyuria, hematuria, pelvic pain, and urinary retention. **Patient:** This patient is a 21-year-old, male athlete that was diagnosed with AVM located within the bladder. The signs and symptoms in our case presented with hematuria (blood in the urine) with clots, fatigue, suprapubic point tenderness, bilateral flank discomfort, and “foamy” urine after intense physical activity. Typically, diagnosis of this condition includes magnetic resonance imaging, magnetic resonance angiography, computed tomography, computed tomography angiography, and ultrasound with color doppler. Diagnosis of the AVM of the bladder for this case included cystoscopy. A hollow tube (cystoscope) equipped with a lens is inserted into the urethra and slowly advanced into

the bladder. Results showed an AVM present in the bladders mucosa. **Intervention or Treatment:** Due to the complexity of each case, multidisciplinary treatment methods were necessary. If removal of a specific AVM is not possible, conservative treatments are used to control symptoms to improve the quality of life for the patient. Typical treatments include surgical resection, radiosurgery, ablation (removing the AVM surgically), and embolization (blocking the blood flow to the malformation with a glue or other adhesive). Radiosurgery and embolization are sometimes combined for treatment when expected results do not occur through a single intervention. Treatments for this case included a cystoscopy and IV transfusions to replace blood lost during episodes of gross hematuria. The transfusions consisted of 0.9% of normal saline solution. The patient was instructed to take iron supplements. **Outcomes or Other Comparison:** The patient remains to have hematuria post exercise. He continues to get transfusions for treatment as needed. His red blood cell count and iron level continues to be monitored, especially when symptoms arise. **Conclusions:** AVM is a rare vascular condition that is even more unusual to present itself in the bladder. If treatments to cure the condition are unable to be completed or unsuccessful, treatments to control and improve signs and symptoms are ideal. The location of the AVM determines the treatments necessary. Signs and symptoms vary based on the location of the AVM as well. **Clinical Bottom Line:** Due to the rare occurrence of AVM (<200,000 diagnosed per year), it is essential that this abnormal defect be studied in order to educate healthcare professionals and help to quickly identify a possible presence of the condition in patients. This will also lead to the establishment of treatment guidelines for this specific location in the body, especially for active individuals.

Diagnosis and Treatment of Idiopathic Benign Paroxysmal Positional Vertigo in Collegiate Dancers

Boydston K, Hansen-Honeycutt JA, Baker R, Ambegaonkar JP:
University of Idaho, Moscow, ID;
George Mason University, Fairfax, VA

Background: Idiopathic Benign Paroxysmal Positional Vertigo (BPPV) is a condition caused by sudden, non-traumatic positional changes in the head resulting in malalignment of crystalline structures within one or more canals of the inner ear. Symptoms associated with BPPV may include lightheadedness, spinning sensations, dizziness, and loss of balance. Symptoms spontaneously resolve with discontinuation of abrupt positional changes to the head. Dancers, gymnasts, divers, and other athletic populations are predisposed to this condition due to complex head and body movements found in daily training routines. Once symptoms are triggered, resolution of complaints without intervention is unlikely, which may severely impact performance. To date, no studies were identified which investigate the assessment and treatment of BPPV in a dance population were identified; therefore our purpose was to identify prevalence of BPPV in collegiate dancers over 2 years, and explore the effectiveness of the Epley maneuver as a treatment option. **Patient:** Dancers between the ages of 18-23 at a single university were included in the case series. Dancers participated in a preventative movement screen protocol, which included a portion designed to assess balance and screen for vestibular dysfunction. Over the past 2 years (n=40) dancers participated in the preventative screen and (n=4) presented with idiopathic BPPV symptoms. Initial clinical examination findings included difficulty balancing with a small

base of support, on unstable surfaces, or without visual input to aid orientation. The confirming factor of the BPPV diagnosis was a positive Epley maneuver, which indicated a malpositioning of the crystalline structures within the posterior canal of the inner ear. **Intervention or Treatment:** Dancers (n=4) classified with positive findings consistent with posterior canal BPPV were treated with the Epley maneuver, which includes a series of abrupt head and body positional changes – namely cervical extension and rotation to the involved side – performed in specific sequence to help reposition the crystalline structures within the inner ear. Patients were also instructed in self-administration of the Epley maneuver, to allow for self-treatment. The treatment was repeated until the patient could complete the sequence without symptoms. Once treatment with the Epley maneuver resolved symptoms, patients completed saccades to reintegrate the visual system with the proprioceptive system. Patients were not removed from classes or rehearsals; however they were asked to modify those activities immediately following athletic trainer-administered treatment. **Outcomes or Other Comparisons:** Patients diagnosed with idiopathic BPPV found resolution of symptoms (e.g., lightheadedness, dizziness, spot-tiness, blurriness, and/or spinning) and improved balance after treatment with the Epley maneuver. Although resolution of symptoms was dependent upon compliance with both self- and athletic trainer-administered treatments, all patients (n=4) in this study found relief within 1-3 weeks, and were allowed to participate in sport-specific activity with some modification for the duration of treatment. **Conclusions:** BPPV can be challenging to diagnose and treat in dancers due to the complex head and body movements associated with training. Preventative balance screening was effective in identifying patients with BPPV signs and symptoms. Treatment using the Epley maneuver was effective in resolving symptoms for all patients within this case series, which had a positive impact on dance training.

Further education regarding screening and treatment for athletic trainers working with any athletic population is necessary, as the prevalence of idiopathic BPPV may be higher in athletic populations than is previously known since symptoms could mimic other conditions (e.g., concussion). Overall, screening for vestibular dysfunctions and recognizing BPPV in patients is essential before administering traditional strengthening and balance exercises. **Clinical Bottom Line:** Recognition, diagnosis, and treatment associated with idiopathic BPPV in athletic populations can improve spatial awareness and technical performance, and eliminate dizziness and/or disorientation during training exercises.

Nerve Hydrodissection Treatment for Chronic Exertional Abdominal Cutaneous Nerve Entrapment Syndrome: A Level 3 CASE Study

Wimpee CL, Kennedy SL: University of Texas, Arlington, TX; Texas Health Physicians Group - Sideline Orthopedics and Sport, Arlington, TX

Background: Chronic Abdominal Wall Pain(CAWP) is often overlooked in the diagnostic process of Chronic Abdominal Pain(CAP), however up to 30% of patients who suffer from CAP with insidious onset suffer from a form of CAWP. Abdominal Cutaneous Nerve Entrapment Syndrome(ACNES) is a potential cause of CAWP but is often underdiagnosed and not appropriately treated. Typical treatment includes local steroidal nerve block injections(SNB) or neurectomy of the symptomatic nerve. Because SNB can be overused and provide only short-lived effects, nerve hydrodissection should be considered as an alternate treatment to surgery. **Patient:** A 16-year-old male soccer player was suffering from exertional abdominal pain diagnosed as a chronic abdominal strain one year prior. The pain would arise fifteen minutes into competition and forty-five minutes into practice. Prior treatments included active release techniques, manipulations, cupping therapy, acupuncture, rest, and rehabilitation with little to no relief. The patient was then referred for a leucocyte rich platelet rich plasma injection which provided mild temporary relief. ACNES at the 9th thoracic vertebral level was later diagnosed using a local nerve block that eliminated pain during exercise. A local SNB was then introduced generating two weeks of pain reduction. Because of the short lived effects of previous treatments, the patient continued to have exertional abdominal pain with activity. **Intervention or Treatment:** The patient received three rounds of ultrasound guided cutaneous nerve hydrodissection. The goal of the hydrodissection was to separate the nerve from adhesions and create previously nonexistent surgical planes.

All three hydrodissections were completed in the same fashion and the patient was instructed to avoid activity for 48 hours after injection. The first hydrodissection took place two weeks after a local SNB, the second took place three weeks following the first and the third took place four weeks following the second hydrodissection. Treatment usually includes SNB that can be reproduced as needed for pain as well as surgical neurectomy to remove the terminal branches of the effected intercostal nerve. **Outcomes or Other Comparisons:** Drastic improvement was noticed by the patient following each hydrodissection. Following the first, the patient was able to complete a three-mile run and more strenuous soccer activities with mild pain that resided quickly. After the second hydrodissection the patient competed with no pain with the exception of mild discomfort lasting seconds. Following the third hydrodissection, the patient competed in an international tournament with one bout of mild pain that occurred forty minutes into the final game with short lived effects. The use of SNB has potential to provide pain reduction but has adverse effects such as muscle atrophy with continual use. Surgical neurectomy has a high rate of success but is more invasive and requires time loss from sport. **Conclusions:** When several attempts of pain relief failed with the standard conservative treatment of SNB, three nerve hydrodissection treatments were provided. The patient reported nearly pain free activity while participating in sport. Athletic trainers and physicians should consider nerve hydrodissection as an alternate conservative treatment for ACNES. **Clinical Bottom Line:** ACNES is consistently underdiagnosed and improperly treated in the athletic population. Nerve hydrodissection may be an immerging treatment option for ACNES that will allow the patient to continue participating while receiving treatment with little to no side effects. It is vital that athletic trainers and physicians work together to appropriately diagnose and provide the most desirable treatment to improve patient outcomes.

Blunt Trauma to the Colon in a Football Player – A Level 4 Case Study

Casmus R, Edwards B, Bartlett C: Novant Sports Medicine, Winston-Salem, NC

Background: A 17 year-old male high school football player reported that while participating in a varsity game he landed with his right lower abdominal quadrant on an opposing player's knee as he was tackled. On-field evaluation revealed the athlete displaying the signs and symptoms of having the "wind knocked out". He had associated pain in the abdominal area that quickly dissipated as he regained his normal breathing pattern. The athlete was further evaluated on the sideline to rule out acute trauma to the chest and abdomen of which findings were unremarkable. The athlete did exhibit signs and symptoms of a mild hip contusion as his chief complaint during the sideline evaluation. He was able to continue participation in the football game without incident after a brief rest period on the sideline. The following day, he developed increasing abdominal pain and hematochezia - bright red rectal bleeding. He was referred to an initially assessed at a local hospital emergency room and then transferred to the regional level one trauma center for further evaluation and care. **Differential Diagnosis:** Abdominal wall muscle contusion, iliac crest contusion, acute appendicitis, diaphragmatic spasm of the solar plexus, acute diverticulitis, colon contusion, bleeding ulcer. **Treatment:** Urinalysis was normal but stool hemoccult lab testing was positive. CT scan was ordered and revealed mild diverticulitis of the descending colon, with wall thickening, bruising and stranding of the proximal ascending colon with concern for mesenteric injury. Because the athlete's vital signs were never compromised or veered from being within normal limits, his appetite remained normal and other than having sporadic hematochezia; the trauma team released him that night to home care and rest for the next 48 hours

with instructions to follow-up with his primary care physician. His follow-up visit with the primary care physician demonstrated resolving hematochezia and he was withheld from contact sports for the next ten days. After this time, the athlete gradually returned to all football activity without further incident. **Uniqueness:** Blunt trauma to the abdominal wall injuring the colon is uncommon. The small intestine is more often injured with blunt trauma than the colon. The colon accounts for a reported 1.1% incidence of hollow viscus injury and there is a .15% incidence of isolated colon injury in patients with blunt trauma. These injuries are usually associated with high energy mechanisms such as automobile and industrial accidents. Shearing forces between fixed and mobile portions of the gastrointestinal tract can cause laceration of the bowel wall and mesenteric vessels. Isolated intestinal injury may initially present with non-specific findings with CT imaging as the preferred diagnostic test. **Conclusions:** Blunt trauma to the abdomen is not uncommon in athletics. Most injuries are short term and the athletes return to play quickly and without any deleterious effects. One must be wary as significant blunt trauma can result in hollow viscus injury and it is imperative to follow-up with those athletes and to educate them on the secondary effects of such trauma. This case illustrates the appropriate evaluation, conservative treatment and care leading to complete resolution of an isolated blunt trauma injury to the colon. The athlete is currently asymptomatic and has returned to all athletic and daily living activities.

Ibuprofen Induced Intestinal Bleeding Presenting as Crohn's in a Collegiate Baseball Player: A Case Report

Warner BJ, Gallegos DM, Cage HM, Cage SA: Grand Canyon University, Phoenix, AZ; The University of North Carolina, Greensboro, NC; The University of Texas, Tyler, TX; Therapy Management Corporation, Tyler, TX

Background: A 22-year-old collegiate baseball player reported to the athletic training staff complaining of persistent low back pain and associated muscle spasm. The patient had initially noticed the pain during the acceleration portion of his pitching motion, but had begun to experience pain during all phases of pitching along with daily activities. The patient stated that he had dealt with low back pain during high school, but had always managed it with rest, OTC ibuprofen, and regular chiropractic adjustments. Further evaluation revealed palpable spasm along the erector spinae muscle at the lower thoracic and lumbar levels, palpable pain at the L4-L5 levels of the lumbar vertebrae, pain with active lumbar extension, and general abdominal muscle weakness. Other than the previously mentioned low back pain, no other pertinent medical history was reported. **Differential Diagnosis:** Facet syndrome, spondylolysis, spondylolisthesis, erector spinae strain **Treatment:** During the initial phase of treatment and rehabilitation, the patient's symptoms were addressed with ice, motor transcutaneous electrical nerve stimulation, cupping therapy, and stretching. As the patient's symptoms began to subside, he began a therapeutic exercise program designed to address core and pelvic instability and weakness. After two weeks of treatment, the patient continued to experience his symptoms with little relief. At this time, the patient was referred to the team physician for further evaluation. The team physician's exam was consistent with facet syndrome, and an MRI was ordered. MRI revealed moderate swelling around the facet joints at the L4-L5 levels, absent of other structural abnormalities. Having obtained the results of the MRI, the patient underwent two more

weeks of rehabilitation, but was unable to progress to return to play. Due to the length of time the patient had remained symptomatic, the decision was made to refer him to a local pain management specialist. After a consultation, the patient consented to a course of cortisone injections into his facet joints. After undergoing three injections over the course of two months, the patient was still not experiencing significant relief. By the time the season had ended, the patient was given a home exercise program prior to his returning home for the summer. During a routine visit, the patient's primary care physician ordered a CT scan to further evaluate the patient's lower back. CT scan revealed findings consistent with Crohn's Disease. With the new diagnosis, the patient began regular infusions of infliximab which provided relief that would subside within three to four weeks of infusion. The patient continued treatment with infliximab infusions upon returning to school for the fall semester, but was hospitalized over winter break with increased intraabdominal pain. A proctoscopic exam found that the patient's intestines had been significantly damaged due to long term use of ibuprofen. With this third diagnosis, infliximab infusions were discontinued and the patient was instructed to cease ibuprofen usage. Throughout the spring semester the patient's symptoms continued to improve until he was ultimately able to return to physical activity pain free. **Uniqueness:** While damage to the intestines through ibuprofen consumption has been well documented in literature, this case describes a situation in which a patient's intestinal damage mimicked the symptoms of both facet syndrome and Crohn's Disease. The presence of inflammation at the facet joints was a confounding sign that complicated the diagnostic process and delayed the administration of appropriate care. **Conclusions:** When treating a patient with a condition that is not responding to conservative treatment, it is paramount that the clinician exhaust all diagnostic options to determine the underlying pathology. Instances conditions presenting with signs and symptoms mirroring other conditions make appropriate follow-up and confirmation of diagnosis crucial to the healthcare process.

Complex Regional Pain Syndrome in a Middle School Female Field Hockey Player

Winkler MP, Procter-Willman C: Texas Wesleyan University, Fort Worth, TX

Background: A 15-year-old female field hockey player was transitioning into basketball season, was complaining of severe knee pain. The patient stated she was participating in the first day of basketball practice but could not continue because of the pain she was experiencing in her knee. The patient stated applying ice made the condition worse. The patient also complained of temperature and coloration changes in her knee, pain with walking on rough surfaces, and extreme sensitivity to touch. Four years prior to this injury, the patient experienced similar symptoms from a gymnastics injury in her ankle; possibly triggered from early childhood complications. **Differential Diagnosis:** Ankle sprain, growth plate fracture, complex regional pain syndrome/reflex sympathetic dystrophy. **Treatment:** The patient underwent multiple diagnostic images including X-ray's and MRIs; all of which displayed negative results for musculoskeletal maladies. Due to continuing symptoms with no perceptible injury, the patient was referred to the neurology and pain management department. Prior to the diagnosis, the patient went through a variety of stretching exercises with the athletic trainer as prescribed by the orthopedist. Such exercises including: quadricep, hamstring, hip, and calf stretches. Once diagnosed with complex regional pain syndrome 3 months later, the patient began progressing into more aggressive and injury focused exercises with the athletic trainers. These exercises being: short arc quads, quad sets, and hip adduction squeezes. The patient also attends physical therapy weekly. The patient states that the most beneficial therapy she does to help with her mental ability to deal with pain is mirror therapy, biofeedback, and meditations. The patient has undergone multiple

nerve block shots, which she stated was more helpful than the one spinal lumbar nerve block procedure. Patient has not returned to play and will be participating in a two-week intensive in-patient physical therapy occupational program in the summer; prognosis is still unknown. **Uniqueness:** This type of injury is not commonly seen in the athletic population. Complex regional pain syndrome was not typically studied in children until recently. Current studies suggest approximately 90% of these cases occur in girls and between the age of 8 and 16. **Conclusions:** Presented was a 15-year-old female field hockey player, diagnosed with complex regional pain syndrome. The patient has undergone many procedures, and countless hours of rehabilitation; some of which has been more beneficial than others. Continuing rehabilitation and consistent moral support from the patient's providers is crucial. Since complex regional pain syndrome is a nervous system disorder, it is critical for athletic trainers to trust the patient and understand the pain they describe.

Repair of a Testicular Fracture in a Collegiate Baseball Player: A Case Study

Martin AD, Lumpkin KJ: Liberty University, Lynchburg, VA

Background: A 20 year-old NCAA Division I male baseball player, with no prior history of genital injury, was playing second base and was side-stepping in a squat to field a ground ball when the ball took an unexpected bounce and hit the athlete in the unprotected genitalia. Athlete was unable to continue due to pain 10/10. During inspection, athlete noticed his right testicle was extremely enlarged and discolored. Athlete reported dysuria, vomiting, and abnormal testicle size and discoloration to the certified athletic trainer **Differential Diagnosis:** Testicular Contusion, Testicular Torsion, Testicular Fracture, Pubic Fracture. **Treatment:** Immediate treatment included a 20 minute ice application. The athlete was transported to the hospital after signs and symptoms persisted. Upon arrival, an ultrasound was performed and it was determined the athlete suffered a complete fracture of the right gonad. A urologist performed emergency exploratory surgery approximately five hours post-injury. Surgery included debridement of necrotic tissue, restoration of the seminiferous tubules within the tunica albuginea, suturing of the tunica albuginea back together, and suturing of the testicle to the scrotal wall. Post-surgery, athlete remained in hospital for less than 24 hours. Treatment the first two weeks focused on rest, wound care, and pain control, which included wearing a scrotal sling for support and edema control. At three weeks, the athlete experienced mild pain, but was cleared to begin throwing less than 90 feet. At 4.5 weeks post-operation, the athlete began a batting progression, starting with batting off a tee, progressing to batting cages. Fielding drills and jogging were allowed at 5.5 weeks after reconstructive surgery. The athlete was participating fully in baseball at 6.5 weeks after surgery, however, full return to weightlifting was limited until eight weeks. During a six month follow up the athlete reported

no pain or problems with sport participation or ADL's, but will occasionally feel a "pinch" within the scrotum; one plausible cause could be stretching between the testicle and its attachment point on the scrotum. **Uniqueness:** Testicular fractures are rare injuries, and as such, little research currently exists on treatment strategies and return to play (RTP) timelines. The testicles have multiple protective mechanisms that make traumatic injury relatively rare. These include mobility of the testes within the scrotum, laxity of the surrounding skin, and reflex contraction of the cremaster muscle. While there is no data to support the most common genital injuries, testicular contusion and torsion are genital injuries that have been more widely documented and encountered clinically. This injury was also unique because the tunica albuginea suffered a complete fracture and was "broken in half," while partial fractures are more common. Additionally, most testicular fractures in baseball are endured by catchers due to blunt force trauma from higher-speed baseball pitches or foul tips, as opposed to infielders fielding slower-speed ground balls. **Conclusions:** Early surgery and intervention is critical for testicular salvaging, as recovery decreases from 90% to 45%. Early intervention is considered 72 hours after initial injury. Healing and functional reintegration are the biggest limiting factors in the athlete's return to participation after successful surgery. Due to Valsalva pressure in the scrotum, weightlifting should be avoided until full recovery, which includes pain-free symptoms with ADL's and functional sports maneuvers. With early diagnosis, timely surgery, and a capable surgeon, successful return to play should occur in approximately two months, without diminishing quality of life. However, more research is needed to establish accurate timelines for RTP based on surgical intervention types. Based on this case study, baseball fielders may elect to wear protective shields for the genitals during participation to prevent such injuries.

Dystonia Diagnosis in Horseback Riding Patient

Jimenez LH, Felton SD, Odai ML, Martinez RE: Florida International University, Miami, FL

Background: Level 4 CASE report presented a 20-year-old (158 cm, 43 kg.) female horseback rider with 15 years of experience. One year ago, the patient was awakened with no sensation in her left fifth digit. The finger was flexed and abducted over the fourth digit, with an inability to move out of this position. In the initial evaluation, the patient experienced a pain level of 6/10. The patient was unable to perform any AROM due to positioning of fifth digit. Supination and pronation were within normal limits. There were no special tests administered due to the patient's inability move freely. The pain significantly increased bilaterally in the digits and radiated proximally to the shoulder.

Differential Diagnosis: Tremors, muscle tightness, blocked nerve activation, Parkinson's disease, myoclonus, chorea and tics are differential diagnoses for dystonia. **Treatment:** Throughout the evaluation process, it was believed that the patient developed an ulnar nerve entrapment due to the initial signs and symptoms of the evaluation. With the information collected from the neurologist, the patient was diagnosed with idiopathic dystonia, which is characterized by involuntary muscle contractions causing repetitive movements or abnormal postures. After seeing a different neurologist in 2018, the patient was diagnosed with final diagnosis of complex regional pain syndrome. In addition, the patient is experiencing sequela ensued with cardiac, respiratory and urinary issues. The patient experienced a significant decreased cardiac function of 53% and has lost 80% of her sense of smell and taste. It is unknown whether these secondary conditions are correlated but they did appear after the initial diagnosis of dystonia. The patient was referred for a genetic test to see if there is a potential mutation causing the secondary effects. The patient contacted

her athletic trainer where she was then diagnosed with ulnar nerve entrapment and was referred to a neurologist where she had an MRI and an EMG conducted. To date, it is unclear if the dystonia and the secondary medical conditions are correlated. During the patient's initial evaluation with the athletic trainer, the AT performed AROM with no progress. The athletic trainer used cupping, MFR/ART and referred to an acupuncturist and an LMT with no significant improvement. From the physician's suggestion, the patient was given an elbow brace to restrict elbow flexion during sleep. Again, there was no significant improvement of symptoms. The patient also treated for her secondary medical issues. For her bladder issues she received breathing exercises and stretches along with ultrasound for internal use and carbidopa-levodopa. **Uniqueness:** The case is unique due to the insidious presentation of signs and symptoms. Based on the research, dystonia typically presents itself secondary to ulnar nerve entrapment and is most commonly found in musicians, especially violinist as a result of the extended position of the hands while holding the bow. There has been no evidence reported of dystonia cases in horseback riding patients. **Conclusions:** This case focused on the insidious onset of dystonia followed by the initial diagnosis of ulnar nerve entrapment. None of the treatments had any significant relief on the symptoms, thus it is imperative for athletic trainers to identify alternative treatments to assist in relieving pain that are linked to neurological, cardiac, or respiratory issues. In addition, this case presented several comorbidities that may be linked to the original diagnosis. The comorbidities further challenged the athletic trainer in properly managing the case. Additional research is needed to correlate the general medical conditions with dystonia and possibly provide athletic trainers with an improved management plans.

Grade 4 Kidney Laceration in a High School Football Player

Simmons TD, Pacious J, Vaughan A, Haro M, Peterson TD: Western Carolina University, Cullowhee, NC; Mountain Area Health Education Center, Asheville, NC; Asheville Orthopaedic Associates, Asheville, NC

Background: The patient was an 18-year-old male high school football player, who had no notable past medical history. He was hit on his left side in the first quarter but was able to complete the game. About 30 minutes after the game, the patient complained of significant pain on his left lower anterolateral thorax. The patient described pain as constant, aching, and a 9/10 on a pain scale. The patient also described associated shortness of breath and pleuritic chest pain. Patients' blood pressure currently was 142/96 and pulse was 80 beats per minute. The athletic trainer found tenderness to palpation in the left upper quadrant but did not have any guarding or rebound tenderness. The patient reported that he had not urinated since approximately five hours before the evaluation. During the actual evaluation, the patient was able to produce urine and reported hematuria to the athletic trainer. **Differential Diagnosis:** Differential diagnosis included left renal trauma, splenic trauma, left costal fracture and associated pneumothorax, intercostal and abdominal musculature contusions, and a muscular strain. **Treatment:** After evaluation by athletic trainer, the patient was referred to the emergency department. Initial assessment by emergency departments physician revealed findings consistent with what the athletic trainer found, and most of his systems were functioning normally. Regarding the specific area of injury, the emergency room physicians found his abdomen to be soft and non-distended with no ecchymoses. He was still point tender to palpation over left upper quadrant as well as the left anterior and lateral lower thorax. His current blood pressure was 138/72 and pulse was 90

beats per minute. In the emergency department, the physician ordered for the following diagnostic tests: Focused Assessment with Sonography for Traumaexam, Complete Blood Count, Comprehensive Metabolic Panel, and Urinalysis. All tests were within normal limits except the urinalysis, which revealed a red blood cell count that was greater than 180. A CT scan of the thorax/pelvis/abs showed a left renal laceration >1cm in depth with surrounding hemorrhage; Gerota's fascia was intact and no active blood extravasation or urine lead identified. This resulted in the final diagnosis of a Grade 4 Kidney Laceration. **Uniqueness:** This case is so unique because renal trauma accounts for only 1-5% of sports trauma cases and a grade 4 kidney laceration specifically only accounts for 10% of all renal injuries. In addition, this type of injury usually occurs during high intensity motor crashes and assaults and not necessarily from a tackle. In addition, this specific injury could have gone undiagnosed since it lacked initial pain to the patient. **Conclusions:** Ultimately, this case illustrates that internal injuries, although rare are still possible especially in collision sports. This spotlights the need for athletic trainers to be prepared to handle both emergency and non-emergency situations. Moreover, this case reinforces the need for athletic trainers to be able to recognize the signs and symptoms of internal injuries, so that they can be proficient with sideline evaluations and recognition of deteriorating conditions because any potential error in evaluation could be detrimental.

Exertional Syncope of an Unknown Origin in a Collegiate Women's Basketball Player: A Level 4 Rare Events Case Study
Fetchen-DiCesaro S, Ramirez-Del Toro J, Washburn N: California University of Pennsylvania, California, PA; The Orthopedic Group, Pittsburgh, PA; University of Pittsburgh Medical Center, Pittsburgh, PA

Background: A 21 year old collegiate women's basketball player reported to the athletic trainer during a pre-season workout describing a feeling of near syncope. Upon examination she was verbally responsive with dyspnea, dizziness, tachycardia, pale appearance and visible full body tremors. She had no abnormal findings upon physical exam. She reported overall general malaise and loss of appetite. She further reported that these symptoms began 5 months prior while home for break but denies exertional syncope. Lab and diagnostic reports from her PCP were negative for thyroid disease, diabetes, electrolyte abnormalities, anemia or intracranial abnormalities. There is a history of depression and disordered eating and she had been taking B-12 injections for the past four months with little improvement. **Differential Diagnosis:** Anemia, hormone imbalance, electrolyte abnormalities, arrhythmia, exertional syncope. **Treatment:** Patient was examined by the team physician within 48 hours with no abnormal findings, instructed to cease physical activity and was sent for a CBC and CMP including magnesium phosphate, B-12 folate, iron, transferrin, ferritin, TSH, T4, free T4, CRP and Vitamin D levels all of which were found to be within normal limits. She was referred to our sports cardiologist who concurred with the team physicians plan of care and ordered a cardiac stress test, 48-hour Holter monitor and electrocardiogram all with subsequent normal findings. A heads-up tilt table test was ordered but not completed. A transthoracic echocardiogram was considered normal but unable to obtain a

subcostal view due to abdominal fluid collection. Subsequently the patient was sent for an abdominal CT which revealed an ovarian cyst "the size of a football". Patient was immediately admitted to the hospital and underwent surgery to remove > 15 cm, 5.90 kg ovarian cyst which was found to be benign on post-op testing. Patient was discharged within 72 hours of surgery with post-op care including transfriction massage for scar tissue management. Patient was allowed to resume light cardiovascular activity at 6 weeks and full activity at 8 weeks including intensive core training. Patient completed the basketball season with minimal issue. Post-season care included continued massage and core strengthening. Additionally, she competed on the varsity tennis team for the spring season and reported minimal abdominal discomfort. **Uniqueness:** Ovarian cysts are somewhat common having been reported to occur in 8% to 18% of all women in the United States with approximately 5% to 10% undergoing surgical exploration. This patient did not report typical findings for ovarian cysts including painful menstruation, dysmenorrhea or pain on palpation. She reported never having had an obstetrical exam. Cardiac symptoms and near-syncope were a result of compression of the thoracic and abdominal structures from the ovarian cyst. **Conclusions:** This clinical case exemplifies the critical need for athletic trainers to complete a thoroughly exhaustive history, physical exam and referral if warranted. This patient did not present with typical findings for an ovarian cyst, and given her exertional symptoms, history of disordered eating and depression seemed more likely to be experiencing an issue psychological or cardiac in nature. An interprofessional plan of care and communication were essential for swift diagnosis and care for this patient leading to a positive post-surgical outcome and successful reentry into athletics.

Idiopathic Chest Pain in Division I Collegiate Track and Field

Athlete: A Case Study

Grimshaw A, Joseph C: University of Central Florida, Orlando, FL

Background: The athlete is a 20-year-old female, African American, Division I track and field student athlete. On January 11th, the athlete traveled to an out of state track meet. After arriving, she presented with cough, congestion, headache, sore throat and fatigue. Over the counter medication was administered for her symptoms. Hours after competing in her race on January 12th, she presented with body aches, labored breathing, chest pain, fever, and cough. Previous medical history consists of pneumonia and asthma diagnoses a year and a half prior. The athlete is a non-smoker with no family history of lung disease. **Differential Diagnosis:** Pneumonia in right middle lobe (RML) with partial atelectasis from apparent right bronchus intermedius (RBI) endobronchial lesion; carcinoid tumor; mucus plug obstructing the RML; acute bronchospasm; allergic bronchopulmonary aspergillosis; influenza. **Treatment:** On January 12th, the athlete was transported to the local emergency room where she was treated with Tamiflu despite a negative flu screen, Solu-Medrol, Duonebs, doxycycline, ceftriaxone, and Toradol. An initial chest X-ray (CXR) concluded questionable right basilar airspace opacity. A CT angiogram detected an endobronchial mass in the RML with secondary multi-segmental atelectasis and pneumonia. Due to prolonged symptoms, she was admitted into the intensive care unit (ICU) on January 13th and continued the use of antibiotics, breathing treatments, and intravenous fluids. A second CXR showed the RML airspace had become more apparent. On January 15th, a bronchoscopy showed the RBI was 80% obscured by an endobronchial tumor arising from the RML takeoff. The RML was completely obstructed by the tumor, but the right lower lobe (RLL) appeared to be

open. All tumor cells were negative for malignancy, which confirmed the diagnosis of a carcinoid tumor. On January 16th, the athlete was discharged from the ICU and the local pulmonologist cleared her to fly home to her university. Immediate consultation was advised with a pulmonologist in Orlando to resect the tumor. On January 26th, the athlete was seen by a thoracic surgeon for consultation and had surgery on February 1st. The athlete underwent a bronchoscopy and robotic-assisted right middle lobectomy with bronchoplastic resection and anastomosis of the RLL and mediastinal lymph node dissection. Five weeks post-operation, the athlete began light cardiovascular activity. On April 2nd, she started progressing into full participation in practice. She made a full return to athletics as a Division I collegiate track and field athlete. **Uniqueness:** Her projected surgical plan included the resection of the RML and RLL, but her RLL was preserved during surgery. There was no expectation to return to her sport based on the original bronchoscopy findings. She is still competing as a Division I scholarship track sprinter. Twenty percent of carcinoid tumors are found in the lungs and account for 1-2% of lung cancers. Lung carcinoid tumors are most commonly found in Caucasians and adults between the ages of 45 and 55. Twenty-five percent of patients do not experience symptoms and the tumor is unlikely to metastasize. **Conclusions:** Symptoms presented very abruptly and the time from initial presentation to surgery was three weeks. Full recovery for this student athlete was three months, but the time to full recovery depends on symptoms and the amount of lung tissue disrupted during surgery. The removal of the RML is not a medical disqualifier for athletic participation. By preserving the RLL during surgery, the athlete was able to maintain an appropriate total lung volume to continue in athletics.

Psychogenic Nonepileptic Seizures in a Collegiate Diver: A Case Study

Skuraton N, Sheehan K: Ithaca College, Ithaca, NY

Background: A 22 year old Division III female diver presented with a 1.5 year history of multiple seizure-like episodes in which she fell into a semi-conscious state with nystagmus, slurred speech, and paresthesia in her distal extremities. These seizures increased in frequency, starting at an average of one every two months to one every 2-15 minutes. Episodes were provoked and intensified by physical and mental fatigue. Post seizure, the patient would experience extreme fatigue. The patient had a history of hypersomnia and unilateral neck and shoulder twitching (for ~7 years). There was also a history of psychological stress known by the athletic training staff. **Differential Diagnosis:** The differential diagnosis for her condition included cardiovascular dysrhythmia, poor cardiovascular fitness, Postural Orthostatic Tachycardia Syndrome, Post Traumatic Stress Disorder, athletic burnout, narcolepsy, epilepsy, and anxiety. **Treatment:** The patient's condition worsened to which she was having recurrent seizures every 2-15 minutes resulting in referral to the emergency room by athletic trainers. She was diagnosed with psychogenic nonepileptic seizures (PNES) through 24-hour EEG testing with video monitoring. PNES are episodes of altered experiences or movement sensations similar to epilepsy but are caused by a psychological process differing in neurobiological origin and electrophysiological changes. Episodes consist of paroxysmal changes in movements, responsiveness, and behavior which can lead to clonic activity. She was treated with a prescription for diazepam and referrals to a neurologist and psychologist for counseling. It was subsequently discovered that the athlete had severe sleep apnea, causing a lack of REM cycles during sleep resulting in hypersomnia. It is hypothesized that the lack of rest for her brain is associated with the culmination of PNES. She was placed on a continuous positive airway pressure machine and methylphenidate

(CNS stimulant). The patient has had a successful outcome post diagnosis with an increase of daily functionality and decrease in seizure occurrence and severity. Return to play was managed and monitored by athletic trainers. Activity began with low intensity strength training while keeping her heart rate under 130 beats per minute. As the seizures diminished in frequency, cardiovascular exercise was gradually re-introduced with heart rate monitoring to avoid tachycardia. She returned to diving 1.5 months post diagnosis. Since the introduction of her treatment 1 year ago, the patient has had a gradual but significant decrease in episodes and has not had an episode in the past 4 months.

Uniqueness: The rate of occurrence of PNES is between 2 and 33 per 100,000 people and is more prominent in the female population. In comparison to this case, within 5 years after diagnosis of PNES, fewer than 40% of adults are expected to become seizure free. The majority of patients are treated with psychological counseling, however, there are no universally accepted guidelines on the duration or type of treatment to aid in recovery. The exact correlation of sleep apnea/hypersomnia and PNES is unknown. There are associated predisposing factors including traumatic brain injury, medical/psychiatric comorbidities, sexual and physical abuse.

Conclusions: After months of investigation, the final diagnosis was PNES. The patient was able to return to diving with the success of competing at the national level. Though the exact cause of her condition is unknown, she has seen significant improvement with psychological counseling, treatment of sleep apnea, and neurological consultations. PNES is still largely misunderstood in the medical field and further research is being done to understand its origin. The role of the athletic trainer in this case was recognition of symptoms, advocacy and referral for diagnosis, and return to play guidelines and monitoring. With the proper care, athletes with PNES can successfully return to play with the correct treatment and management of exercise.

Idiopathic Gastroparesis in a Female Collegiate Swimmer

Nestrowitz S, Gildard M, Powers
ME: Marist College, Poughkeepsie, NY

Background: A 19 year old female Division I swimmer reported to her athletic trainer complaining of gastrointestinal discomfort. Her personal and family history were negative for diabetes however there was a family history of Crohn's Disease. Her chief complaints were nausea, vomiting, epigastric pain, diminished appetite, and loose bowel movements. The patient reported similar issues had occurred several weeks earlier and were relieved by discontinuing dairy intake. However, at this time, the symptoms did not appear to be associated with a specific dietary intake. By the time the patient reported her symptoms she had very limited caloric and food-variety intake but had no significant weight loss.

Differential Diagnosis: Crohn's Disease, Gastric ulcer, Gastroenteritis, Gastroparesis, Giardiasis, Inflammatory bowel disease, Lactose intolerance.

Treatment: Upon referral to a gastroenterologist, the patient underwent stool and blood samples which were negative for helicobacter pylori, gastric cancer, and peptic ulcer disease. A colonoscopy was performed and was unremarkable. Later, the patient complained of blood in her stool which was determined to be caused by hemorrhoids. Based on her clinical presentation and unremarkable diagnostic testing, the patient was diagnosed with idiopathic gastroparesis. Omeprazole and Zofran were prescribed to alleviate her nausea and vomiting. While gastroparesis may be confirmed via scintigraphy or gastric endoscopy, her physician felt these were unnecessary. A diet high in starches, low in fruits and vegetables, and excluding alcohol was recommended which the patient followed briefly but discontinued due to no relief in her symptoms. Maintenance of proper hydration and electrolyte levels were also strongly recommended and this did seem to aid the patient's symptoms. Several months after the diagnosis, the patient revealed to her athletic trainer that

she had also been suffering from bulimia nervosa for several years. She was subsequently referred to counseling services. The presence of an eating disorder posed complications in the physical manifestation and management of her gastroparesis especially considering the potential for stress and anxiety to develop in a patient due to the symptoms of gastroparesis. The patient was able to continue sport participation at a high level despite her condition. She continues treatment for her gastroparesis and disordered eating while swimming competitively.

Uniqueness: Gastroparesis is a chronic disorder that causes delayed gastric emptying in the absence of mechanical obstruction and often presents with gastric pain. While some cases of gastroparesis are classified as idiopathic, the condition is more commonly seen in patients with diabetes mellitus. In addition, gastroparesis is most commonly diagnosed in females approximately 40 years of age. The prevalence of gastroparesis is about 0.2% but there is an overall lack of epidemiological studies. Our patient was outside the normal age range for diagnosis and did not suffer from diabetes mellitus, a common comorbidity to gastroparesis. Her bulimia nervosa added to the complexity of this case.

Conclusions: Gastroparesis can be a difficult condition to diagnose and manage particularly for the interscholastic or college athletic trainer. It is an uncommon condition and may be idiopathic. It has been theorized that a potential change in electrical signal between the stomach's interstitial cells of Cajal could trigger gastroparesis. Gastric pain is the most common symptom but is often overlooked and under-reported by patients. The association of gastroparesis with diabetes mellitus, idiopathic nature, and proclivity to lead to psychosocial issues in patients requiring a multidisciplinary approach to treatment. It has also been reported that the addition of psychological treatment may benefit patients diagnosed with gastroparesis due to the stress and anxiety associated with the condition.

Recurrent Dizziness and Fainting in a Female Collegiate Rower: A Case Report

Bahr K, Joseph C: University of Central Florida, Orlando, FL

Background: The athlete is a 21-year-old, female, Caucasian, NCAA division I rowing athlete. She had not participated in rowing prior to this season. She previously participated in football, track and field, and cross country in high school. Her medical history includes exercise induced asthma and attention deficit hyperactivity disorder for which she takes Vyvance and Dextroamphetamine. She never experienced previous unexplained dizziness or loss of consciousness. On January 11, the athlete reported bouts of dizziness and nausea during training. She removed herself from training to avoid loss of consciousness. She ingested Powerade and sat until symptoms improved. While recovering, the athlete reported feeling cold and weak, with fatigue remaining the rest of the day. **Differential Diagnosis:** Cardiac Arrhythmia, Hypertrophic Cardiomyopathy, Exertional Syncope, Neurocardiogenic Syncope, or Valvular disease. **Treatment:** The athlete was evaluated by the team physician and treated for suspected Neurocardiogenic Syncope. She was instructed to increase salt intake prior to and during exercise to increase blood pressure. She was also instructed on increasing intrathoracic pressure utilizing counterpressure maneuvers. After two weeks of continued symptoms, the physician ordered a complete metabolic panel (normal results) and prescribed midodrine, a vasopressor. Over the next month she experienced two episodes resulting in loss of consciousness while training. She was removed from training and referred to a cardiologist for further assessment. The cardiologist's assessment revealed a normal electrocardiogram, normal echocardiogram, normal cardiac stress test, and a positive tilt table test. A 24-hour Holter monitor showed intermittent sinus bradycardia with concurrent sinus arrhythmia and rare, isolated, multifocal premature ventricular contractions. This confirmed the initial diagnosis of Neurocardiogenic Syncope. She was instructed to stop midodrine, prescribed Fludrocortisone daily, a

glucocorticoid assisting in salt and water balance and regulating blood pressure, and permitted to return to training as tolerated. Her symptoms temporarily resolved, but after five weeks intermittent symptoms returned. Upon follow-up with the cardiologist, she was instructed to stop using Fludrocortisone and focus on salt intake and hydration. After the season she sought a second opinion from Cardiology and Electrophysiology. She was prescribed beta-blockers to regulate heart rhythm, but after 2 weeks reported no effect. The electrophysiologist explained that the next treatment would be a pacemaker to control episodes, but due to the athlete's history, a pacemaker was not necessary. **Uniqueness:** Neurocardiogenic syncope has a prevalence of 22% of the general population but is not generally associated directly with physical activity. Removal of the stimulus causing syncope can resolve symptoms, however, this did not occur due to the athlete's desire to continue training. A pacemaker is only recommended in patients over 40 and have incurred multiple injuries, limited prodromes, and asystole. The athlete competed throughout the spring season using counterpressure maneuvers to prevent symptoms from progressing. Due to rowing being conducted on the water, tactics were developed to ensure the safety of the athlete. These tactics included placing her in front of the coxswain allowing for constant communication, coaches on launch boats were notified of any symptoms and limiting time spent training on the water. **Conclusions:** The most effective treatment in this case was teaching the athlete counterpressure maneuvers. The maneuvers are easily done during participation and allowed her to continue training through minor symptoms. Medications and increased salt intake improved symptoms temporarily, before physiologic adaptation and reduction in effectiveness occurred. While not a disqualifying condition, the only true care appears to be removal of the stimulus or a pacemaker. Due to the athlete's desire to not continue experiencing symptoms she decided to remove herself from rowing after the season concluded. She has reported a reduction in symptoms since discontinuing rowing.

DVT in D1 Collegiate Rower

Linnell EJ, Bernhardt DT, Sanfilippo JL: University of Wisconsin, Madison, WI

Background: Paget-Schroetter syndrome, or effort thrombosis, is a venous subset of thoracic outlet syndrome (TOS). More specifically, compression of the subclavian vein resulting in the formation of a deep vein thrombosis (DVT). Patient: 20-year-old male predominantly starboard varsity rower with 6 years' experience and no previous history of upper extremity injury or vascular disorders. Chief complaint of extreme right arm swelling and associated heaviness following an on-water rowing practice. Blue distended veins evident upon inspection. Neurological exam equal and normal when compared bilaterally. **Differential Diagnosis:** Thoracic outlet syndrome, rhabdomyolysis, allergic reaction, compartment syndrome, DVT, lymphedema, tumor, muscle strain. **Treatment:** The patient was immediately referred to the emergency department and venous duplex confirmed axillary/subclavian DVT consistent with venous TOS/Paget-Schroetter. An occlusive thrombus was found within the subclavian vein extending into the axillary, proximal cephalic, and proximal basilic veins. Right upper extremity (UE) venogram, pharmacomechanical thrombectomy, and lysis catheter placement with ultrasound was performed within 12 hours of admission. A nearly occlusive thrombus was noted in the axillary and subclavian vein following angiojet. The patient received lysis overnight and the following morning underwent right UE venogram, angioplasty of subclavian vein and lysis catheter removal. Venogram showed resolution of the thrombus. The patient was discharged from the hospital 48 hours after admission. At the time of discharge, the patient was prescribed Apixaban for 3 months and UE usage was reduced to ADL. The patient was allowed to perform all lower extremity strengthening and cardiovascular exercise. The angioplasty did not improve the subclavian stenosis due to the thoracic outlet obstruction by the first rib. Following the 3-month anticoagulant regiment, mechanical decompression of the subclavian vein was performed by surgical removal of

the 1st rib. During the procedure the patient sustained a pneumothorax that required a chest tube insertion 4 days' post-surgery. Upon removal of the chest tube the patient had a small apical pneumothorax however remained asymptomatic and discharged for home. **Uniqueness:** Obstruction of the vein with vigorous activity is present in 60%-80% with an incidence of 1-2 per 100,000 individuals annually¹. Effort thrombosis is often related to strenuous overhead activity in sports such as volleyball, baseball, swimming, waterpolo, tennis and weightlifting. The incidence in rowers much less frequent than the previously mentioned sports. **Conclusions:** In the weeks preceding the occlusion the patient was consistently being seen for reported upper trapezius tightness and scapular pain. The patient reported temporary relief from multiple treatment strategies including instrument assisted soft tissue mobilization, cupping therapy, electrical stimulation and passive stretching. Relief lasted a few hours to a day and discomfort most commonly returned following particularly difficult workouts. The day of the DVT formation the athlete participated in two practices. Following the morning practice the patient reported a cramping sensation in his right biceps brachii. No swelling or discoloration was noted upon evaluation and all symptoms were reportedly resolved within 15 minutes of practice completion. The patient completed the second practice of the day following a 3-hour break between sessions. After practice the patient reported significant swelling, heaviness, and blue distended veins. It is possible the upper trapezius and scapular discomfort was referred discomfort from the early onset of the subclavian vein compression. Practitioners should consider advanced imaging for patients showing similar signs and symptoms for extended periods especially when patients are participants of high risk sports for Paget-Schroetter Syndrome.

Spontaneous and Atypical Rhabdomyolysis in a Collegiate Tennis Athlete

Fulcher JG, Thompson AJ: Indiana Wesleyan University, Marion, IN

Background: A healthy 19 year old male tennis player participated in two tennis practices (am and pm) on the first day of pre-season (5.5 total hours). After practices, he and other teammates requested post-activity ice-bath immersion treatment. The patient exhibited no signs of heat illness prior to leaving the second practice. Upon ice immersion, the patient developed severe cramps in the lower extremity. Therapeutic interventions consisting of self and clinician-assisted stretching and massage were initiated along with fluid replacement. Attempts to alleviate cramping were unsuccessful. EMS was activated and the patient was transported to the emergency room (ER) for advanced medical care. Laboratory tests indicated a creatine kinase (CK) level of >8000 IU/L (normal range, 45-260 IU/L). **Differential Diagnosis:** Exertional heat cramps, dehydration, rhabdomyolysis. **Treatment:** The attending physician diagnosed the patient with rhabdomyolysis, admitted and treated the patient with intravenous fluids. The patient was prescribed with rest and rehydration and was released from the ER five days after admission. Blood tests were repeated throughout inpatient care and by eight days post incident, CK levels were within normal limits. Fourteen days after the initial incident, the patient described no other symptoms and was allowed to return to full tennis activities. **Uniqueness:** The patient demonstrated no signs of heat illness prior to leaving practice but experienced severe lower extremity cramping as he attempted ice-bath immersion, resulting in a diagnosis of exertional rhabdomyolysis. The patient showed no other signs of rhabdomyolysis other than elevated CK levels during inpatient care. Altered mental status was absent and heart rate and blood pressure were within normal limits. This is an atypical presentation

of exertional rhabdomyolysis and may have been identified very early in the progression of the condition. It is suggested that further complications were prevented and permanent organ damage prevented. **Conclusions:** In this patient, CK levels appear to be a poor indicator of rhabdomyolysis. This patient demonstrated no other signs of heat illness during or after the incident, yet CK levels remained elevated for at least 5 days. Although the patient in this case showed no other signs of exertional rhabdomyolysis, the ability of clinicians to identify signs and symptoms of heat illness is critical in preventing the patients' condition from deteriorating and potentially causing permanent organ damage. Anticipatory detection of progressing signs and symptoms of heat illness promote timely diagnosis and facilitates earlier return to participation.

Exertional Rhabdomyolysis in an International Student Athlete

Carmosino JG: Case Western Reserve University, Cleveland, OH

Background: 19 year old female, Division III volleyball player, international student from China. Arrived two days before preseason. On first day of practice she completed 3 conditioning tests, a verticle jump test, pushup test, a 1.5 minute suicide, and a half mile run. She completed the first three tests without problems. The last test of practice was the half mile run, during which she was visibly struggling, and slowly jogging the last 200 meters. Upon finishing she fell over and laid on the ground. The athletic trainer assisted her to a standing position. The athlete was nauseous. The athletic trainer asked questions about her nutrition over the past 24 hours. The athlete stated she had not eaten in 36 hours, and said she flew in from China 2 days prior and had been sleeping the past 2 days because she was not adjusted to the time zone , and was not accustomed to eating American food. She was held from all athletic activities for the day. The next day she reported with hamstring pain and back pain, and with tightness in her piriformis muscles, and reported pain that radiated from her back into her legs. **Differential Diagnosis:** The athlete complained of hamstring and back pain. Initial examination showed the athlete had tightness in her hamstrings and piriformis. It was thought she strained her hamstrings. She reported radiating pain from her back into her legs. Due to weakness there was concern for a herniated disc. With no improvement with rest, she was saw a physician who referred her for bloodwork. The team physician believed the issue was muscular but gave her a script to get blood work done to check CK levels. The physician said they wanted to order back x-rays if blood work was negative. The athlete was admitted to the emergency room since her CK levels were above 40,000. She was given IVs to rehydrate and

was kept for 3 nights in the hospital. **Treatment:** She was given IVs to rehydrate because her CK levels were above 40,000 upon initial examination. On day two, her CK levels were 12,000. She was released after 3 days. Two days after being released her CK level was 1217. The athlete was withheld from activity for 2 weeks, and then began a return to play progression. After an additional 3 weeks of activity progression the athlete returned to play without restrictions. **Uniqueness:** International student athletes traveling across time zones are exposed to shifts in circadian rhythm. This shift causes sleep disorders, irritability, fatigue, loss of appetite, and gastrointestinal disturbances. These direct and indirect effects of travel fatigue could increase risk factors for heat-related illness. Being an international student athlete, traveling across multiple time zones, and adjusting to a new culture of food are risk factors for rhabdomyolysis. There was no information in the literature on how being an international student athlete may be a risk for such illnesses, this is the first case known for this specific population. **Conclusions:** A 19 year old international student athlete, on a Division III volleyball team was diagnosed with rhabdomyolysis after completing preseason physical conditioning testing. She was admitted to the emergency room with a diagnosis of rhabdomyolysis having CK levels above 40,000. This case is important to the athletic training profession because more athletic trainers are coming in contact with international student athletes. It is important that athletic trainers are aware how the effects of travel increase risk factors for heat-related illnesses such as rhabdomyolysis. This presentation will help identify risk factors for rhabdomyolysis including travel related circadian shifts and identify acclimatization plans for international athletes.

Differences in Return to Play Between Two American Collegiate Football Players Diagnosed With Exertional Rhabdomyolysis: A Level 4 CASE Series

Bareis DR, Gaal W, Wilson K, Girouard TJ, Samuels MN, Radzak KN: University of Nevada, Las Vegas, NV

Background: During the first practice of the fall collegiate football season, which was helmets only, an offensive lineman (Patient 1: 21 years old, 73 inches, 301 lbs.) presented with muscle cramps in the lumbar and abdominal region. The athletic trainers were notified and began assessment of the athlete on the field. The player was removed from practice, given electrolytes (Powerade ION 4 Electrolyte Boost Packets, water), and brought into the athletic training room. Vital signs were taken (temperature:98.2°, blood pressure:159/113 mm/Hg, pulse:113 bpm, respiration rate:18 r/m) while the patient was monitored, continued with electrolyte and fluid replacement, and affected muscles were massaged. Cramping did not decrease with conservative treatment, and the patient was transported to the hospital. The following day, a second player (Patient 2: defensive lineman, 19 years old, 72 inches, 335 lbs.) presented with abdominal and thigh cramping following post-practice ice bath. Vital signs were taken (temperature:98.2°, blood pressure:139/65 mm/Hg, pulse:83 bpm,

respiration rate:20 r/m), the patient was hydrated like Patient 1 and monitored. Patient 2 was transported to the hospital after 30 minutes of conservative treatment did not alleviate symptoms. Both patients had been taking a pre-workout (KarbolyN Hydrate) and post-workout (whey protein) supplementation routinely. Both reported creatine monohydrate use (5g/day) over the summer. Both were African American and sickle cell trait negative. **Differential Diagnosis:** hyperthermia, heat stroke, heat exhaustion, heat cramps, acute kidney injury, exertional rhabdomyolysis. **Treatment:** Hospital blood analysis revealed increased creatine kinase (CK) levels (Patient 1: 1703u/L, Patient 2: 2258u/L, reference range: 44-196u/L). Both were diagnosed with exertional rhabdomyolysis. Patients were given medication and fluids intravenously (Patient 1: 1000ml NaCl, 5000u Heparin, 20mg Famotidine; Patient 2: 3000ml NaCl, 15mg Toradol, 650mg Tylenol, 8mg Zofran) while CK levels were monitored (see Table 1). Patient 1 was released from the hospital following one night of observation (22 hours) with CK levels of 2549u/L. Patient 2 was admitted for three nights and released with CK levels of 465u/L. Both underwent the Consortium for Health and Military Performance (CHAMP) guidelines for return to play (RTP) following exertional rhabdomyolysis. The CHAMP guidelines included stages of rest, increased aerobic activity, and sport specific exercises before clearance. Neither

patient saw any increase, or new, symptoms during RTP. RTP was completed by Patient 1 in five days and Patient 2 in 14 days. **Uniqueness:** Environmental factors were unique for time (August, morning practice) and location (Las Vegas, NV). The temperature on the first day was 84° with a relative humidity of 53%. The second day was 86° with 12% relative humidity. The true uniqueness of the current case series was the differences in recovery. Patient 1 was discharged with higher CK levels than at admittance, however, due to a rapid decline in symptoms his RTP progressed within one week. Patient 2's CK decreased by 1371u/L over the three-day hospitalization. Despite decreased CK levels, symptoms continued to present, therefore prolonging RTP. **Conclusions:** Blood analysis can be useful when progressing an athlete through RTP, however, clearance should be multi-modal. Symptoms for Patient 1 subsided quickly, although his CK levels remained elevated. In contrast, Patient 2 decreased in CK levels, but symptoms took longer to subside. Ultimately, Patient 1 achieved full clearance before Patient 2 based upon asymptomatic progression through RTP. Although the presentation and treatment of exertional rhabdomyolysis in both players were similar, CK levels and symptoms decreased at different rates. It is important for athletic trainers to understand that patients will recover at different rates, and that CK levels do not always align with symptoms.

Table 1. Creatine Kinase Levels Via Blood Draw

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Patient 1	1703 u/L	2549 u/L *				
Patient 2	2258 u/L	2057 u/L	1406 u/L	887 u/L *	602 u/L	465 u/L

*Day of hospital discharge

Paget-Schroetter Syndrome and Complications in a Division 1 Men's Lacrosse Athlete

Unislawski J, Gildard M, Power ME:
Marist College, Poughkeepsie, NY

Background: A 19-year-old male NCAA Division I lacrosse athlete presented to the athletic trainer complaining of pain with swelling and discoloration of his right upper extremity following practice. The athletic trainer noted edema and redness of the arm along with early cyanosis in the hand. Further evaluation revealed that there was pain with forward shoulder flexion and a noticeable grip strength deficit in the right hand. Tests for thoracic outlet syndrome were inconsistent. He was immediately referred to the on-site team physician who then referred him to the emergency department. **Differential Diagnosis:** Arterial thoracic outlet syndrome (TOS), chronic venous insufficiency, deep venous thrombosis (DVT), venous TOS, superficial venous thrombosis. **Treatment:** The patient received anticoagulation therapy at the emergency department. Upon evaluation by a vascular surgeon the following day, he was diagnosed with venous TOS based on clinical signs and symptoms and confirmation via a computed tomography (CT) scan showing a DVT in the right subclavian vein. Four days after his initial visit to the athletic training facility he underwent a right trans-axillary first rib resection and a right subclavian vein DVT removal. Four days after surgery, complications began to arise. The patient complained of a recurrence of symptoms including a throbbing, right shoulder pain. CT scan revealed another thrombosis in the subclavian vein. The patient then underwent an exploration and washout of a right axillary hematoma with drain placement as well as a correction for subclavian vein stenosis. He was diagnosed with Paget-Schroetter Syndrome, which is the presence of a thrombosis in the axillary or subclavian veins due to repetitive stress. Following surgery, the patient was placed on a three-month course of

anticoagulation therapy to prevent DVT recurrence. The surgeon gave the patient the option to attend physical therapy, which the patient declined. Following conclusion of anticoagulation therapy, the patient was prescribed low-dose aspirin for daily prophylactic use. Three months after his initial symptom onset, the patient was cleared to return to sport participation. He is now back to his normal daily activities, including lacrosse training and competition. **Uniqueness:** This case study serves to bring attention to the risks of venous TOS and Paget-Schroetter Syndrome as well as complications that may arise following surgical intervention for these conditions. Vascular TOS accounts for only 5% of all thoracic outlet syndrome cases while Paget-Schroetter Syndrome accounts for 1-4% of all upper extremity thromboses. Treatment often requires a first rib resection and may also require an aggressive treatment course of anticoagulation therapy if the thromboses arise again. While a rib resection via trans-axillary approach is a common technique to treat a DVT, complications are rare. A review of the literature revealed only six post-operative hematomas in 538 patients who underwent rib resections. It has been suggested that other procedures, such as a rib-saving scalenectomy, may be successful in preventing complications. **Conclusions:** The incidence of venous TOS is far lower than that of arterial, neurogenic or idiopathic TOS. Venous TOS and Paget-Schroetter Syndrome associated with the axillary or subclavian veins should be suspected via clinical signs and symptoms and confirmed with diagnostic imaging including CT scan or Doppler ultrasound. The diagnostic validity and reliability of many TOS special tests are questionable. Post-surgical complications are rare but may present difficulties for patients.

Free Communications, Poster Presentations: Hamstrings and Quadriceps

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;

Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Relationships Between Quadriceps Thickness and Knee Extension Rate of Torque Development

Chang E, Yang JH, Park DH, Kwak HB, Kim CS, An YW: Inha University, Incheon, South Korea; Dongduk Women's University, Seoul, South Korea; New Mexico State University, Las Cruces, NM

Context: Context: Muscle thickness is a significant intrinsic factor to generate muscle force. Quadriceps muscle group consisted of five different muscles and greater rectus femoris and vastus lateralis thicknesses have been shown primary contributors for knee extension peak torque. However, the relationships between each quadriceps muscle thickness and rate of torque development (RTD), which is an indicator of muscle performance in a specific time period, has not been reported. **Objective:** To assess relationships between each quadriceps muscle thickness and knee extension RTD calculated for initial 50 (RTD50) and 200 (RTD200) milliseconds (ms). **Methods:** **Design:** Cross-sectional. **Setting:** Research laboratory. **Patients or Other Participants:** Thirty-six recreationally active volunteers (22.2±2.0 years, 171.7±9.6 cm, 67.4±11.3 kg). **Interventions:** Three measures of quadriceps muscles' thickness; rectus femoris (RF), vastus intermedius (VI), vastus lateralis (VL), vastus medialis (VM), and vastus medialis oblique (VMO) were recorded using a portable ultrasound in a random order. RF and VI measured at 50% on the line between anterior superior iliac spine (ASIS) and superior patella pole (SPP). VL was measured at 10% lateral from RF and VI measurement site. VM was measured at 12.5% medial from 20% to distal on the line between ASIS and SPP. VMO was measured at 4 cm superior and 3 cm medial from SPP. Dominant leg knee extension torques were

recorded using a dynamometer (Cybex Humac Norm 770). Participants were placed in standardized testing positions with 70 degrees of knee flexion and contracted isometrically as hard and fast as possible following the verbal cue. **Main Outcome Measures:** Muscle thickness was measured using ImageJ software. RTD was calculated by fitting a line of best fit to the recorded torque-time curves for the initial 50 ms and 200 ms from the onset where the torque signal exceeded 2.5% of the recorded peak torque. RTD was then normalized using body mass. Peak value from three valid measurements were used for analysis. Pearson's product-moment correlation was used to assess the relationships between each quadriceps muscle thickness and RTD50 and RTD200. **Results:** Results: Each muscle thickness (mm) were RF=21.31±3.26, VI=22.16±3.78, VL=24.94±3.17, VM=29.65±5.04, VMO=20.21±3.38. RTD values (Nm/s/kg) were RTD50=12.16±3.26 and RTD200=12.23±2.37. RTD50 was fairly correlated to VI (r=0.330, p=0.033) and VMO (r=0.357, p=0.022) muscle thickness. However, RTD200 was fairly correlated to all quadriceps muscles; RF (r=0.414, p=0.009), VI (r=0.325, p=0.035), VL (r=0.329, p=0.033), VM (r=0.382, p=0.015), and VMO (r=0.403, p=0.011). **Conclusions:** Conclusions: While VI and VMO thickness were related to the early stage of contraction (RTD50), RF, VL, and VM thickness influenced to the late stage of contraction (RTD200). Since early stage of muscle activation has been proposed to significant factor for performance enhancement and dynamic stability of knee joint for injury prevention, the results suggest that VI and VMO training would be significant for athletic performance and further knee joint health.

The Effects of Soft Tissue Flossing on Hamstring Flexibility and Lower Extremity Power

Maust ZH, Bradney DA, Collins SM, Wesley CA, Bowman TG: University of Lynchburg, Lynchburg, VA

Context: Flossing includes wrapping a latex band around a joint or muscle group providing compression and partially occluding blood flow followed by performing exercises. Flossing is hypothesized to improve flexibility by dissipating myofascial adhesions; however, research is lacking. The purpose of this study was to determine if applying a floss band to the thigh would increase hamstring flexibility as well as lower extremity power. We hypothesized that floss band application would increase hamstring flexibility and power compared to control and sham treatments. **Methods:** Our laboratory, crossover study included 21 recreationally active individuals (8 male, 13 female, 22.62±2.99 years, 171.52±9.08 cm, 73.57±11.37 kg). Our crossover study design included two within factors; intervention (floss, sham, control) and time (pre-test, post-test). The participant first warmed up on a stationary bike, followed by hamstring flexibility measurement of supine hip flexion using the iHandy level iPhone App (reliability=0.98, validity=0.99). After the flexibility test, we used a JustJump mat with a single-leg vertical jump to test power. After pre-measurements, we applied interventions in a counterbalanced order. Floss treatment included wrapping a Wide Rogue® Voodoo Floss Band from the proximal knee to the gluteal fold at 140-200 mmHg as measured by a calibrated TekScan pressure sensor (reliability=0.97, validity=0.98). The sham treatment included wrapping the same band with a tightness of 10-40 mmHg. The control did not have a band applied. Participants performed

10 bodyweight squats, 10 lunges on each leg, and 20 non-weighted standing hamstring curls as part of the exercise protocol. The participants walked for 1 min after removing the band and then we remeasured flexibility and power. Hamstring flexibility and power were compared between the interventions and across time using separate 3x2 repeated measures ANOVAs ($p > 0.05$).

Results: For flexibility, the interaction for time and session was significant ($F_{(2,40)} = 17.54$, $p < 0.001$, $\eta^2 = 0.47$). Post hoc tests showed significant differences between pre (86.14 ± 8.06 degrees) and post (90.81 ± 7.69 degrees) for the floss session ($p < 0.001$, Mean Difference = 4.67, CI95 = 3.35-5.98) and between pre (87.67 ± 7.51 degrees) and post (89.86 ± 7.88 degrees) for the sham session ($F_{(2,40)} = 0.001$, Mean Difference = 2.19, CI95 = 0.98-3.40). For jump power, the interaction for time and session was not significant ($F_{(2,40)} = 1.82$, $p = 0.18$, $\eta^2 = 0.08$, $1 - \beta = 0.36$). **Conclusions:** Flossing treatment increased flexibility without affecting power. Flossing could be beneficial when rehabilitating injuries with a goal of increased flexibility without hindering power. With positive outcomes in a healthy population, future studies should continue to examine the clinical effectiveness of flossing on an injured population.

Lower Extremity Injury Following a Hamstring Strain in Division 1 Collegiate Football Athletes

Sanfilippo JL, Lund BS, Kliethermes SA, Moll MK, Heiderscheid BC: University of Wisconsin, Madison, WI

Context: Re-injury rates of hamstring strain injuries have been reported as high as 34% in Australian rules football. Prior hamstring strain injury (HSI) is a well-known risk factor for future HSI, due in part to the morphological and neuromuscular changes resulting from the injury. It has been suggested that these persistent deficits may also predispose an athlete to greater risk of incurring other lower extremity (LE) injuries upon return to play from the HSI. However, the extent of this effect has not been previously described. The purpose of this study was to determine if LE injury risk in NCAA Division I collegiate football athletes is increased following a HSI. **Methods:** This cross-sectional study retrospectively analyzed data from a collegiate football team over one academic year while all HSIs were recorded. An HSI was included if it caused the athlete to miss at least one practice or competition. Medical records were reviewed for the first LE injury of the season or first injury following the return to sport from the HSI that resulted in an athlete being removed from team participation for at least 1 day. Athletes were excluded if they underwent a LE surgery or sustained a HSI in the prior 1 year. Chi Squared analysis was used to compare the observed injury risk in those who sustained a HSI and those who did not sustain a HSI. **Results:** A total of 98 athletes were included, of which 15 sustained an HSI. Among those who had a HSI, 9 incurred a subsequent LE injury during the monitoring period, while 25 of those that did not have a HSI ($n = 83$) sustained a different LE injury. A relationship between prior HSI and the frequency of subsequent injury was found $\chi^2 (1, N = 98) = 5.01$, $p = 0.025$. The odds of incurring a LE injury following

a HSI are 3.48 (95% CI = 1.119, 10.821) times greater compared to those that did not sustain an HSI in the season. The most common subsequent injury among those with an HSI was a second HSI. A sub-analysis removing athletes with recurrent HSI ($n = 3$) did not detect a significant association between initial HSI and subsequent LE injury [$\chi^2 (1, N = 95) = 1.885$, $p = 0.170$; OR = 2.320 (95% CI = 0.682, 7.897)]. **Conclusions:** LE injury risk is greater among D1 collegiate football athletes who sustain a recent HSI compared to those that do not. However, when subsequent HSI is not considered, no difference was detected. Nonetheless, this finding reinforces the need to better characterize neuromuscular deficits following HSI (e.g., changes in torque-angle relationship, reduced eccentric knee flexor strength, and altered muscle-tendon dynamics), as these same factors may be contributing to the increased risk for overall LE injury.

Patients With Unilateral Anterior Knee Pain Present Bilateral Deficits in Quadriceps Neuromuscular Function and Hip Joint Flexibility: A Cross-Sectional Study

Kim S, Park J: Kyung Hee University, Yongin, Korea

Context: Unilateral anterior knee pain (AKP) may cause bilateral quadriceps weakness and inhibition. However, it is unclear how unilateral AKP affects bilateral quadriceps endurance and hip joint flexibility. We examined if patients with unilateral AKP present bilateral deficits in quadriceps neuromuscular function and hip joint flexibility when comparing with the matched healthy knees. **Methods:** Study design: Cross-sectional study. Setting: Laboratory. Patient population: Twenty-three patients with unilateral AKP (8 females, 15 males; age: 22.0 ± 1.2 years, height: 171.7 ± 2.9 cm, mass: 70.6 ± 7.5 kg, body mass index: 23.8 ± 1.9 kg/m², time since pain: 46.5 ± 15.0 months) and 23 matched healthy controls (8 females, 15 males; age: 22.7 ± 1.3 years, height: 171.0 ± 3.0 cm, mass: 70.8 ± 5.6 kg, body mass index: 24.1 ± 1.5 kg/m²). Outcome measures: Pain perception using visual analog scale (cm), functional outcomes using the Lower Extremity Functional Scale (score), and knee joint effusion (sum of the circumferences of the superior and inferior pole of patella in cm) were obtained. Quadriceps neuromuscular function was assessed by strength (isometric in N·m/kg), endurance (isokinetic at 180°/s in N·m/kg), and voluntary activation (central activation ratio). Hip joint flexibility was measured by single straight leg raise and modified Thomas test (°). Statistical analyses: Parametric or a non-parametric tests ($P < .05$) with calculations of Cohen's d effect size with 95% confidence intervals were performed. **Results:** Knee joint circumference was not different, indicating that our AKP patients did not have joint effusion ($P = .28$). As compared with the matched healthy controls, patients with unilateral

AKP showed (1) a greater pain perception (0.0 ± 0.0 versus 4.3 ± 0.7 cm, $P < .0001$, $d = 3.50$); (2) a lower score on functional outcomes (79.6 ± 0.3 versus 56.3 ± 4.6 score, $P < .0001$, $d = 1.20$); and (3) a less quadriceps strength (3.5 ± 0.2 versus 2.8 ± 0.2 N·m/kg, $P < .0001$, $d = 1.15$), endurance (peak torque: 1.65 ± 0.07 versus 1.51 ± 0.05 N·m/kg, $P = .02$, $d = 0.65$; total work: 76.5 ± 3.0 versus 69.6 ± 2.3 N·m/kg, $P = .01$, $d = 0.75$), and voluntary activation (0.95 ± 0.02 versus 0.83 ± 0.03 , $P < .0001$, $d = 1.41$), and hip joint flexibility (flexion: 86.7 ± 4.6 versus $72.5 \pm 4.3^\circ$, $P = .001$, $d = 0.92$; extension: 11.9 ± 1.4 versus $7.8 \pm 2.3^\circ$, $P = .03$, $d = 0.64$). **Conclusions:** Our data suggest that unilateral AKP, without the absence of joint effusion, results in bilateral deficits in quadriceps neuromuscular function and hip joint flexibility. Since chronic AKP may cause bilateral symptoms, clinicians should consider restoration of both neuromuscular function and the joint flexibility along with pain reduction.

Hamstring Syndrome in Collegiate Track Athlete

Daddario S, Burkey T, Wallace J: Youngstown State University, Youngstown, OH

Background: The patient was an 18-year-old female track and field sprinter with no significant medical history. She reported to the athletic training room complaining of posterior right thigh pain and had tenderness over the biceps femoris. Pertaining to ROM, her knee flexion had slight deficiency, her knee extension was WNL, she had discomfort with hip flexion, and hip external rotation was lacking when compared bilaterally. Following a thorough examination, the athletic trainer concluded that this athlete had a hamstring strain and would be withheld from participating in sport-related activity until symptoms subsided. Further, she would begin an exercise rehab program. The athlete's symptoms would diminish but would then show up in different spots along muscle with some numbness after rehabilitation sessions. Following 12 weeks of rehabilitation exercises, the symptoms subsided, and the athlete was allowed to return to sport. The following athletic season, the athlete re-injured her hamstring and clinical findings from the evaluation were similar to the initial injury. No new source of pain could be identified; however, she presented with one new symptom: a complaint of hamstring soreness/tightness when sitting. The athlete saw a physician in her hometown and the possibility of a hamstring syndrome diagnoses was presented. **Differential Diagnosis:** Hamstring strain or biceps femoris tendinopathy were considered. An MRI revealed no noticeable deformity. With the addition of soreness/tightness when sitting and no gross deformity noted, the potential diagnoses for hamstring syndrome was presented. **Treatment:** After visiting with the team doctor it was suggested to continue the exercise rehabilitation program and the official diagnoses of hamstring syndrome was documented. After the athletic trainer did some researching, it was stated in the literature that adding a vibration

plate to the rehabilitation program could potentially relieve symptoms. Using a local chiropractors office that had a vibration plate, the athlete was scheduled to work out on the vibration plate two for twelve minutes times per week, over three weeks. After four weeks the athlete had complete relief of symptoms that she had suffered from for over a year. The rehabilitation program was as follows; quarter squat, quarter squat hold with heel lift, full squat hold, RDL hold, seated hamstring stretch (thigh on plate) with the vibration plate set at 45-megahertz pulse. Then the athlete would perform single leg lunge hold, single leg lunge hold with toe up, single leg quarter squat hold, standing single leg hamstring stretch, seated hamstring stretch (on floor with heel on plate) with the vibration plate at a setting of 40-megahertz pulse. Each exercise was performed for 60 seconds with minimal rest in between sets. **Uniqueness:** This case is unique due to the conclusion of hamstring syndrome which is an uncommon diagnosis. However, it could be what is truly happening in athletes experiencing chronic, re-occurrent strains. If this is the case, then the athletes with a potential hamstring syndrome must be treated differently than an athlete with an acute hamstring strain. Using this research, it could offer an athletic trainer a method to solve an athlete with a chronic hamstring complaint. **Conclusions:** The potential for a diagnoses of hamstring syndrome presents a possible explanation to athletes that suffer from chronic or repetitive hamstring injuries. Due to the lack of research or information on hamstring syndrome, there is no true diagnostic criteria or rehabilitation programs for this syndrome. This case study could introduce athletic trainers to hamstring syndrome and provoke thought when working to rehabilitate an athlete suffering from chronic hamstring strains. In addition, using a vibration plate for hamstring injuries could be a benefit to athletes with a hamstring injury.

Quantitative Comparison of Individual Lower Limb Muscle Volumes Between Soccer and Basketball Players

Feng X, Xie T, Blemker SS, Meyer CH, Hart JM: Springbok Inc, Charlottesville, VA; University of Virginia, Charlottesville, VA

Context: Lower limb muscles play essential roles in various aspects of athletic performance including jumping, sprinting and torque production. Elite-level athletes in different sports may develop different muscle profiles to achieve a high level of performance. With high-resolution MRI individual muscle volumes can be calculated after segmenting each muscle from the resulting images yielding an athlete profile of individual muscle volume distribution in the lower extremity. The purpose of this study is to compare the muscle volumes between soccer and basketball players. **Methods:** Total of 21 NCAA Division 1 varsity athletes including convenience samples of 11 soccer (age range=19-21, height=183.34±7.87cm, mass=79.84±8.22kg) and 10 basketball (age range=19-24, height=198.88±6.23cm, mass=100.58±7.31kg) players were recruited for this study. All subjects had no injury in the past 6 months and no contradictions for MRI. Informed consent was obtained from each subject for the MRI study. All MRI Scans were performed on a Siemens 3T scanner to obtain fat-suppressed proton-density weighted images of the entire lower limb from T12 to the ankle. Manual segmentation was performed to delineate the boundaries for all 35 muscles on each leg. Volume calculation was performed by counting the number of voxels within each muscle and the average values of the left and right legs were used for analysis. To account for the differences in body sizes, the muscle volumes were normalized by the body surface area estimated as the square root of height*mass. Two-sided Welch's t-test was performed on each muscle between the two groups. Alpha level was 0.05. **Results:** Table 1 shows the mean

normalized volumes for soccer players and basketball players, the differences in percentage between the two and the corresponding p-values for selected muscles with p-values < 0.2. Due to the relatively small sample sizes, statistically significant differences were found in only 4 muscles: obturator internus, fibulari, flexor digitorum longus and soleus, with flexor digitorum longus being the only muscle that soccer players had larger volumes. For muscles with absolute large volumes (normalized volume >2.0) including soleus, vastus medialis, adductor magnus, psoas major and gluteus maximus, basketball players tended to have larger normalized volumes compared to soccer players in all but psoas major. On average, 22 of the 35 lower extremity muscles exhibited larger volumes and 13 were smaller for basketball players compared with soccer players. **Conclusions:** When normalized to body size, basketball players had larger volumes in most large, primary moving muscles in the lower extremity suggesting sport-specific distribution of lower extremity muscle volume. The ability to characterize differences or changes in muscle volumes may help sports medicine practitioners identify targets for training, skill acquisition or potentially rehabilitation.

Free Communications, Poster Presentations: Hydration in Various Settings

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Fluid Replacement Behaviors of Active Firefighters

Graves WM, Winkelmann ZK, Games KE: Indiana State University, Terre Haute, IN

Context: Hydration is an integral component of performance for physically active individuals. Firefighters' jobs are complex and include fire suppression, search, rescue, extraction, and medical response. These tasks require proper and sustained baseline hydration given the unpredictability of these tasks. The purpose of our study was to explore the hydration status and fluid replacement behaviors of active firefighters before and after a 24-hour shift, and following a passive, primary prevention strategy to promote proper hydration. **Methods:** We used a quasi-experimental non-control study design within two fire stations in the Southeastern United States. Twenty active, career firefighters (age=29 years old \pm 8.33, height=181 cm \pm 5.77, mass=87.6 kg \pm 24.23, male=19, female=1) working a 24-hour shift and on unrestricted work duty volunteered for this study. Each participant provided a urine sample at the start and end of two 24-hour shifts. Throughout the 24-hour shift, the participant maintained a fluid intake journal. Urine specific gravity (USG) was measured using a digital refractometer. Following the initial data collection, a passive, primary prevention strategy was deployed for six weeks. The strategy included multiple urine color charts placed within the fire station lavatories. Following the six-week intervention, urine samples were again collected pre- and post-24-hour work shift. USG data were analyzed using a one-way repeated measures analysis of variance and when appropriate, dependent t-tests. Descriptive statistics were calculated. Fluid intake journal entries were assessed the frequency and volume of consumption of different types of beverages during the 24-hour

shift. **Results:** Participants in the study were mildly dehydrated at the start of each shift, regardless of the primary prevention intervention (pre-intervention pre-shift USG = 1.0207, post-intervention pre-shift USG = 1.0206). Likewise, participants remained mildly dehydrated at the end of the shift, regardless of intervention (pre-intervention post-shift USG = 1.0181, post-intervention post-shift USG = 1.0195). We found no significant interaction or main effects of time or intervention (p-value range = 0.15-0.23). Participants in this study tracked their daily fluid intake and serving amount of each fluid ingested. Pre-intervention measures of fluid consumption showed an average of 1.8 servings of water, 0.7 servings of soda, and 0.7 servings of coffee. After the intervention, we found that firefighters averaged 3.5 servings of water, 1.1 servings of soda, and 0.7 servings of coffee. **Conclusions:** Firefighters enter and exit their shifts at similar levels of dehydration. Due to the job expectations of firefighters, this level of dehydration may place firefighters at an increased risk for musculoskeletal and cardiovascular injuries. A passive, primary prevention intervention was not effective at altering significantly altering hydration levels in our sample. Future research should examine if active forms of primary prevention interventions can improve pre- and post-shift hydration levels in firefighters.

Hydration Status and Perception of Fluid Loss in Male and Female University Rugby Union Players

Muth T, Pritchett R, Pritchett K, Blank R, DePaepe J: Central Washington University, Ellensburg, WA

Context: Dehydration is the process of losing body water and can have detrimental effects on performance if more than 2% of body weight is lost. Rugby union players are at risk for dehydration due to the high physiologic demand of the sport. Dehydration could be due to the lack of knowledge of fluid lost during activity. Therefore, the purpose of this study was to observe the hydration status and fluid loss estimations in male and female university rugby union players over three consecutive training sessions. **Methods:** Twenty male (19.6 ± 1.4 yr, 96.1 ± 12.3 kg) and sixteen female (20.6 ± 1.9 yr, 77.8 ± 15.0 kg, and 158.1 ± 39.7 cm) university rugby union players chose to participate in this field-based, observational, cohort study. Training sessions consisted of indoor

weight lifting followed by rugby practice on the university's outdoor rugby pitch. Body mass, urine specific gravity, and a self-reported thirst scale were collected pre and post training for all three training sessions. Participants were each given a 32-ounce water bottle following pre-training measurements to track fluid intake during the training sessions. Participants were asked to estimate how much fluid they lost after each training session. Actual fluid loss was calculated after each training session and shown to the participant following the fluid loss estimation. Paired t-tests were used to determine significance between pre and post training body mass, USG, and thirst level for each day. A general linear mixed-effect model was used to determine significance of the difference between variables within gender and within days. Statistical significance was accepted at $p < .05$. Data analyses were conducted using SPSS (version 21.0 SPSS Inc, Chicago, IL). **Results:** Main findings showed mean body mass changes did not exceed 2% lost for either gender on any of the three training

sessions, remaining in an adequately hydrated state (Table 1). Males significantly underestimated sweat loss by ~81% ($p < .01$) after session one and improved estimations to ~36% after session three, however still significantly underestimated ($p < .01$). Females also significantly underestimated sweat loss by ~64% after session 1 ($p < .01$), and also improved estimations to ~60% after session three, however, still significantly underestimated ($p < .01$). **Conclusions:** In conclusion, the participants, on average, remained in an adequately hydrated state throughout the three training sessions, maintaining proper body mass, USG and thirst levels. Open access to water provided by athletic trainers during university sports team practices is seemingly enough to adequately replace fluid lost. Although fluid loss can serve as a method of gauging fluid replacement, participants significantly underestimated sweat lost after each training session. This study has shown education of sweat lost can help improve measurements and therefore improve fluid replacement during training.

Table 1. Body mass changes by gender. (Mean \pm SD)

Gender (N)	Day	Mass Change, kg	Mass Change, %
Male (20)	1	-0.5 \pm 0.5*	-0.6 \pm 0.6
	2	-1.1 \pm 0.6*	-1.1 \pm 0.5
	3	-0.5 \pm 0.6*	-0.5 \pm 0.7
	Total	-0.7 \pm 0.6	-0.7 \pm 0.6
Female (16)	1	0.3 \pm 0.6	0.3 \pm 0.8
	2	0.3 \pm 0.5*	0.3 \pm 0.6
	3	-0.1 \pm 0.7	-0.2 \pm 1
	Total	0.2 \pm .6	0.1 \pm 0.8

Note: * significantly different from pre to post training, $p < .05$

Perceived Gastrointestinal Distress Symptoms Among University Marching Band Musicians

Uriegas NA, Torres-McGehee TM, Emerson DM, Yeargin SW, Kelly MR, Hirschhorn RM, Smith A, Weber SR, Usuki H, Hatcher M: University of South Carolina, Columbia, SC; University of Kansas, Lawrence, KS

Context: Marching musicians face many physically active demands during rehearsals and performances. Gastrointestinal (GI) distress is a common complaint during exercise and may be a result of a combination of dehydration and intense rehearsals and game performances in extreme environmental temperatures. The purpose of this study was to examine perceived GI distress symptoms in marching band (MB) musicians during activity.

Methods: We utilized a cross-sectional design. Participants were recruited from two NCAA Division I university marching bands (MB1: $n = 10$; MB2: $n = 9$). Nineteen volunteers completed the study (male: $n=6$, female $n=13$, age= 20.5 ± 0.9 yrs; weight= 73.3 ± 18.9 kg; height = 164.9 ± 6.8 cm; body fat = $27.5 \pm 11.4\%$). As part of a larger study, data collection occurred during 3 rehearsals and 2 football game performances. At pre- and post-activity, participants completed a previously developed GI symptom index divided into 3 sections: 1) upper abdominal (e.g., heartburn, reflux, nausea, vomiting), 2) lower abdominal (e.g., pain/cramping, flatulence, diarrhea), and 3) systemic problems (e.g., dizziness, headache, urge to urinate). Symptoms were scored on a 10-point scale (0 = no problems at all and 9 = worst it has ever been). A score >4 was considered "serious". Statistical analysis included descriptives (mean \pm standard deviation) and Wilcoxon signed-rank, Mann-Whitney U, and Chi-square tests to determine differences in symptom frequency and % serious overall, between rehearsal and games, and between and

within musicians at MB1 and MB2. Significance was set at $\alpha < 0.05$.

Results: There were no significant differences in overall pre- and post-activity GI symptoms. Headache and urge to urinate received the highest scores (7/10). Dizziness was the only significantly different symptom between event (rehearsal or game performance), with 4.5% considered serious and all occurring at a game performance ($X^2 = 6.78$, $P = 0.009$). There were no significant differences in upper and lower symptoms pre- or post- between MB1 and MB2. However, systemic GI scores were significantly higher for MB2 than MB1 at pre- ($U = 477.5$, $z = -2.023$, $P = 0.043$) and post-activity ($U = 628.0$, $z = -3.642$, $P < 0.001$). Within MB2, dizziness was reported as serious 6.7% of the time and more frequently at post-game ($X^2 = 4.82$, $P = 0.028$). Within MB1, systemic symptoms occurred more often post-games than post-rehearsals ($U = 184$, $z = -2.122$, $P = 0.034$). **Conclusions:** Although there were no differences between groups, it is important to note that marching musicians reported GI distress. Healthcare professionals working with this population should be aware of minimizing risks associated with GI distress (e.g., exercising in hot and humid environments, inadequate hydration and dietary intake, and any other stressors such as medications and poor sleep).

Hydration Status, Fluid Intake, and Thirst Among University Marching Band Musicians

Yeargin SW, Emerson DM, Torres-McGehee TM, Hirschhorn RM, Smith A, Weber SR, Kelly MR, Uriegas NA, Hatcher M, Usuki H: University of South Carolina, Columbia, SC; University of Kansas, Lawrence, KS

Context: Marching band musicians commonly rehearse and perform for long periods in hot environmental conditions. Athletes who play in the same manner frequently experience hypohydration but research has not determined if this true in the marching band population. The purpose of our study was to describe hydration status, fluid variables, and sweat variables among marching band musicians and determine if differences exist between rehearsals and game performances.

Methods: We utilized a cross-sectional design. Participants were 24 university marching band musicians (8 male, 16 female; age = 20.7 ± 0.9 yrs; 74.2 ± 17.7 kg; 166.6 ± 8.5 cm; 26.7 ± 11.2 body fat %). Data collection occurred pre-, during, and post- afternoon rehearsals (3) and football games (2). Game-days also included morning rehearsals (2), for 7 data collections. Dependent variables were urine specific gravity (Usg), percent change in body mass (%BM), urine volume (Uvol), sweat rate (SwR), fluid volume rate (FVR), and perceived thirst (9-point scale). Statistical analysis included descriptive (mean \pm standard deviation) for all variables. One-way ANOVAs determined differences in variables between event type (PM rehearsal, AM rehearsal, game). When significance was identified, post-hoc analysis utilized Games-Howell corrections. Paired sample t-tests determined differences between pre-post Usg and thirst. Significance was set at $\alpha < 0.05$. **Results:** Overall, musician's %BM = $-0.4 \pm 1.1\%$ with a SwR = 216 ± 233 ml/hr, FVR = 307.1 ± 206.5 ml/hr, and Uvol = 135.1 ± 161.9 ml. Usg significantly increased pre- ($1.021 \pm$

0.008) to post-activity (1.024 ± 0.009 , $P < 0.001$) as well as thirst (pre: 3.5 ± 1.6 ; post: 4.5 ± 1.9 , $P < 0.001$). Using >1.025 as a threshold for hypohydration, 38% and 50% of band musicians were hypohydrated pre and post activity respectively. Within event type, pre-Usg at PM rehearsal was significantly lower (1.018 ± 0.009) than AM rehearsal (1.023 ± 0.006 , $P = 0.008$) and games (1.024 ± 0.009 , $P = 0.002$). Sweat rate was significantly higher during games than AM rehearsal (356.1 ± 286.4 ml/hr vs 173.3 ± 163.3 ml/hr, $P = 0.009$). FVR was significantly less during AM rehearsals (221.6 ± 184.7 ml/hr) than PM rehearsals (331.7 ± 154.2 ml/hr, $P = 0.002$) and games (360.9 ± 274.9 ml/hr, $P < 0.017$). There were no differences in post-Usg, %BM, or thirst between event types. **Conclusions:** Marching band musicians began rehearsal hypohydrated but moderate SwR with adequate FVR minimized %BM changes. Game SwR, Usg, and FVR in general were higher than rehearsals, most likely due to environmental conditions, uniform configuration, and other unique factors. Clinicians working with this population should develop educational and hydration interventions based on event type.

Gastrointestinal Distress, Core Temperature, and Hydration Among Marathon Runners Using and Not Using NSAIDs

Kelly MR, Emerson DM, McDermott BP, Laursen RM, Troyanos C, Duckett A, Butts CL, Caldwell AR, Gibson ME: University of Kansas, Lawrence, KS; University of Arkansas, Fayetteville, AR; Boston University, Boston, MA; International Institute for Race Medicine, Norfolk, MA; University of Missouri, Kansas City, MO

Context: Non-steroidal anti-inflammatory drugs (NSAIDs) are considered anti-inflammatory and anti-pyretic and are known to induce gastrointestinal (GI) damage. Research thus far is conflicting regarding NSAIDs' effects on multiple physiological systems during and after intense exercise. The purpose of this study was to examine physiological and perceptual NSAID effects on GI distress, GI temperature (TGI), and hydration status in marathon runners.

Methods: This study was a cross-sectional design. Participants were recruited from the 2017 Kansas City Marathon. Average race temperature = 19.3°C and relative humidity = 68.1%. Twenty-two volunteers (13 male, 8 female; age = 39 ± 10 yrs; weight = 70.7 ± 10.1 kg; height = 171.0 ± 7.7 cm) completed the study in either the Control ($n = 15$) or NSAID ($n = 7$) group. NSAID participants were required to be taking non-selective NSAIDs for ≥ 2 days prior and intended to take NSAIDs on race day. Dependent variables were perceived upper, lower, systemic, and other GI distress symptoms (e.g., nausea, cramping, fullness); TGI; urine specific gravity (Usg); and percent body mass change (%BM) measured at pre-, post-, and 24 hours post-marathon. Statistical analysis included descriptive (mean \pm standard deviation and percent occurrence), one-way ANOVAs within and between conditions; and Wilcoxon-signed-rank and chi-square tests for non-parametric data. Significance was set at $\alpha < 0.05$. **Results:** There

were no significant differences for GI, TGI, Usg, or %BM change between groups. TGI increased pre- ($37.1 \pm 0.3^\circ\text{C}$) to post-race ($38.6 \pm 0.6^\circ\text{C}$, $P < 0.001$). Overall, participants lost $2.9 \pm 1.0\%$ BM from pre- to post-race. The NSAID group gained $3.4 \pm 1.4\%$ BM and Control $2.0 \pm 1.3\%$ BM from post- to 24 hours post-race. Usg significantly increased from pre (1.014 ± 0.009) to post- (1.023 ± 0.004 , $P = 0.017$) and 24 hours post-race (1.025 ± 0.011 , $P = 0.001$). Six participants (3 NSAID and 3 Control) had 24 hour post-race Usg > 1.030 . The most common and "serious" GI symptom scores ($>4/10$) occurred for nausea, urge to defecate and urinate, headache, muscle cramps, and thirst. At 24 hours post-race, NSAID participants reported 5.6% upper, 2.4% lower, 0% systemic, and 8.3% other GI symptom scores as serious. Control participants at 24 hours post-race reported 0% upper, 1.1% lower, 4.5% systemic, and 5.7% other were serious. **Conclusions:** Non-selective NSAID use over a short period (minimum of 2 days prior and during the marathon) did not have a significant effect on TGI, hydration status, or GI distress symptoms before or after completing a marathon in a cool environment. Participants consumed fluids that replaced %BM loss; however, Usg indicated several were still hypohydrated the day after the race. Many participants experienced GI symptoms the day after the race, suggesting potential residual effects from intense running.

A Comparison of Sweat Rate and Sweat Sodium Concentrations Between the First and Second Hours of Running While Using Two Different Hydration Strategies

Hunt DL, Fowkes Godek S, Stehman M, Worley M, Morrison KE: West Chester University, West Chester, PA

Context: Sweat and electrolyte losses are thought to negatively affect thermoregulation or exercise performance. Sweat samples for analysis of sodium concentration $[Na^+]$ are generally collected at the beginning of an exercise bout, but it is unknown whether these samples are representative of $[Na^+]$ over time. Additionally, hydration state affects sweat rate (SwtR) and therefore, possibly $[Na^+]$. The purpose of this study was to determine whether SwR and sweat $[Na^+]$ differed between the first(Hr1) and second(Hr2) hours of continuous running while subjects drank to thirst (Thirst) versus a pre-determined schedule (Scheduled). **Methods:** Sixteen subjects (10M/6F; Age=37.13±13.03yr, Ht=171.5±14.5cm, Wt= 70±12.8kg, body fat=17.5±6.6%, VO₂max= 51.7±8.6ml/kg/min) participated in this crossover study. Subjects had baseline BODPOD and VO₂max testing prior to participating in 2 different randomly assigned, 2-hour treadmill running trials in a climate-controlled chamber. Scheduled drinking was based on the 2000 NATA fluid replacement guidelines and for Thirst, subjects drank when they felt a deep-seated desire for water. Nude body weight was recorded pre-trial, and then at Hr1 and Hr2 of running. SwtR was calculated as change in body weight adjusted for urine volume and fluid intake for each hour. Sweat samples (forearm and low back sites) were collected using absorbent patches. The patches were removed during the first 30-45 min of each hour of running. Sweat was analyzed for $[Na^+]$ by ion selective electrode. Sodium losses were calculated for ease of interpretation

by converting mmol/l to mg and multiplying by SwtR. A 2(trial) x 2(hour) ANOVA was used with correlated t-tests and $P<.05$. **Results:** Environmental conditions (WBGT=16±0.98°C), core temperature (37.9±17.12°C), and heart rate (135.2±20.8bpm) were not different between hours or trials. Sweat $[Na^+]$ was higher Hr2 (51±24.3 mmol/l) versus Hr1 (46.9±42.6 mmol/l, $p<.05$) but was not different between trials ($p=.507$). No differences existed in SwtR: Thirst Hr1 (1.04 ± .490l/hr) and Hr2 (1.024 ± .364l/hr), Scheduled Hr1 (1.085 ± .304l/hr), and Hr2 (1.046 ± .403l/hr). No differences were found in SwtR (Thirst and Scheduled combined) between Hr1 (1.039± .402 l/hr) and Hr2 (1.035± .363l/hr) ($p=.445$). Na⁺ loss was also not different: Thirst Hr1 (1199.5 ± 1114.6mg), Hr2 (1340.1±1188.0mg), Scheduled Hr1 (1177.0± 929.1mg), and Hr2 (1137.5±575.4 mg), $p=.216$. Body weight changes were observed between hours ($p=0.01$), but more importantly between trials ($p= <.0001$). Body weight increased by the end of Hr2 in Scheduled (0.3 ± .39kg, range= 0.55-1.00kg) and decreased during Thirst (-0.77± .54kg, range= -0.63-2.13kg). **Conclusions:** Although $[Na^+]$ increased during Hr2, it was not caused by a differences in SwtR, and SwtR was not affected by hydration status as others have reported. Sweat Na⁺ losses were nearly identical regardless of hour or hydration method. Notably, Scheduled produced an increase in body weight, whereas Thirst resulted in minimal weight loss which is recommended.

A Comparison of the Sex Differences in the Physiological Effects of Drinking to Thirst Versus Drinking to a Generic Schedule During 2 Hours of Running in Thermoneutral Conditions

Stehman ME, Fowkes Godek S, Worley ML, Hunt D, Morrison KE: West Chester University, West Chester, PA

Context: Hydration status and thermoregulation were linked for decades. Consequently, both male and female endurance athletes frequently follow pre-determined hydration strategies instead of their thirst mechanism to minimize dehydration-induced heat illness or improve performance. The purpose of this study was to examine sex differences in the physiological effects of drinking to thirst (Thirst) versus a generic schedule (Scheduled) during 2 hours of running. **Methods:** In a randomized crossover study, eleven male (age = 39.4 ± 13.3 yr, ht = 176.4 ± 7.7 cm, wt = 77.1 ± 10.2 kg, body fat = 16.6 ± 7.4%, VO₂max = 60.4 ± 7.7 ml/kg/min) and nine female (age = 35.3 ± 10.1 yr, ht = 161.6 ± 16.4 cm, wt = 59.2 ± 8.8 kg, body fat = 19.6 ± 6.4%, VO₂max = 52 ± 2.0 ml/kg/min) trained endurance

runners completed two experimental trials. VO₂max (Bruce Protocol) and body composition (Bod Pod) was determined prior to the experimental trials. Participants ran for 2 hours at 60% VO₂max in a climate-controlled chamber (21°C and 40% RH) while heart rate and intestinal temperature were monitored continuously. In Thirst, participants drank when they felt a deep-seeded desire to drink and stopped when satisfied. The water consumed was measured (mL). The Scheduled trial, based on the 2000 NATA fluid replacement guidelines, required water consumption as follows: 600mL 2 hours pre-trial, 300mL 20min pre-trial, and 300mL every 10min during running. Nude body weight was obtained pre and post-exercise, and urine volume was measured post-trial. Blood samples were taken via lancet technique at pre-trial, mid-trial, post-trial, and 20min post-trial, and analyzed for sodium by ion-selective electrode. Sweat rate was calculated by change in body weight, urine output, and fluid intake. Data was analyzed by two-way and one-way ANOVA and then correlated T-tests with a Bonferroni correction, and P<0.05. **Results:** There were no sex or trial differences in environmental conditions, HR or intestinal temperature. Sweat rate for males and females combined was lower in

Thirst (1.82±820mL/hr) compared to Scheduled (1.986±.684 mL/hr), P<.01. For blood sodium, the Sex x Trial x Time ANOVA revealed a significant difference between groups over time. Final data comparisons are shown in the table. Body weight change and urine output was different between trials for both females and males (p<.01), but no differences existed between the sexes. Trial differences were found for both males and females for fluid intake, both P<.01. However, there were no sex differences in fluid intake in the Thirst trial. In the Scheduled trial total time of participation was different (P<.01) between males (118.8±3.9min) and females (102.1±21.2min), and with males and females combined differences were found between Thirst (120±0min) and Scheduled (111.3±16.43min), P<.01. **Conclusions:** Both sex groups experienced weight gain and dilution of blood sodium in response to drinking according to the 2000 NATA guidelines. However, all participant's physiological measures remained within normal limits when following their thirst mechanism, demonstrating that drinking to thirst is the safest hydration strategy as mentioned by the 2017 NATA fluid replacement guidelines.

Blood Na⁺ (mean ± SD) during Thirst and Scheduled Trials in Male (M) and Female (F) Subjects

	Pre-Trial	Mid-Trial	Post-Trial	20min Post-Trial
M Thirst	139.9 ± 2.1	141.2 ± 2.3	141.9 ± 3.2	142.8 ± 3.1
Range	137-142	138-145	137-148	137-147
M Scheduled	140.7 ± 2.5	138.6 ± 2.0	136.4 ± 1.9	136.5 ± 2.3
Range	137-145	135-141	133-139	131-140
Paired T-Test	No difference	P<.0004	P<.0001	P<.0001
F Thirst	139.6 ± 1.7	141.9 ± 2.7	142.8 ± 2.5	142.6 ± 2.1
Range	137-142	138-147	139-147	140-146
F Scheduled	139.3 ± 2.8	136.7 ± 2.5	134.4 ± 2.6	134.7 ± 3.2
Range	135-145	133-140	132-138	131-141
Paired T-Test	No difference	P<.006	P<.001	P<.0003
M & F Thirst	139.8 ± 1.9	141.6 ± 2.4	142.4 ± 2.9	142.7 ± 2.6
Range	137-142	138-147	137-148	137-147
M & F Scheduled	140.1 ± 2.7	137.8 ± 2.4	135.5 ± 2.4	135.7 ± 2.8
Range	135-145	133-141	132-139	131-141
Paired T-Test	No difference	P<.0001	P<.0001	P<.0001

Free Communications, Poster Presentations: Low Back Pain Assessment and Rehabilitation

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Muscle Activation of the Lumbo-Pelvic-Hip Complex During Incline Walking

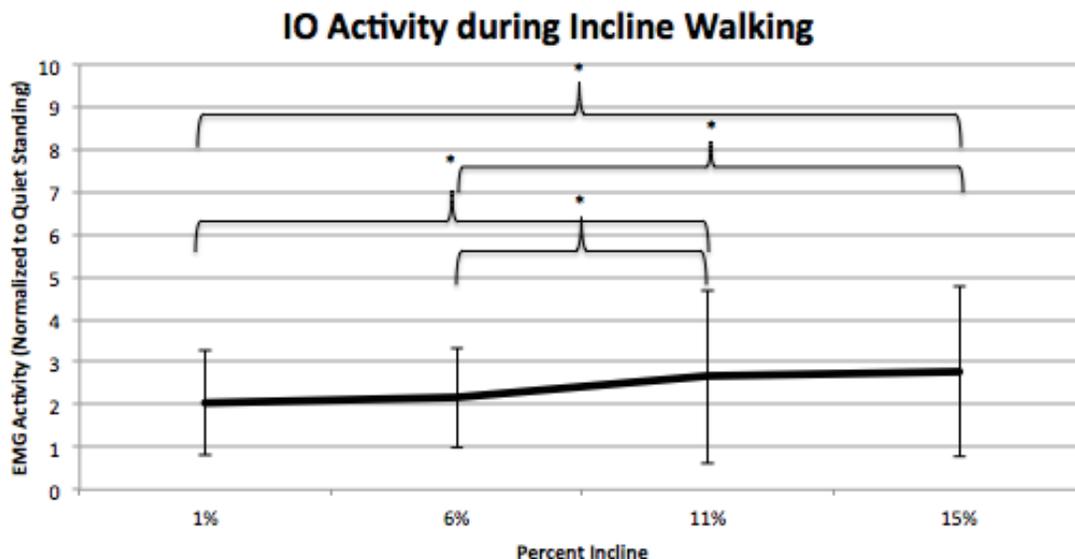
Zambarano EK, Glaviano NR: The University of Toledo, Toledo, OH

Context: The structures of the lumbo-pelvic-hip complex (LPHC) are important for stabilizing the spine and hips and allowing for optimal force generation and movement of the distal extremities. It is not currently understood how activation of the LPHC changes with different workloads. The purpose of this study is to observe the muscle activity of the LPHC at different levels of incline walking. It was hypothesized that activation of the abdominal and lumbar musculature would increase as the incline increased. **Methods:** This is a descriptive laboratory study observing 22 healthy, recreationally active individuals (12 females, 10 males; 23.5±3.1 yrs; 1.73±0.09 m; 76.1±10.7 kg). Participants were included in the study if they scored a 5-8 on the Tegner

Activity Scale, had no recent history of major back or lower extremity injury, and had a body mass index <30. The independent variable was treadmill incline. The dependent variables were the normalized amplitude of muscle activation during walking. Wireless electromyography (EMG) was used to record muscle activity of the rectus abdominis (RA), external oblique (EO), internal oblique (IO), erector spinae (ES), gluteus medius (GM), vastus lateralis (VL), and vastus medialis (VM). Participants walked on a treadmill at 3.0 mph for four 5-minute intervals during which the incline increased by 1% each minute until it reached 15%. EMG data was collected at 1%, 6%, 11%, and 15% incline. A repeated measure ANOVA was used to assess the differences in normalized muscle amplitude at the different inclines. **Results:** Statistically significant time main effects were found in the IO, ES, VM, and VL ($p \leq .05$). Activation of the IO increased significantly across four separate time points (Figure 1). Activation of the ES increased significantly between

1% and all other levels (1%: 4.03±4.49, 6%: 5.61±7.32, 11%: 6.05±4.71, 16%: 7.28±4.93, $p < .05$). VM increased significantly from the 6% incline to the 11% incline (6%: 10.86±7.26, 11%: 16.56±13.59, $p = .005$) and was also significantly greater at the 15% incline (15%: 20.88±14.5, $p < .001$). There was a significant increase in activation of the VL from 11% to 15% (11%: 9.19±4.74, 15%: 10.5±5.11, $p = .028$). GM, VM, and VL were the only muscles that experienced a decrease in activation at any point. **Conclusions:** An increase in incline during walking requires greater force generation and these findings suggest that the musculature of LPHC increases in activation in order to achieve this goal. Being the closest in proximity to the spine, the consistent increase in activation of the ES and IO suggest that increased stability of the spine is necessary to work against an incline. Observing this relationship can help clinicians better understand the role of the LPHC with this activity and at increasing workloads.

Figure 1: EMG activity of the internal oblique muscle at different % inclines of treadmill walking
* statistically significant difference



Effectiveness of an Exercise Program on Range of Motion, Strength, and Lumbopelvic Stability in Division I Collegiate Baseball Players

Meggs S, Plummer HA, Diaz P, Chien A, Michener LA: University of Southern California, Los Angeles, CA; Andrews Research & Education Foundation, Gulf Breeze, FL

Context: Deficits in shoulder range of motion (ROM), strength, and lumbopelvic stability are associated with risk of arm injury in baseball players. The purpose of this study was to assess the effects of a standardized exercise program on shoulder ROM, shoulder and hip strength and lumbopelvic stability over the course of a playing season in collegiate baseball players.

Methods: This was a prospective cohort study performed in the athletic training room of Division I baseball players (n = 43; age = 19.6 ± 1.2 years; height = 185.8±5.5cm; weight = 90.5 ± 7.0 kg).Data were collected prior to and following the season. Passive shoulder IR, ER, and horizontal adduction

ROM was measured with an inclinometer. Shoulder IR and ER strength was measured with a hand-held dynamometer with the arm at the side. Hip abduction strength was measured with a hand-held dynamometer in side-lying. For all strength measures, two maximal isometric contraction trials were performed on each extremity, and the average used for analysis. Lumbopelvic stability of the lead leg (contralateral to throwing arm) was assessed dynamically using a single-leg step-down (SLSD) task in which participants stood on their lead leg and lowered to the floor from an 8” step. Participants performed a strengthening, stability, and stretching program three times a week for four months over the course of the season. Shoulder IR and ER strengthening exercises targeted those respective muscles. Shoulder stretching exercises were aimed at improving IR, ER, and horizontal adduction. Dynamic core exercises targeted a stable trunk position with upper or lower extremity movement. Hip strengthening exercises targeted the gluteals. Static core exercises required use of the abdominal muscles to stabilize the spine isometrically. Paired samples t-tests were performed

to compare pre-season to post-season outcome measures. **Results:** Data are presented in Table 1. From pre-season to post-season, there were significant increases in hip abduction strength (Mean Difference= 11.1Nm; p=0.015), horizontal adduction ROM (Mean Difference= 6.1°; p<0.01), shoulder IR strength (Mean Difference= 1.4kg; p=0.046). ER strength significantly decreased over the course of the season (Mean Difference= -1.1kg; p=0.004). There were no significant changes in lumbopelvic stability as measured by trunk lean, trunk flexion and pelvic drop during the SLSD task; or in IR or ER ROM. **Conclusions:** The exercise program was effective in improving horizontal adduction ROM, shoulder IR strength, and hip abduction torque of the lead leg. The lack of change in IR and ER ROM and lumbopelvic stability with the intervention, may be related to the lack of deficits at the start of the season. Alternatively, the dosing and duration of the program may not have been adequate to elicit change. Future studies need to determine if changes in strength and ROM found in this study are related to decreased injuries, to demonstrate the value in reducing injury risk.

Table 1. Throwing Shoulder Range of Motion (ROM), Strength, and Motion during the Single-Leg Step-Down (SLSD) Task

	Internal Rotation ROM (°)	External Rotation ROM (°)	Horizontal Adduction ROM (°)	SLSD Trunk Lean (°)	SLSD Trunk Flexion (°)	SLSD Pelvic Drop (°)	Hip Torque (Nm)	Internal Rotation Strength (kg)	External Rotation Strength (kg)
Pre	29.7 (10.9)	109.8 (11.3)	-4.0 (6.4)	3.7 (2.9)	19.1 (11.1)	7.0 (3.3)	147.5 (28.4)	16.4 (4.1)	13.3 (3.1)
Post	29.7 (8.9)	112.1 (10.5)	2.1 (5.6)	3.5 (2.6)	19.5 (9.3)	6.9 (2.7)	158.6 (23.0)	17.8 (3.7)	12.2 (2.7)
Mean Change (95% CI); p-value	0 (-3.0, 3.1); p=0.979	2.3 (-6.3, 1.7); p=0.259	6.1 (-8.5, -3.7); p<0.01	-0.2 (-1.0, 1.6); p=0.679	0.5 (-3.0, 2.3); p=0.789	-0.1 (-0.9, 1.1); p=0.861	11.1 (-19.8, 2.3); p=0.015	1.4 (-2.7, -0.02); p=0.046	-1.1 (0.4, 1.8); p=0.004

Using MyoKinesthetic™ System (MYK) in Treatment of Low-Back Pain (LBP)

Klein M, Martinez RE, Odai ML, Felton SD: Florida International University, Miami, FL

Background: This is a level 3 case study focusing on the evaluation, diagnosis and treatment of two acute incidents of low back pain (LBP). Low back pain is a common injury affecting 80% of the population and may manifest with lower extremity pain. Despite extensive research on various treatment options, most of the findings contradict each other, making providing an effective treatment that much more difficult. Typically, low-back pain can be treated with patient education, heat, or manipulations done by a physician. These interventions focus on local solutions and do not incorporate a global approach to treatment. **Patient:** Patient A: 31-year-old female recreational weight lifter with previous SI joint dysfunction was diagnosed with an acute erector spinae muscle strain after performing Romanian deadlifts at the gym. Upon initial evaluation she reported pain free but limited active flexion, and pain when returning to standing. Special tests revealed (-) straight leg raise test, (-) well straight leg raise test, (-) Valsalva, and (-) Kernig test. Patient reported outcome measures included a DPAS 25, NRS worse 8/10, NRS current 2/10, and OSW 4%. On day three, no treatment was administered. Patient was discharged reporting DPAS 1, NRS worse 0/10, NRS current 0/10, OSW 0, and GRoC 5. Patient B: 27-year-old male, recreational weight lifter with a previous acute erector spinae muscle strain. Patient was deadlifting when tension was felt in low back. He then proceeded to his cardio exercises and stopped due to sharp pain. Patient reported difficulty sleeping through the night. Physical examination revealed pain (3/10) with active flexion, pressure with extension but no pain, and right sided pain (4/10) with lateral left flexion. Passive flexion also produced pain (3/10). Patient was

tender to palpations along right erector spinae, S1, and L4-5 region. During initial visit DPAS was reported at 15, NRS worse 6/10, NRS current 3/10, OSW 12%. Patient was diagnosed with an acute erector spinae strain. On day three, no treatment was administered. Patient was discharged reporting DPAS 0, NRS worse 0/10, NRS current 0/10, OSW 0%, and GRoC 5. **Intervention or Treatment:** The Myokinesthetic System was used to treat both patients. Treatment consists of a postural exam to evaluate static postural deviations and matching to dysfunctional nerve root pathways. Bilateral treatment of the muscles along the dysfunctional nerve root pathway inhibits and facilitates muscles while in motion to improve communication between the central nervous system and all muscles innervated by that nerve root, restoring postural balances, and reestablishing a functional kinetic chain for movement (Uriarte, 2010). **Outcomes or Other Comparisons:** During their initial visit each patient was symptomatic and had a complete resolution of symptoms after two interventions. **Conclusions:** LBP is typically treated with patient education, heat, spinal manipulation, exercises, and other treatments. In this case study, traditional treatment protocols were not used. While most interventions focus on hip strengthening and increasing flexibility, this study shows the value of correcting posture when a patient presents with LBP. Only two treatments were needed to diminish pain and restore function. **Clinical Bottom Line:** The evaluation of posture can be the factor that corrects LBP. The body is a kinetic chain which may be affected by poor postures and muscular misalignments in the lower and upper extremity. Addressing these issues and taking a global approach might be a more effective solution to LBP.

Spondylolisthesis in a Field Hockey Player

Beam S, Lumpkin KJ: Liberty University, Lynchburg, VA

Background: A 16 year old, female, field hockey player was hit from behind during competition. The athlete had mild symptoms that relieved with motion, therefore the athlete continued to play. A few months later during deadlifting the athlete reached full extension, felt a sharp pain in her back and dropped to the floor, unable to move. Athlete and parents did not seek medical care until seven months later because pain progressively worsened. Most pain was reported with prolonged sitting and sleeping. **Differential Diagnosis:** Vertebral fracture, vertebral stress fracture, bilateral pars fracture, spondylolysis, spondylolisthesis, lumbar herniated disk. **Treatment:** When seen by a sports medicine physician, a diagnosis of an acute bilateral pars defects was determined by X-rays. The athlete was removed from participation for one month but returned early to compete for a national championship. After failed conservative treatment for three months, the athlete opted for surgery. The pars interarticularis repair, consisted of a bone graft from the iliac crest including two screws and a metal wire which required a five day hospital stay. The following three months, the athlete was not allowed to lay flat, bend, twist, or lift anything more than five pounds. ADL's required a back brace. At four months, she returned to school and began rehabilitation, which limited bending and twisting with core strengthening. At seven months, the athlete was cleared for running and lifting progressions. Participation was restricted to field hockey practice but not games. At one year the CT showed an unsuccessful surgery. The athlete returned to training anyway, however in a short period she experienced pain and paresthesia in her legs. She was experiencing extreme pain causing losing consciousness and throwing up. At year and a half post-op, the fracture was becoming increasingly

worse, with more forward slippage. The new diagnosis of spondylolisthesis was accompanied with instructions to discontinue field hockey and consideration of more surgery. Other treatments like injections and cauterization of the nerves around her fracture site were not successful therefore surgery was selected. At 2 years and 4 months after onset, the athlete underwent an anterior lumbar interbody fusion (ALIF) and a posterior lumbar interbody fusion (PLIF). She was again braced during ADLs and had similar lifting restricts as stated early. Her rehabilitation plan began at 3 months with running at 6 months and weightlifting at 11 months. RTP was not recommended. **Uniqueness:** An adolescent requiring this degree of back stabilization after multiple surgeries is a rare event. Typically a bilateral pars defects will become less inflamed with rest and core rehabilitation, unfortunately this case is quite the opposite. A year after injury, a minimally invasive procedure known as a pars repair (which is not very common) was necessary to treat the chronic pain. However, due to a failed bone graft, a combination surgery of ALIF and PLIF were performed 2.41 years after onset. This final surgery is rarely performed in young athletes due to possible complications, limited motion, and longevity of success. **Conclusions:** Back injuries for youth can be devastating and debilitating. Atypical cases can linger for years and require multiple surgeries. Early physician referral is necessary with back pain. A 19 years old athlete is now pain-free with normal ADL's, however, she is restricted in motion and does not play high impact or collision sports. Too often the youth have an invincible mental attitude that playing is more important than their health and well-being. Based on life changing consequences certified athletic trainers should take ample time to explain the risks of continued play while dealing with back pain.

Pain Education With Therapeutic Exercise in Chronic Non-Specific Low Back Pain Rehabilitation

Tocco EC, Jones KC, Goetz KA, Valovich McLeod TC, Marshall AN, Welch Bacon CE: A.T. Still University, Mesa, AZ

Context: Chronic non-specific low back pain (NS-LBP) is a disabling condition that often leaves patients frustrated with a myriad of treatments that may not result in improvements. Treatments commonly utilized by clinicians for acute low back pain are not necessarily effective for chronic pain, and notably do not consider psychosocial factors. The incorporation of pain education, an intervention that seeks to educate patients about the biology of pain, can help clinicians practice within a patient-centered model. This review addressed the following clinical question: Does pain education combined with therapeutic exercise, compared to therapeutic exercise alone, improve pain in adults with chronic NS-LBP over a 2-3 month treatment period. **Methods:** The literature was searched for studies that investigated exercise therapy and pain education in patients with chronic NS-LBP with a treatment time frame of 2-3 months. Databases searched included EBSCO, PubMed, Ovid, the Cochrane Database, and MEDLINE. Search terms included (sport OR athlete*), low back pain, chronic low back pain, depression, pain education, patient-rated outcome measure. Studies were included if they were original research, written in English, published between 2009-2018, used the Visual Analog Scale (VAS) or the Numerical Pain Rating Scale (NPRS), and incorporated therapeutic exercise or therapeutic exercise with pain education. Studies were excluded if the participants were prescribed cognitive behavior therapy, had acute low back pain or any associated structural abnormalities, or had chronic or systemic illness. Qualitative methods were used to synthesize the findings of the included studies. **Results:** The literature search returned 8 potential studies,

three of which met the inclusion criteria and were included in this review. All included studies were single-blind randomized controlled trials, and were considered CEBM level 2 evidence. Two of the three studies appraised found that patients who received pain education prior to therapeutic exercise experienced a greater improvement in self-reported pain rating compared to patients who completed therapeutic exercise alone. The last study found no significant difference between therapeutic exercises with and without pain education. All studies suggested exercise therapy reduces chronic NS-LBP symptoms and improves functional disability and kinesiophobia following the pain education and therapeutic exercise intervention. **Conclusions:** Grade B evidence exists to support the use of patient education in conjunction with therapeutic exercise to decrease pain in patients with chronic NS-LBP. A patient's knowledge and understanding of pain may change their perspective on management and control of pain and alter their opinion on defining pain. Pain education helps clinicians provide patient-centered care and should be implemented as a part of the rehabilitation paradigm for patients with chronic NS-LBP. Future research in this area should investigate whether pain education reduces the duration of rehabilitation for chronic NS-LBP as well as explore short-term and long-term effects of this treatment strategy.

Muscle Activity Differences of the Lumbar Multifidus During Rehabilitation Exercises in Patients With and Without Non-Specific Low Back Pain

Morris KA, Mangum LC, Higgins M, Saliba S: University of Virginia, Charlottesville, VA; University of Central Florida, Orlando, FL

Context: Non-specific low back pain (NSLBP) is a highly prevalent condition, across all ages and levels of physical activity. The relationship between the global movers and segmental stabilizers of the lumbopelvic-hip complex play an important role in the rehabilitation of individuals with NSLBP. However, it is currently unclear how these core muscles, specifically the lumbar multifidus (LM), activate during rehabilitation exercises. The purpose of this study was to compare activation of the LM, during rehabilitation exercises traditionally targeted at improving NSLBP, using ultrasound imaging (USI) of muscle thickness to quantify muscle activity. **Methods:** A descriptive laboratory study was designed to determine muscle activation differences using USI of LM in participants with and without NSLBP during commonly used rehabilitation exercises. 24 healthy individuals with no history of NSLBP or recent lower extremity injury (Age: 20.38 ± 1.50 years, Height: 172.08 ± 12.96 cm, Mass: 71.13 ± 10.21 kg), and 24 individuals with a self-reported history of NSLBP (Age: 22.5 ± 4.0 years, Height: 170.26 ± 6.84 cm, Mass: 76.39 ± 18.45 kg) participated in this study. NSLBP was defined as experiencing 5 episodes of pain in their lifetime or 2 episodes of pain within the past year. USI was used to measure muscle thickness bilaterally during a rested position and during each exercise to determine a functional activation ratio (FAR). Exercises included: Bird Dog, seated Swiss ball march, prone extension and overhead squat exercises. Rested positions were the starting positions for each exercise, which was either quadruped, seated on a Swiss ball, prone,

or standing. A 2x4 analysis of variance was used to determine the effects of group and exercise. Mean differences, standard deviations, and Cohen's d effect sizes with 95% confidence intervals were calculated to determine magnitude of change. **Results:** The NSLBP group showed a higher level of LM activation compared to the healthy group during the overhead squat on the right LM (FAR of 0.98 ± 0.18 for NSLBP group, FAR of 0.85 ± 0.15 for healthy group; $p = .01$; Cohen's $d = 0.79$). No differences were found between groups in the Bird Dog, Swiss ball march, and prone extension exercises. Significant main effect for exercise was found during the Bird Dog transition exercises ($P < .001$) with FAR increasing as difficulty of Bird Dog increased in both groups. **Conclusions:** USI showed similar activity in the LM during most of the lumbopelvic-hip complex targeted exercises assessed in this study. Individuals with NSLBP had higher LM activation during an overhead squat, which could be attributed to an increased reliance on the spinal stabilizer in a functional, gravity-dependent position. As the Bird Dog exercises increased in difficulty, the FAR increased as well, regardless of group, which aligns with other studies that used electromyography to quantify muscle activation.

Transverse Abdominis and Lumbar Multifidus Activity in Individuals With and Without Low Back Pain During Walking

Hill KB, Mangum LC, Sutherlin MA, Hart JM, Higgins M, Saliba S: University of Virginia, Charlottesville, VA; University of Central Florida, Orlando, FL; State University of New York College at Cortland, Cortland, NY

Context: Decreased muscle activation of the transverse abdominis (TrA) and lumbar multifidus (LM) has been observed through ultrasound imaging of muscle thickness in individuals with non-specific low back pain (NSLBP). Additionally, NSLBP can lead to worse patient-reported outcome measures (PROM) related to pain, disability, and physical activity. Walking has been a suggested exercise to address NSLBP, but spatiotemporal walking characteristics may be impacted by the presence of pain. Assessment of relationships between muscle activation and PROMs during walking could lead to a better understanding of activity limitations and treatment recommendations in those with NSLBP. The purpose of this study was to better understand differences in and relationships between muscle thickness during walking and spatiotemporal walking variables in healthy individuals and those with NSLBP. **Methods:** A descriptive laboratory study was conducted to compare TrA and LM muscle activity during walking using ultrasound imaging between those with NSLBP and their healthy counterparts. Relationships between ultrasound imaging measures, spatiotemporal walking variables, and PROMs were also explored. 22 healthy participants (Age: 22.3 ± 7.8 yrs, Height: 169.4 ± 3.5 cm, Mass: 68.1 ± 12.7 kg) and 22 with NSLBP (Age: 25.5 ± 10.7 , Height: 171.6 ± 3.3 cm, Mass: 70.3 ± 11.8 kg) were included for analysis. Bilateral functional activation ratios (FARs) of TrA and LM were calculated by dividing muscle

thickness during walking, with image capture at ipsilateral heel strike, by muscle thickness at rest, while standing. All FARs were normalized to body mass. PROMs included LBP history, pain levels, disability, fear-avoidance, and physical activity measures. Self-selected walking speed, step length, step cycle, and percentage of time spent on each foot were collected during treadmill walking. The FAR for each muscle was compared between groups using an independent t-test. Pearson's r correlation coefficients were calculated to determine relationships between walking FAR, walking variables, and PROMs. **Results:** No differences were observed for TrA or LM FARs during walking between NSLBP and healthy individuals (all $p > .05$). There were also no differences in walking measures between groups (all $p > .05$). A positive correlation was observed between the average step cycle and both the left TrA FAR ($r = 0.544$, $p = .009$) and left LM FAR ($r = 0.582$, $p = .005$) in the NSLBP group. No correlations were found between PROMs and walking FAR for either group, however negative correlations were observed between the average step cycle and the age of the first NSLBP episode ($r = -0.610$, $p = .003$), and current pain level ($r = -0.493$, $p = .02$). **Conclusions:** Participants with previous NSLBP presented with similar FAR muscle activation during walking as the healthy group. However, these relationships between PROMs and step cycle suggest that previous episodes of NSLBP may be enough to initiate compensatory strategies during gait. As pain and disability increase, these individuals may complete less step cycles per second to protect from additional pain or injury.

Comparison of Core Muscle Activity in Patients With Non-Specific Low Back Pain, Patellofemoral Pain, and Healthy Individuals in Static and Dynamic Positions

Mangum LC, Hryvniak D, Hart JM, Hertel J, Saliba SA: University of Central Florida, Orlando, FL; University of Virginia, Charlottesville, VA

Context: The role of core musculature is important for proximal stability and is linked to non-specific low back pain (NSLBP). A similar role of core stability in another chronic musculoskeletal injury, patellofemoral pain (PFP), has recently been investigated. The transverse abdominis (TrA) is a spinal and core stabilizing muscle that can be dysfunctional in NSLBP and lack of core stability has been linked to PFP. The link of core stability through TrA characteristics has not been explored in both a NSLBP and PFP population, with a healthy comparison. The purpose of this study was to determine TrA activity in rested and functional positions using ultrasound imaging in chronic

musculoskeletal conditions, NSLBP and PFP, as compared to their healthy counterparts. **Methods:** A cross-sectional study was completed in a university laboratory to compare differences in TrA activity in various positions in NSLBP, PFP, and healthy individuals. 100 participants were included in this study. 25 individuals had NSLBP (19F, 6M; Age: 22.2 ± 4.2 yrs; Height: 168.5 ± 7.7 cm; Mass: 69.2 ± 15.0 kg; Tegner: 6.5 ± 2.3), 25 had PFP (20F, 5M; Age: 23.3 ± 4.8 yrs; Height: 169.2 ± 7.2 cm; Mass: 68.1 ± 13.7 kg; Tegner: 5.7 ± 1.6), and the remaining 50 participants were healthy (39F, 11M; Age: 21.1 ± 2.4 yrs; Height: 165.1 ± 26.3 cm; Mass: 66.5 ± 14.5 kg; Tegner: 6.4 ± 1.6). Ultrasound imaging thickness measures of TrA were collected in a supine, hook-lying position (tabletop), bipedal standing, unipedal standing, and at peak knee flexion during a single leg squat (SLS). For tabletop, an image during an abdominal draw-in maneuver was also captured for contracted thickness. All thickness values (mm) were normalized by body mass (kg). An ANOVA was used to determine the effects of position and group. Mean differences and Cohen's d effect sizes were calculated to show

magnitude of difference with alpha level set a priori at $p \leq .05$. **Results:** There were no significant group or position effects when all 3 groups were compared. When NSLBP and PFP groups were combined, and compared to healthy individuals, there was a significant group main effect in normalized thickness for unipedal ($p=.048$, $d=.41$) and SLS positions ($p=.044$, $d=.41$) with the injured population having lower TrA thickness (Table 1). A traditional activation ratio (contracted/rested thickness) in the tabletop position revealed a 14% decrease in the injured group ($p=.045$, $d=.42$). **Conclusions:** Although there were no significant findings in the comparison of each injured group to the healthy controls, the decreased thickness in both single leg positions when NSLBP and PFP were combined is meaningful. The 14% percent decrease in activation while supine also revealed a lack of abdominal draw-in ability for the injured population. These groups do appear to have similarly decreased local stabilization at the core, which could affect clinical focus in rehabilitation for individuals with chronic injuries of the low back and lower extremity.

Table 1. Transverse abdominis activity for NSLBP, PFP, healthy group, and combined injured (NSLBP+PFP) group (mean \pm standard deviation)

	Position	NSLBP (n=25)	PFP (n=25)	Healthy (n=50)	Injured (NSLBP+PFP) (n=50)	P value (NSLBP+PFP vs. Healthy)
Normalized thickness at rest (mm/kg)	Tabletop	0.060 \pm 0.012	0.064 \pm 0.012	0.064 \pm 0.024	0.062 \pm 0.012	.654
	Bipedal	0.072 \pm 0.021	0.071 \pm 0.018	0.081 \pm 0.032	0.072 \pm 0.019	.090
	Unipedal*	0.074 \pm 0.018	0.075 \pm 0.015	0.084 \pm 0.029	0.074 \pm 0.017	.048
	SLS*	0.081 \pm 0.019	0.086 \pm 0.024	0.095 \pm 0.035	0.083 \pm 0.021	.044
Normalized thickness contracted (mm/kg)	Tabletop	0.089 \pm 0.021	0.098 \pm 0.024	0.101 \pm 0.036	0.093 \pm 0.023	.206
Activation Ratio $\frac{thickness_{cont}}{thickness_{rest}}$	Tabletop*	1.486 \pm 0.255	1.543 \pm 0.295	1.655 \pm 0.407	1.511 \pm 0.274	.045
Functional Activation Ratio $\frac{thickness_{unipedal}}{thickness_{bipedal}}$	Unipedal	1.053 \pm 0.172	1.079 \pm 0.143	1.070 \pm 0.149	1.066 \pm 0.157	.874
	SLS	1.169 \pm 0.267	1.225 \pm 0.287	1.226 \pm 0.233	1.197 \pm 0.276	.570
						$\frac{thickness_{SLS}}{thickness_{bipedal}}$

Abbreviations: NSLBP, non-specific low back pain; PFP, patellofemoral pain; SLS, single leg squat; cont, contracted.

Alpha level set at $p \leq .05$

*Significant group effect, Injured (NSLBP+PFP) vs. Healthy

Free Communications, Poster Presentations: Lower Extremity Case Studies

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

The Role of Athletic Identity in the Etiology of Medial Tibial Stress Syndrome in Collegiate Runners

Reeder LM, Beachy KD, Farnsworth JL, Sled E: Texas State University, San Marcos, TX; Cedarville University, Cedarville, OH

Context: The Athletic Identity Measurement Scale (AIMS) is a psychological survey that assesses how strongly an individual identifies with their athlete role. Those who more strongly identify as an athlete may push themselves further to excel in sport or not adhere to medical advice when they need to lessen their training load leading to potential overtraining. This overtraining can result in medial tibial stress syndrome (MTSS) and eventually lead to stress fractures if training loads are not appropriately managed. To date athletic identity has not been examined in relation to MTSS incidence. Therefore, the purpose of this study was to determine what the relationship is between athletic identity and MTSS. **Methods:** Thirty-three collegiate cross-country and track athletes (mean age=20.1 ± 1.2 years; 81.8% female) participated in this cross-sectional study. An online survey was created to collect information about various well-known risk factors as well as demographic information (e.g., age, sex, running events, injury history, running history, history of disordered eating, and menstrual history). In addition, participants were asked to complete the AIMS and the Compulsive Exercise Test (CET). The survey was hosted online through Qualtrics and distributed by email to potential participants. A binomial logistic regression analysis was used to determine the relationship between AIMS scores, CET scores and history of a diagnosed MTSS injury while controlling for covariates (e.g., age, sex, height, weight,

history of disordered eating behavior). **Results:** Thirteen (39.4%) of the participants in this study reported being diagnosed with MTSS. The average AIMS and CET scores among participants were 28.1 ± 8.5 and 68.1 ± 20.2 (Mean ± SD), respectively. When controlling for covariates both CET score (Wald $\chi^2 = 4.46$; $p = 0.35$) and history of disordered eating behavior (Wald $\chi^2 = 4.87$; $p = 0.34$) were significantly associated with history of MTSS. No association, however, was identified between AIMS scores and MTSS (Wald $\chi^2 = 0.95$; $p = 0.33$). **Conclusions:** While athlete identity may be an important psychological factor related to patient well-being, there were no associations identified between AIMS scores and MTSS incidence in this study. Psychological intervention may be necessary, however, for individuals who score highly on the CET to minimize the risk of developing MTSS or other overuse injuries of the lower extremity.

The Comparison of Sports-Related Stress Fractures Among Collegiate and High School Athletes

Collins CL, Quetant S, Morris SN, Wasserman EB: Datalys Center for Sports Injury Research and Prevention Inc, Indianapolis, IN

Context: Rigorous training and inadequate diet among athletes can lead to stress fractures that often limit sports participation for several weeks and, when left untreated, may affect long-term health. Previous studies have examined stress fractures in collegiate and high school athletes; however, none have directly compared stress fractures in the two populations. Because high school athletes may be still developing physically, injuries among high school athletes may differ from collegiate athletes. The objective is to compare stress fractures sustained by collegiate and high school athletes. **Methods:** Athletic trainers (ATs) participating in the National Collegiate Athletic Association Injury Surveillance Program (NCAA-ISP) reported athlete-exposure (AE) and injury data for 25 sports during the 2009/10-2016/17 academic years. ATs participating in the National Athletic Treatment Injury and Outcomes Network (NATION) reported AE and injury data for 27 sports during the 2011/12-2013/14 academic years. Stress fractures occurred during a school-sanctioned practice or competition and required medical attention. Along with stress fracture characteristics, injury rates per 100,000 AEs were reported with 95% confidence intervals (CIs). **Results:** From 2009/10-2016/17, ATs reported 279 stress fractures among NCAA athletes for an injury rate of 4.15/100,000 AEs (95% CI:3.66-4.63). Women's cross country (28.19; 95% CI:16.91-39.47), women's gymnastics (23.85; 95% CI:13.40-34.30), and men's cross country (18.44; 95%

CI:9.11-27.78) had the highest rate of stress fractures. From 2011/12-2013/14, ATs reported 50 stress fractures among high school athletes for an injury rate of 0.97/100,000 AEs (95% CI:0.70-1.24). Girls' gymnastics (3.32; 95% CI:0.00-9.82), girls' outdoor track and field (3.18; 95% CI:0.82-5.54), and boys' cross country (2.32; 95% CI:0.46-4.18) had the highest rate of stress fractures. For both NCAA and high school athletes, the most commonly injured body parts were the lower leg (42.3% and 44.0%) and foot/toe (40.9% and 34.0%) and the most common mechanism of injury was overuse/non-contact (87.3% and 86.8%). A similar proportion of NCAA and high school stress fractures resulted in a time loss of more than three weeks (46.6% and 38.8%). A greater proportion of stress fractures in NCAA athletes were recurrent (18.9%) than in high school athletes (5.3%). Of NCAA stress fractures, 4.7% required surgery, compared to none of high school stress fractures. **Conclusions:** Stress fracture injury rates were higher among collegiate athletes compared to high school athletes, and a greater proportion of collegiate stress fractures were recurrent and required surgery than high school stress fractures. Despite the potential physiological differences, other characteristics of stress fractures were similar between the two groups including sports with the highest injury rates, body parts injured, and mechanism of injury. More research is needed to determine how to effectively reduce stress fractures among all collegiate and high school athletes.

An Unusual Mechanism of Injury for Compartment Syndrome in a Collegiate Softball Player

Siler TC, Moffit DM, Reinstein E:
Idaho State University, Pocatello, ID

Background: Acute compartment syndrome typically occurs due to direct trauma. Subsequent swelling inside the affected compartment increases pressure on neurovascular structures because the fibrous outer fascia does not expand, resulting in decreased blood flow and/or numbness/tingling. Left untreated, hypoxic ischemia can occur. In this Level 3 case, the patient had no mechanism to suggest this condition. **Patient:** An NCAA Division I softball player (22-years-old) hit a home run. Rounding first base, she began celebrating by jumping into the air. She landed awkwardly on her right foot but continued to run the bases. Returning to the dugout, she reported mild pain located on the lateral mid- to proximal-lower leg. An evaluation revealed point tenderness at the proximal peroneals. MMTs (ankle inversion, eversion, plantarflexion, dorsiflexion) rated 4/5 with pain. Active and passive ROM was unaffected. The athlete was diagnosed with a mild peroneal strain. She demonstrated full weight-bearing and sport-specific functional movements. The ankle was taped to support the lower leg and she returned to play. The athlete continued to report discomfort and was re-evaluated during the break between games. Lateral lower leg edema was noted, but no ecchymosis. After the third inning of the second game, the athlete was removed from play due to increasing pain and discomfort. At this time, the team's orthopedic physician evaluated the injury and supported the diagnosis of a mild peroneal strain. Her ankle was wrapped with ice, and she was sent home with a compression wrap with instructions to report to the athletic training facility the next day for re-evaluation. **Intervention or Treatment:** At approximately 10:00 pm that night, the team physician contacted the athlete who reported increased pain and numbness in the toes/foot area. Her leg felt tight and there was

increased temperature. She reported redness but no discoloration. The team physician had her report to his house for further evaluation. He immediately recognized compartment syndrome and referred her to the hospital for emergency surgery. An emergency fasciotomy ensued at approximately midnight. The athlete spent four nights in the hospital. During the first two days of hospitalization the leg was drained via the open wound in a vacuum-sealed enclosure. Three days post-surgery a second surgery was performed to close the incision. **Outcomes or Other Comparisons:** The athlete was non-weight-bearing for one week, progressing to partial-weight-bearing as tolerated the following week. She improved to sport-specific physical activity during the four-week progression. Initially she was non-weight-bearing (i.e., isometric contractions all ankle directions; ankle pumps and side-to-sides; BAPS board ROM). Once she was weight-bearing, she started weight-shifts and quarter squats (approximately 12 days post-surgery). At 2 weeks, exercises were added (i.e., heel/toe walks; 3-way calf raises; dot drill; squats with band; BOSU hops; skiers; biking for cardio). Modalities during this period included Game Ready when indicated, ice and E-stim, ultrasound, manual therapy when indicated (e.g., massage, Graston), foam roll and stretching, and thermotherapy when indicated. With protective padding and taping to prevent the site of the incision re-opening she was able to finish out the remainder of the season. **Conclusions:** It is uncommon for acute compartment syndrome to develop after minor injuries (e.g., strain, sprain). This athlete had a mechanism with signs and symptoms of a mild peroneal strain. However, the lateral compartment was compromised, leading to the necessary fasciotomy. **Clinical Bottom Line:** Acute compartment syndrome may not always follow typical mechanisms such as blunt trauma. Injuries creating edema in the lower leg can increase pressure. As with any injury, patient education is key. Increasing pain, paresthesia, pallor, or paralysis may necessitate an emergency room visit.

Effectiveness of Surgical Repair Techniques for Ankle Dislocation With Weber B Fibular Fracture and Associated Complete Deltoid Ligament Rupture in a Collegiate Football Athlete

Sagstetter ES, Collins RG, Popp JK: Purdue University, West Lafayette, IN

Background: Ankle dislocations with associated fibular fractures and medial ligament damage are common in athletic populations. Based on a recent systematic review, open reduction internal fixation (ORIF) surgery is recommended for optimizing patient outcomes. This Level 1 validation case study examines the evidence associated with surgical techniques to the outcomes of a recent patient case to determine the efficacy of surgical interventions in the treatment of ankle dislocation injuries. **Patient:** A 22-year-old, Division I male football athlete suffered a right ankle dislocation during competition. The dislocation was reduced on the field by the athletic trainer, and the patient was transported to the emergency department. Following relocation, the patient was referred to an ankle specialist. Radiograph findings showed a right fracture dislocation of the ankle with a Weber B fibular fracture. The presence of a complete deltoid ligament tear was predicted due to swelling, pain and laxity at the medial ankle. Surgery was recommended. **Intervention or Treatment:** The surgical procedure involved an ORIF of the right fibula with an 8-hole plate. While in surgery, the specialist identified a small posterior malleolar fragment that was not seen in the imaging, and confirmed the complete rupture of the deltoid ligament. The posterior malleolar fragment was positioned to heal on its own, and the deltoid ligament tufts were repaired with horizontal sutures. An anteromedial chondral lesion of the talus was also identified during the procedure and debrided. Following surgery, the patient was casted with the ankle at 90 degrees for 2 weeks, followed by placement in a boot for 6 additional weeks. At 4 weeks post-surgical, rehabilitation was initiated by the athletic trainer. Initial focuses included plantar flexion and dorsiflexion active ROM exercises, but inversion and eversion

range of motion was avoided to protect the deltoid ligament repair. At 8 weeks, ROM restrictions were lifted, and the patient was fitted for a custom ankle-foot orthosis. At this point, the rehabilitation emphasis was non-weight bearing open-kinetic chain strengthening of the ankle and lower-extremity kinetic chain. At 3 months post-operative, rehabilitation focused on closed-kinetic chain and proprioception exercises, and by 4 months, the patient was performing sport-specific drills with no complications. The patient fully participated in spring football while wearing a brace and progressed to in-season participation during the fall 2018 season wearing only tape support. **Outcomes or Other Comparisons:** Based on this patient outcome, the ORIF with deltoid ligament repair was successful in that his range of motion, strength, and function have been restored, and he is fully participating in football. The referenced systematic review citing 7 articles that included a total of 793 patient outcomes confirms the ORIF surgical procedure as the best technique for returning athletes to sport in the least amount of time, and little to no long-term complications. Conversely, in a randomized-controlled trial that examined the effects of deltoid ligament repair in 22 subjects, suturing the torn ligament is not proven beneficial in decreasing time to return with 3 subjects displaying decreased functionality when the deltoid ligament was repaired. **Conclusions:** The efficacy of ORIF in treatment of fibular fractures secondary to ankle dislocation is proven in the observed patient outcome and published evidence. Discrepancies occur related to patient outcomes following a surgical repair of the deltoid ligament; however, this patient case supports surgical repair for full return to high-level sports participation. **Clinical Bottom Line:** Ankle dislocations with associated fibular fracture, and injury to the deltoid ligament should be surgically fixated utilizing an ORIF technique. More evidence supporting the abdication of deltoid ligament repair is needed to verify the results are significant in impacting immediate return to play, and long-term patient outcomes.

Spontaneous Hip Dislocations in a High School Basketball Player

Blunk LB: University of Kentucky, Lexington, KY

Background: Due to the anatomy of the hip joint it is typically a very stable joint which means great force is required to dislocate this joint. This type of dislocation is even more uncommon in adolescents. Typically, when this type of dislocation occurs it is the result of massive trauma like that of a motor vehicle accident where the hip is flexed, and an axial load is applied to the femur when the patient's knees are forced into the dash. This is one reason posterior dislocations are more common. The case I am presenting is unique in that its mechanism of injury was atraumatic. **Patient:** This case involves a 16-year-old male basketball player with five years of competitive basketball experience with two episodes of spontaneous hip dislocation. This individual had no previous injury to either the involved or contralateral hip. The initial dislocation happened in June of 2017 while participating in a game with his AAU basketball team. He was dribbling the ball down the court and went to sprint and cut under some pressure and fell to the ground. The second happened with his high school basketball team during practice February of 2018 while participating in a full court lay-up drill. Both episodes were non-contact in nature. Both times basic observation and palpation revealed a hip dislocation and EMS was activated and neurovascular status monitored. There were no attempts made to reduce his hip prior to arrival at the emergency department with either episode. Radiographs obtained at the hospital confirmed a posterior hip dislocation with a fracture to the posterior lip of the acetabulum. The patient has reduced head neck offset with an alpha angle of 75. He has a deficient posterior wall at baseline when compared to the contralateral side resulting in increased hip instability. **Intervention or Treatment:** Both reductions were closed reductions performed in the

emergency department under sedation. The second dislocation was accompanied with a posterior acetabular fracture that was repaired with internal fixation. Following surgery, the patient was kept NWB for the first month then transitioned to “weight of leg weight bearing” for the second month. He resumed full weight bearing by two months post-op along with gait training and glute abductor strengthening following posterior hip precautions. The literature shows us that most hip dislocations in this age group are a result of some form of acute trauma which was not present in this case. **Outcomes or Other Comparisons:** Following internal fixation of the acetabular fracture this patient underwent physical therapy for approximately eight months before being medically cleared to return to sport. **Conclusions:** Due to the patient’s anatomical predisposition to hip instability he does have an increased risk of recurrent dislocations in the future. Risks have been explained to the patient and his family and they have elected to let him continue to play basketball without and further surgical intervention to stabilize the joint. In the event that he has another dislocation episode, a partial replacement will be considered. **Clinical Bottom Line:** Hip dislocations can be atraumatic, and it is important to recognize these injuries and refer immediately taking care to monitor any neurovascular changes.

Platelet-Rich Plasma Injection in a Second-Degree Strain of the Peroneus Longus

Deal HA, Lumpkin KJ: Liberty University, Lynchburg, VA

Background: A collegiate male high-jumper presented with a history of right Achilles tendon strain, bilateral patellar tendinitis intensified on right leg, and bilateral fibular head hypermobility with increased laxity on right leg. Patient presented with pain at the distal one-third of the fibular and an inability to maintain normal gait after jumping off an everted foot in February 2018. Patient claimed he did not feel immediate pain but heard a pop during beginning of jump and within an hour described pain as indiscriminate with a pain level of ten on a ten-point scale. Swelling and point tenderness were present over distal one-third of the fibula when evaluated by the certified athletic trainer. AROM and PROM were unremarkable at time of evaluation. All motions of the ankle were evaluated for strength, however, these tests did not reveal significant muscular weakness at time of injury. **Differential Diagnosis:** Fibular stress reaction, fibular fracture, and/or peroneal strain. **Treatment:** Initial treatment was directed for fibular stress reaction for one-week post-injury, incorporating electrical stimulation, ice, and tape during practices and conference competition, with occasional soft tissue massage and heat. Patient attempted to compete in conference meet in late February 2018, 13 days post-injury, but was restricted by pain. Diagnostic ultrasound was performed after his inability to compete. The report demonstrated peroneus longus muscle belly tearing and tissue swelling. Physician’s final diagnosis of second-degree peroneus longus strain was determined 16 days post-injury; platelet-rich plasma (PRP) injection was recommended and administered. Patient was restricted to a Continuous Ankle Motion (CAM) Walker for four days, then started range of motion and strengthening exercises with pain control as needed. More

aggressive rehabilitation occurred approximately 5 days after the injection based on patient’s pain level. The patient began sport-specific activities including spring-board jumps and running 23 days post-injury. The patient fully returned to competition at 34 days post-injury, performing at pre-injury levels. No further problems with the peroneals were reported throughout rehabilitation or upon an 8-month follow-up. **Uniqueness:** An important finding of this case is that more thorough initial evaluations of the lateral ankle complex are needed, based upon 40% of peroneal strains having delayed diagnosis. **Conclusions:** Although this high jumper had a delayed diagnosis and attempted to compete earlier than capable, his RTP with diagnostic ultrasound and a PRP injection was remarkable. However, more comprehensive research is needed in the use of PRP injections to determine physiological effects, RTP timeline, and anatomical tissue selection.

Ankle Reconstruction and Microfracture Chondroplasty in a Basketball Player

Lumpkin KJ, Galley B: Liberty University, Lynchburg, VA

Background: A 20 year old collegiate female athlete with a history of multiple ankle sprains in high school presented with lateral ankle pain after an inversion stress during an event in November 2017. Although the athlete was able to return to play (RTP) with tape, the ankle pain persisted. Initial evaluation by the certified athletic trainer found a negative anterior drawer and Kleiger's test but positive for inversion stress test. Point tenderness was noted on the calcaneofibular (CF) ligament and inferior to the medial malleolus. Swelling was found over the CF and posterior to lateral malleolus. After a 7 day rehab of RecoveryPumps, GameReady, underwater treadmill, AROM, RROM and PWB, the athlete was able to RTP for 1 hour of contact. At day 10, she was RTP without restrictions. Athlete reported zero pain during participation but slight pain after play. A flare up of pain occurred in January, 7.2 weeks after onset. **Differential Diagnosis:** Osteochondritis dissecans (OCD), CAI, fibular stress reaction, fibular fracture, avulsion fracture, peroneal strain and/or peroneal tendinitis. **Treatment:** Controlled ankle motion (CAM) walker was used as needed for ADL's. X-ray was negative for fracture and physician recommended prednisone for pain and inflammation. Treatment during full participation included strengthening, soft tissue massage, foam rolling, taping during participation and ice post play. Due to chronic ankle pain post-season, athlete followed up with the physician in March 2018 (4 months after injury). An MRI was ordered. These results showed a stage 3 OCD at the lateral talar dome, anterior-talofibular ligament partial tear, and Deltoid (anterior-portion) ligament tear with slight avulsion fracture. Athlete then consulted with an Orthopedic about surgery or conservative care. After 6 weeks of rehabilitation with little success, a repeat MRI was scheduled because of an increase in insidious

lateral ankle pain. A repeat x-ray denoted an osteophyte of the distal anterior, medial malleolus which lead the patient and physician to elect for ankle reconstruction and microfracture chondroplasty (MC). The MC and osteophyte removal surgery occurred in August (9 months post injury) and the Broström reconstruction was a second surgery in September. The athlete was restricted to NWB for 4 weeks between surgeries. After the reconstruction, 6 weeks of NWB and casting was indicated. Next the athlete was placed in an aircast and allowed to WB while ambulating, however, she was restricted from bicycling and ankle exercises, other than light theraband. Full RTP is yet to be determined. The rehabilitation plan is 3 months of progressive exercises, proprioceptive activities, and sports specific drills prior to RTP in March, if no complications develop. **Uniqueness:** While 15% of sports injuries occur in the ankle, the prevalence of OCD is increasing in athletes. Cartilage defects are present in 50% of ankle sprains while CAI is found in approximately 23% of those athletes¹. Lateral ankle reconstruction for CAI is more prevalent but more outcome data is needed. Since surgical strategies for OCD vary without one being superior more research is needed in this area². **Conclusions:** Although this athlete was able to continue play for one season with mild ankle pain, it is important to continue to follow up with specialists when pain persists. This case demonstrates the excellent care provided to an athlete who struggled with chronic ankle pain. This athlete reports wearing ankle braces and tape during high school participation and 2 college seasons. The continuous stress placed on competitive young athletes could be a factor in the rise of ankle reconstructions during college. After two surgeries and progressive rehabilitation for 7 months (1.3 years post injury), it is suspected that this athlete will have a full RTP.

Hip Complications Post-Multiple Surgeries in a College Football Athlete

Swanson SJ; Craddock J: Florida Gulf Coast University, Fort Myers, FL

Background: Athlete is a 21-year-old (180 cm and 75 kg) male NAIA football player. Athlete's prior medical history includes hip impingements from birth, right hip labral surgery 5 years prior, left hip labral surgery 2 years prior, 3 left hip wash outs 2 years prior, and a second left hip surgery one year prior. Athlete reported to the athletic trainer following practice during fall camp complaining of pain in his left hip that started the day before and was consistently painful after the two practices. Athlete denied any specific mechanism. Initial evaluation revealed swelling and slight heat to the anterior side of the left hip. Athlete showed no point tenderness, discoloration, or other deformities. Full Passive ROM and 3/5 MMT with hip flexion, extension, abduction, adduction, internal and external rotation. **Differential Diagnosis:** Infection, Hip Impingement, Acute Inflammatory Response, Lymphadenopathy, Chondromalacia, Femoral Head Fracture, Acetabular Labral Tear. **Treatment:** Athlete began conservative treatment with athletic trainer and after one week with progress and began drill exercises. Two days later, athlete returned to Athletic Trainer complaining of his inability to walk without extreme pain. The Athletic Trainer also noted major swelling around the hip. Athlete was referred to the team physician due to change in pain and swelling. Athlete underwent an MRI and aspiration. Aspiration drew no fluid which suggests no infection. MRI imaging revealed possible infection with moderate asymmetric external iliac lymphadenopathy, mild asymmetric left inguinal lymphadenopathy, diffuse soft tissue and muscle edema. Imaging also revealed degeneration of the anterior aspect of the left femoral head and neck, deficient left acetabular labrum, diffuse high-grade anterosuperior acetabular chondromalacia and advanced osteoarthritis of the left hip joint resulting in

bone-on-bone appearance. Lastly, imaging revealed large prominent edema with debris dissecting anteriorly and laterally throughout the wide capsular defect anteriorly and prominent periarticular marrow edema affecting the left acetabulum as well as the left femoral head and neck extending to the level of the intertrochanteric plane raising concern for osteomyelitis and septic joint. It was noted that there is uncoverage of the superior outer aspect of the left femoral head with shallow acetabular concavity suggestive of underlying hip dysplastic changes. Athlete was further treated conservatively with prescription antibiotics (meloxicam and tramadol) and ongoing therapeutic exercises. After one month of treatment and antibiotics, athlete's swelling and pain decreased but unable perform sport related activities. The athlete underwent an aspiration and is awaiting results. **Uniqueness:** The acetabular labrum can be compared to the knee menisci and glenohumeral labrum for its purpose of absorbing forces and providing cushion to the surrounding bones. Research suggests that repetitive impact loading, such as running, can be an underlying cause due to subtle instability as well as subtle acetabular dysplasia. Another study suggests that 73% of patients with labral complications also have chondral damage. This case highlights the different complications that can result in labral tears. This case is unique because there are few studies that research outcomes of acetabular labral post surgery complications and differing treatments for each complication that may have resulted. **Conclusions:** This case highlights the diagnosis and treatment of an athlete suffering from postsurgical hip complications and whether there will be a successful return to play through a total hip replacement or steroid injection. This case further highlights the complexities of treating athletes with prior history of hip complications after surgery.

Foot Pain In a High School Girls' Basketball Player

Jacobs D, Ullery LR, Smoot MK:
University of Kentucky, Lexington,
KY

Background: Background: A 14-year-old female basketball player (height: 5ft 2in± 157.48cms, mass: 102±46.2kgs) reports to the Athletic Trainer, complaining of left foot pain during and after activity. She had been involved with basketball activities for 5 weeks. There was no acute injury to her left foot, the onset of pain was insidious, and was gradually worsening. The pain was located over the second metatarsal, and was reported as an 8-10 on numeric pain scale, worse with weight-bearing activities, and described as sharp and achy. The evaluation revealed edema over her forefoot, no ecchymosis, neurologically intact, and strong distal pulses. She also had full strength and ROM of the foot, ankle and toes, which did not cause her pain. She had a prior history of Freiberg's infraction on her right foot three years earlier. The Athletic Trainer placed her in short boot and crutches, and referred her to the sports medicine clinic. **Differential Diagnosis:** Differential Diagnosis: Stress fracture, Metatarsalgia, Morton's neuroma, Freiberg's Disease. **Treatment:** Treatment: X-rays ruled out a stress fracture, but revealed a flattening of the second metatarsal head. No additional imaging was ordered, given the deformity present on the x-ray. The patient was advised to continue to wear the boot with a foam metatarsal arch support and crutches. In addition, she was prescribed an NSAID for the inflammation and pain. Custom orthotics were ordered with an empty space in the metatarsal area to off load the second metatarsal. She was to report back the clinic if the pain did not subside. The patient continued to work on ROM and strength for three weeks with the Athletic Trainer to reduce pain and swelling. During this time, she began weight-bearing activities and gradually, weaned out of the boot. By 6 weeks, she was able to participate in basketball with her orthotics in her shoes. She was able to complete the

season without further problems of the second and third metatarsals. Most only occur in a single metatarsal and only 10% of the injuries were reported bilaterally. **Uniqueness:** Uniqueness: Freiberg's disease is a rare condition where avascular necrosis causes osteochondrosis to occur. It is commonly found in the second metatarsal head due to the length of the bone. The third metatarsal head is the next common site, but can occur in any of the five metatarsals. This injury is subdivided into five categories based on the x-ray presentation. At first, the injury was found to be an infraction since the cause was thought to be a traumatic mechanism of injury. However, there has not been a consensus of the cause of Freiberg's disease. The disease has a commonality with other osteochondrosis conditions because of the growth disruption of the epiphysis or apophysis in growing bones. Usually this injury occurs in active females ages 10-17, with a ratio of 1:3 male to female. Freiberg's disease has been found in ages as young as 8 and as old as 77. Multiple factors are reported to cause this injury including repetitive trauma, anatomical predisposition, shoe wear, low blood supply to the area, and lack of mobility of the second and third metatarsals. Most only occur in a single metatarsal and only 10% of the injuries were reported bilaterally. **Conclusions:** Conclusion: Freiberg's disease or infraction is an uncommon injury, and can be caused by multiple factors. Bilateral involvement is rare. All classifications can be treated conservatively, and those that do not heal with conservative treatment may require surgery. When evaluating foot injuries, clinicians working with adolescent athletes should be aware of the various bony injuries possible and follow their current treatment plan to obtain x-rays if bone pain continued. The patient was able to return to basketball with conservative treatment wearing bilateral orthotics in her shoes, without any further complaints.

Morel-Lavallee Lesion at the Knee in a 19-Year-Old Collegiate Football Athlete

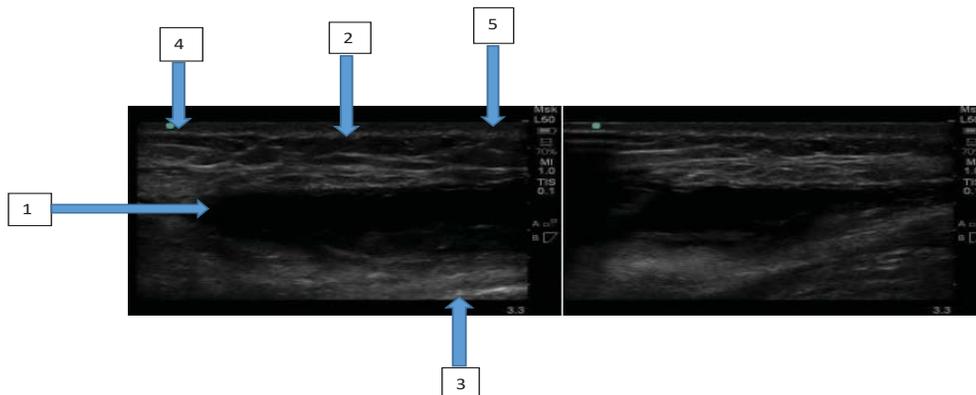
Hoskins T, Wasik M, Pan J, Kulpa T: King's College, Wilkes-Barre, PA; Misericordia University, Dallas, PA; Geisinger Orthopaedics and Sports Medicine, Wilkes-Barre, PA

Background: Morel-Lavallee Lesions (MLL) are an uncommon injury in the athletic setting.^{1,2} Although magnetic resonance imaging (MRI) is the standard diagnostic tool in the literature, emerging evidence points towards the use of musculoskeletal ultrasound (MSK-US) as a valuable point-of-care diagnostic tool. **Patient:** A 19-year football athlete reported to the athletic training facility complaining of knee pain after contact with the ground and knee rotation during practice. The patient presented with significant 2+ knee edema and effusion, and point tenderness at the medial joint line, medial patellar facet, and pes anserine. Physical exam also revealed decreased range of motion and strength in knee flexion and extension. Ligamentous testing was unremarkable and the patient was neurovascularly intact. **Intervention or Treatment:** The patient remained out of practice for three days receiving daily treatment targeting the patient's

significant edema and was referred to the team physician for evaluation. Upon evaluation four days post-injury the team physician confirmed the athletic trainers physical exam findings, was functionally tested, and gradually returned to practice over the next two days without functional limitation. Although fully functional, the patient continued to have significant edema and ecchymosis resulting in an MSK-US evaluation. The findings demonstrated a compressible hypoechoic echotexture between the superficial fat and underlying fascia, superficial to the potential suprapatellar bursa space (figure 1), consistent with a closed de-gloving injury (MLL). Treatment consisting of compression and edema control was continued and the patient was not restricted from participation. At two-weeks post injury the patient demonstrated a significant decrease in edema and ecchymosis and remained fully functional without complication the rest of the season. **Outcomes or Other Comparisons:** Uniquely, this patient's injury occurred to the medial knee, a location that often does not come in contact with the playing surface. Moreover, MSK-US was the only diagnostic tool used to determine the correct diagnosis. Literature states that MRI is the current gold standard for diagnosis due to its ability to visualize soft tissue injury. However, MRI often shows discrete fluid

collections that may have tapering margins that fuse with nearby fascial planes.³ MLL's have a dynamic course in its formation and resolution, thus MSK-US can show hypoechoic to anechoic collections in the fascia and fat, better than MRI.³ **Conclusions:** A closed de-gloving injury or MLL, is marked by separation of the subcutaneous tissue from the underlying fascia. These injuries are most commonly reported in the soft tissues surrounding the greater trochanter, flank, and the buttock.¹ MLL of the knee are rare and often underreported in athletics.² Furthermore, delayed diagnosis of a MLL may result in further complications such as infection, recurrent fluid accumulation, and skin necrosis. MSK-US will allow the clinician to have a diagnosis within minutes rather than waiting for MRI results. When a MLL is suspected, MSK-US can be a direct, dynamic, and cost effective way to diagnose the injury.¹ **Clinical Bottom Line:** MLL's are an uncommon injury in athletics and are rarely reported at the knee. Athletic trainers should be aware of the mechanism of injury as well as the signs and symptoms of MLL to facilitate timely diagnosis and treatment of this injury. When physical exam demonstrates the need for further diagnostics, MSK-US can be used for an immediate diagnosis to possibly prevent further complications before they occur.

- MSK-US of the patient's right knee.
- Highlighted areas:
 1. The hypoechoic echotexture.
 2. Outside of the leg.
 3. Shaft of the femur.
 4. Towards the thorax/head.
 5. Towards the patella/knee/foot.



A Salter-Harris Type II Fracture of the Distal Femoral Epiphysis in an Adolescent Athlete: A Case Study

Helly KL, Bain KA: University of Kentucky, Lexington, KY

Background: The distal femoral physis is responsible for approximately 70% of femur growth and is the fastest growing physis in the body. Due to this rapid growth, a Salter-Harris fracture to this epiphysis can cause complications and significant disability following injury. In most circumstances, these injuries are seen in adolescents involved in high speed motor vehicle accidents. The purpose of this Level 3 case study is to present and discuss an atypical presentation of a 12-year-old football player who sustained a Salter-Harris Type II fracture of the distal femoral epiphysis. **Patient:** While playing defensive end during a middle school football game, a 12-year-old, 5-foot-tall, 131-pound African American male sustained an anterior force to the left knee, resulting in excessive hyperextension. Upon evaluation, he complained of generalized posterior knee pain, but there were no visible or palpable deformities, ligamentous tests were inconclusive secondary to pain, and unremarkable neurovascular screen. On the sideline, patient was re-evaluated with no change in findings and denied previous knee injury or pain prior to injury. The ATC elevated the patient's leg and applied ice. After initial treatment, he demonstrated a slight extension deficit but could flex his knee more than 90°. He could bear weight but exhibited an antalgic gait pattern. Despite being advised to report to an orthopedic clinic the following morning for follow-up, the patient failed to present, despite multiple attempts to contact. Patient finally returned to ATC for follow-up, five days post-injury, stating that his family had decided to treat the knee conservatively. He was unable to achieve greater than 90° of knee flexion, lacked 20° of extension, and had moderate knee effusion. The patient presented for physician evaluation six days post-injury. He stated his pain fluctuated and was sharp in nature. Upon

evaluation, peripheral vascular exam was normal. The patient demonstrated significant soft tissue swelling, a 15° extension deficit and could only achieve 100° of knee flexion. A palpable depression was now noted along the distal femur. Manual muscle testing of the quadriceps and hamstrings was strong but painful and no laxity was noted with ligamentous testing. All other testing was deferred secondary to pain. An x-ray of the knee revealed a posteriorly displaced Salter-Harris Type II fracture of the distal femoral physis. **Intervention or Treatment:** The patient was admitted to the emergency department six days post-injury, where he underwent a closed reduction. Two smooth percutaneous Steinmann pins were placed in cross fashion for fixation. He was placed in a long leg cast and is currently non-weightbearing for six weeks. The typical treatment for a physis injury to the femur is fixation, whether displaced or non-displaced. **Outcomes or Other Comparisons:** Fractures to the femoral physis typically result in significant disability and immediate physician referral. This case is unique because the patient reported generalized pain, was able to weight-bear, and had no deformity at the time of injury and delayed physician follow-up. **Conclusions:** Approximately 5-15% of all physeal fractures involve the distal femur, with varying clinical presentations. Ideally, the patient would have been evaluated by a physician within 24 hours, but the patient's non-compliance with ATC's instruction and nature of the injury increases the complexity of this case. This presentation contains a wide variety of potential pathologies that should be included in the differential diagnosis that must be ruled out prior to final diagnosis. **Clinical Bottom Line:** Although rare, ATCs must always consider a physeal injury as a differential diagnosis when working with adolescent athletes.

Bilateral Tibial Tubercle Distalization in a College Student With Recurrent Patellar Dislocations Due to Patella Alta

Parke M, Stein JL, Lawrance SE: Purdue University, West Lafayette, IN

Background: Patella alta is a biomechanical alteration in the patellofemoral joint where the patella is seated abnormally high in relation to the femur, leading to decreased bony stability. Due to increased height of the patella, there is insufficient engagement between the articular surfaces of the patella and trochlear groove in both extension and early phase of knee flexion, making it a risk factor for patellar instability. Patella alta is present in 30% of patients with recurrent patellar dislocations. The most popular current operation for recurrent dislocations involves medial patellofemoral ligament reconstruction to increase patellar stability. This Level 3 CASE study highlights an alternative management plan to correct the abnormal biomechanics by distalizing the tibial tubercle. **Patient:** The patient is a 22-year-old female with a chief complaint of recurrent bilateral patellar dislocations. She reported a 12-year history of bilateral recurrent dislocations. Her instability progressed to where they could spontaneously dislocate/subluxate with ambulation. Differential diagnoses included recurrent patellar instability, patellar malalignment, and patellofemoral syndrome. Imaging was utilized prior to surgical intervention to determine any patellofemoral malalignment or soft tissue injury. MRI and radiographs both revealed bilateral patella alta. **Intervention or Treatment:** After failing several attempts at conservative management, she elected to have tibial tubercle distalization surgery on her left knee in late summer prior to her senior year of college and her right knee five months later. Surgically, the procedure involved an osteotomy of the tibial tubercle and distalization with surgical fixation of the tubercle to the tibia, effectively lowering the patellar height and restoring normal patellofemoral biomechanics. Following surgery, the patient was allowed to ambulate using an immobilizer with crutches and was weight bearing as tolerated for three weeks with a home exercise program of quad sets,

straight leg raises, and heel slides. The athletic trainer performed early rehabilitation that focused on progressive ROM and resistive exercises, gait training, and neuromuscular re-education. For each recovery, she was progressed from her crutches at 6 weeks post-op and off the immobilizer at 9 weeks post-op. The rehabilitation program continued to focus on leg strength and functional movements until the patient had regained normal ADLs and was able to participate in desired recreational activities. **Outcomes or Other Comparisons:** The patient completed her rehabilitation recovery 29 weeks after having her right tibial tubercle distalized. The final outcome revealed full, symmetric knee ROM and knee extension/flexion strength within 10% of the opposite leg. Subjective IKDC scores were 86 on the right knee and 94 on the left knee approximately one year following the second distalization procedure. These values match or exceed published normative data from the general population. She was able to return to all desired activities, including running and racing. She has not had any other complications or patella instability. **Conclusions:** This patient was symptomatic bilaterally. Her condition was so severe she would often dislocate with ambulation or twisting her body to change directions while her knee was extended. Patella alta is a relatively uncommon condition and treatment can be challenging with outcomes varied. Surgical reconstructions are often unsuccessful, and patients can have returning recurrent instability. The distalization procedure performed on this patient is not commonly performed but can lead to a successful outcome if performed correctly. This patient was able to progress through both post-operative recoveries without incident or complication and return to desired activity levels. **Clinical Bottom Line:** Tibial tubercle distalization results in normalization of patellar tendon height and a stable patellofemoral joint, restoring a normal extensor mechanism. Good long-term knee function with low patellar dislocations recurrence rate in patients with patella alta can be achieved following the surgical procedure and proper rehabilitation.

Chondral Defect of the Patella: Osteochondral Autograft Transplantation With Stem Cell Implantation in a Collegiate Female Basketball Player

Johnston M, Belik D, Wilkins S, Rosen A: University of Nebraska, Omaha, NE; Creighton University, Omaha, NE

Background: An Osteochondral Autograft Transplantation (OATS) procedure can be used to repair a chondral defect. In active individuals who are still competing at a high level after having this surgery usually take at least eight months to return to play. Stem cell implantation during the procedure has been shown to decrease the patient's recovery time. **Patient:** 20-year-old female Division 1 collegiate basketball player (height = 170.18 cm, mass = 57.72 kg) performed a spin move to avoid the defender while going up for a layup. The patient stated the outside of her knee "felt different." Previous history included a meniscal tear and stretching of the ACL on the ipsilateral knee approximately four years prior. A meniscal repair was performed to repair the defect. For the current injury, X-ray results showed a loose body chipped off the lateral femoral condyle. In November 2017, surgery was performed to remove the loose body and visualize the chondral defect. The athlete returned to play basketball, but would need another surgery to repair the defect after season. **Intervention or Treatment:** An OATS procedure with stem cell implantation was performed on April 4th, 2018. A five-phase rehabilitation protocol was used to guide therapy. During phase one (weeks 0-6), the patient was non-weight-bearing, only performing heel touches during rehabilitation. Continuous passive motion (CPM) was used for 6 hours per day, beginning at 0° and increasing to 40°, advancing 5-10° daily as tolerated. Exercises consisted of quad sets, straight leg raises, calf pumps, and passive leg hangs at 90° at home. At week three, exercises consisted of: passive range of motion (PROM) and assisted active range of motion (AAROM) as tolerated; patella and tibiofibular joint mobilizations; quadriceps, hamstring, and glute sets; straight leg raises; and side lying hip and

core exercises. During phase two (weeks 6-8), she was at full ROM and advancing 25% weight bearing weekly until she was full weight-bearing while completing the same exercises in phase one, but added weight or resistance. During phase three (weeks 8-12), full weight-bearing and full range of motion was achieved. Exercises consisted of: gait training exercises, beginning closed kinetic-chain activities such as wall-sits, mini squats, toe raises, unilateral stance activities, and balance training. The patient began interval training during week 8 post-op. During phase four (3-6 months), workload increased from previous activities by increasing glute, core, and pelvic stability and adding eccentric hamstring exercises. The patient advanced to the elliptical, pool, or bike as tolerated during this phase. During week 12, work began on defensive slides, box jumps, and running. The final phase (6-12 months) consisted advancing functional activity. The patient was released by the physician and was able to return to sport specific activity at five months with a continued maintenance program for quadriceps strength and endurance. **Outcomes or Other Comparisons:** On September 10th, contact during individual drills began, and on September 19th, the patient competed in an inter-squad scrimmage. Due to the size of the defect, the patient was a candidate for stem cell implantation. Using stem cell treatment expedited the recovery time by approximately three months. **Conclusions:** A direct blow to a bent knee on the lateral femoral condyle is a common mechanism of injury for chondral defects. Clinicians should be familiar with chondral defects of the patella with basketball athletes due to the stress, particularly on the knee, during their playing career. Stem cell therapy is a novel procedure in conjunction with the OATS procedure and little research evidence is available demonstrating its effectiveness. **Clinical Bottom Line:** Based on this individual case and the success that was obtained by the patient, clinicians should consider this procedure in consultation with supervising physicians.

Anterior Cruciate Ligament Rupture During Syndesmotom Ankle Sprain Return to Play in a Female Soccer Athlete: A Case Study

Clawson PA, Fisher L, Gribble PA: University of Kentucky, Lexington, KY; Danville High School, Danville, KY

Background: The risk of anterior cruciate ligament (ACL) injury is among the highest in female athletes and most likely multifactorial. Laboratory-controlled studies suggested that individuals with history of ankle sprains and individuals with ACL injury have similar biomechanical alterations. However, there are few clinical case studies illustrating the potential association that an ankle sprain may have on subsequent ACL injury. Therefore, the purpose of this case study is to discuss the occurrence of an ACL rupture following a syndesmotom ankle sprain in a female soccer player. **Patient:** A 16-year-old female soccer athlete sustained a left syndesmotom ankle sprain during a match when the left ankle was planted on the ground while rotating into ankle inversion. The patient reported feeling a “pop”, pain on the distal lateral malleolus, and inability to bear weight on the affected ankle. The Ottawa Ankle Rules were employed and warranted confirmatory diagnostic imaging. A physician ruled out a fracture and provided a diagnosis of a grade II syndesmotom left ankle sprain. The patient was cleared for return to sport by the athletic trainer after participating in three weeks of rehabilitation with an athletic trainer. In the first full soccer match back, she sustained an ACL rupture in the right knee. She reported feeling and hearing a pop during a cutting motion in which she felt the right knee go into an excessive valgus position. The patient exhibited positive Lachman’s and anterior drawer tests. All additional components of the evaluation were unremarkable. The patient was referred to an orthopedic clinic, where MRI confirmed a complete ACL rupture in the right knee. **Intervention or Treatment:** The patient’s rehabilitation for her ankle sprain focused on restoring range of motion (ROM), strength, and neuromuscular control. The patient was held

from sport activities for 16 days. A return to play (RTP) assessment was implemented which required: ROM equal and pain-free bilaterally, manual muscle testing of strength to be 5/5, and functional and agility testing (T-test, 5-10-5 Shuffle, and zig zag test) without limitation. After successful demonstration of these milestones, the patient was progressed back to play with two days of non-contact practice, and game/competition re-integration of 5 minutes per half, 10 minutes per half and then fully released with no play time restriction. Only soreness reported during the first partial competition. The patient underwent patellar tendon graft ACL reconstruction for her injured right knee and is currently completing a prescribed ACL rehabilitation protocol. **Outcomes or Other Comparisons:** There is limited documentation on the association of previous ankle injury to ACL ruptures. The suggested potential biomechanical relationship between individuals with ankle sprain and ACL injury raises awareness of the importance of thorough ankle rehabilitation protocols. Rehabilitation and RTP for this case followed traditional protocol and a common RTP progression. However, this raises question if the ankle rehabilitation dosage was large enough and if some ACL rehabilitation protocol aspects should be incorporated into ankle rehabilitation. Additionally, perhaps clinicians should evaluate for deficiencies that could indicate risk for subsequent injuries when returning from an ankle sprain. **Conclusions:** Many factors predispose athletes to ACL injury. In this case, a female adolescent athlete may have had potential gender-based risk factors amplified by a recent ankle injury. The close proximity of time in which the two injuries occurred brings question to if there needs to be a more conservative return to play or a different protocol for individuals that sustain a syndesmotom ankle sprain that may have additional injury risk factors. **Clinical Bottom Line:** More thorough rehabilitation and RTP protocols may be needed for ankle sprain patients as the link to additional injury risk becomes documented.

Pseudogout in a 19-Year Old Division I Collegiate Female Soccer Player

Calpino KM, Norberg JD, Tarsic A: Salem State University, Salem, MA; Harvard University, Boston, MA

Background: A 19-year old collegiate female soccer player complained of insidious onset of knee swelling, stiffness, and pain. She underwent an ACL reconstruction with a hamstring autograft 17 months prior. Her postoperative rehabilitation was uncomplicated and she returned to full competition 11 months later. The patient began experiencing symptoms one month into the soccer season. Upon examination, she had swelling rated 2+ on the modified stroke test, full knee ROM with pain at end range of knee flexion and extension, and tenderness at the tibial fixation site. She demonstrated difficulty with achieving full active terminal knee extension, but symmetrical quadricep bulk. Her knee was otherwise stable with no clinical signs of graft or other ligamentous laxity, or meniscal injury. Due to these symptoms, the patient’s knee was aspirated by the team physician revealing 31cc of cloudy yellow fluid, indicating joint inflammation. **Differential Diagnosis:** Hardware Irritation, Infection, Lyme Disease, Rheumatoid Arthritis, Gout, Pseudogout, Chondral Defect, Meniscus Tear, ACL Graft Failure **Treatment:** Radiographs showed postoperative changes consistent with ACL reconstruction, a biocomposite screw and staple on the tibia at the site of pain, and a preserved tibiofemoral joint. An MRI revealed mild swelling, an intact ACL graft, menisci, and chondral surfaces. The patient was referred to a rheumatologist for further evaluation. Blood work completed included a basal metabolic panel, hepatic function panel, cyclic citrullinated peptide antibody, thyroid panel, rheumatoid factor, c-reactive protein, iron panel, magnesium, complete blood count, Lyme disease screening, and sedimentation rate tests. The only abnormal findings were low glucose and high absolute neutrophils. The aspirated fluid revealed normal cell count, normal gram staining, and the presence of calcium pyrophosphate crystals. These findings resulted in a diagnosis of pseudogout (calcium pyrophosphate

dihydrate crystal deposition disease). She was prescribed 0.6 mg colchicine twice a day and 500 mg naproxen daily in order to treat the gout and decrease inflammation, respectively. Physical rehabilitation included electrical stimulation strengthening in order to assist quadriceps activation in terminal knee extension, intermittent compression to decrease swelling, and cryotherapy to control pain. Her symptoms were well controlled with only mild stiffness and swelling that did not limit her from athletic participation. Her playing time increased dramatically in the last three games of the season, that resulted in a significant increase in knee joint effusion and concomitant pain and stiffness. The patient's knee was aspirated again prior to the last game with 25cc of yellow, cloudy fluid extracted. The recurrence of symptoms and resulting aspirated fluid indicates a likely persistence of pseudogout despite treatment. **Uniqueness:** Pseudogout is cited to be the most common cause of acute monoarthritis in the elderly. It most commonly occurs unilaterally in the knees and wrists. The most common causes of pseudogout include stress and recent surgery with existing chondrocalcinosis. Individuals with a thyroid condition, kidney failure, or disorders that affect calcium, phosphate, or iron metabolism are also more susceptible. Pseudogout in young people and athletes is very uncommon. Although the case discussed presents a unilateral incidence of pseudogout in a commonly affected postoperative joint, the patient's age, lack of chondral defects or radiographic abnormalities, normal bloodwork, and otherwise insignificant medical history make this case unusual. **Conclusions:** Pseudogout is uncommon in young healthy individuals. The patient's initial signs and symptoms mimicked those of common postoperative complications, which made the diagnosis very unique. Patients with those complaints who fail to respond to conservative treatment should be referred for further medical evaluation. If an orthopedic cause is not apparent, the possibility of systemic or other medical diagnoses should be considered.

Proximal Tibial Plateau Salter-Harris Fracture That Undercuts the Tibial Tuberosity in a Male High School Track Athlete

Cottrell C, Peters J, Beard MQ:
Capital University, Columbus,
OH; Bishop Hartley High School,
Columbus, OH

Background: A 14-year-old male, high school high jumper sustained an injury to his left knee during an indoor track meet. The athlete went down after his jump and reported a pop in his left knee during push off. Upon approaching the athlete, the athletic trainer immediately noted a bony deformity. The athletic trainer activated the Emergency Medical System and he was transported to the local Emergency Department (ED). The athlete's pain was an 8 out of 10. The athlete reported that he had a previous diagnosis of Osgood-Schlatter's disease of his left knee. During his evaluation, the ED Physician reported large joint effusion, an anteriorly displaced tibial tuberosity and decreased range of motion. The ED physician identified on radiographic imaging, a Salter-Harris type 1 injury of the proximal tibia which undercut the tibial tuberosity, creating a 1.2 cm diastasis and 25 degrees of angulation. The athlete was placed in a knee immobilizer and on crutches. The team physician referred the athlete to an orthopedic surgeon. **Differential Diagnosis:** Patellar dislocation, patellar tendon rupture. **Treatment:** All risks, benefits and expected post-operative plan were discussed with the athlete and his mother, and consent was obtained. An open reduction, internal fixation surgical procedure was performed 6 days post injury. The athlete was placed in a knee immobilizer, locked in extension and non-weight bearing with crutches for four weeks. The athlete was then weight bearing with the knee immobilizer left in 0 degrees of knee flexion for the next four weeks. The athlete started rehabilitation exercises with a physical therapist 8 weeks post-operation. He completed 16 visits in 8 weeks. The athlete regularly checked in with the athletic trainer during this time and received treatment on his off

days. He was released to return back to full participation 16 weeks post-injury by the team physician. He is currently participating in football with no reports of pain or dysfunction. **Uniqueness:** The incidence of proximal tibial physeal fractures is less than 1% of all pediatric fractures. Proximal tibial physeal fractures are uncommon accounting for 0.5 to 3% of all physeal fractures. Salter-Harris type 1 fractures result in 6.0-8.5% of physeal fractures, making it the 2nd rarest type of Salter-Harris fractures. A growth disturbance of a physeal fracture is measured on radiograph and defined by a deformity of more than 25 mm in separation, or more than 5 degrees of angulation. Physeal fractures may produce irreversible damage to growth cells, resulting in a post-traumatic leg deformity. The proximal tibial physis contributes about 28% to total leg growth, and approximately 55-60% of tibial growth, therefore if a growth disturbance occurs at the proximal tibial physis it can affect tibial and leg growth. Over 45% of individuals with a growth disturbance at the proximal tibial physis resulted in a post-traumatic leg deformity. These deformities include rotational and axial malalignment, valgus angulation, recurvatum, and leg length discrepancies. **Conclusions:** Proximal tibial physis fractures should be referred to an orthopedic surgeon as soon as possible for evaluation and radiograph imaging to determine if a growth disturbance is present. Physis fractures must be watched closely for premature physeal closure and subsequent development of a post-traumatic leg deformity. The sports medical team needs to educate the patient about long-term health and monitor for recurring pain and other chronic pathologies which can result from a leg length discrepancy and malalignment of the leg.

Knee Injury in a High School Football Player

Williams SJ, Smoot MK, Stone W, Bandow B: University of Kentucky, Lexington, KY

Background: A 17 year old quarterback presented to the Athletic Trainer for R shoulder rehabilitation. While sitting, it was observed by the AT that he had a large effusion of his right knee. When asked, the athlete stated that his knee had been like that for a while and he wasn't having any problems. He had been practicing normally for the first month of pre-season and was expected to be the starting quarterback at the team scrimmage the next day. He did not remember having an injury to his knee. Physical exam and testing was normal, aside from the effusion. The athlete stated he had grown 5 inches in the last year, his current height was 6'3" and he weighed 145.2 lbs. His father was diagnosed with Juvenile Rheumatoid Arthritis (JRA) when he was 11. **Differential Diagnosis:** Bursitis, Meniscal tear, JRA, Osteochondral defect (OCD) **Treatment:** The athlete was allowed to play in the scrimmage the following night and was closely monitored. The athlete was then referred to a primary care sports medicine physician the next morning. X-rays revealed an abnormal patella with an uneven undersurface in the patellofemoral groove. MRI was ordered and an OCD lesion of the patella was detected. The physician consulted with an orthopaedic surgeon who specializes in cartilage reconstruction. Because the athlete was still functional and no mechanical symptoms could be appreciated, the surgeon recommended that the knee joint be aspirated and then injected with a steroid. If the effusion did not return and the athlete was functional with sport specific activities, he would be cleared to participate in football for the remainder of the season. If the joint effusion returned after the aspiration and injection, the surgeon recommended that the athlete have a procedure to remove the patellar lesions. The athlete had an aspiration of 46cc of joint fluid that was sent for lab testing. He was injected with a combination of 4cc of

lidocaine, 4cc of bupivacaine, and 2cc of kenalog. The athlete rested for 72 hours, wearing a compression sleeve and using cryotherapy. After three days, his effusion did not return and he was still pain free. His lab results were normal. The athlete was able to perform football activities and returned to full sport. **Uniqueness:** Patellar OCD lesions are very rare, only making up 2-5% of all knee OCD lesions. The etiology of patellar lesions is mostly unknown. Leading theories for these lesions are a shearing force in the patellofemoral groove or repeated impacts to the cartilage. Intervention is normally recommended when the lesions are loosened away from the patella or when there is swelling. Even though the athlete had a moderate effusion, his lesions were not detached from the patella and he had no complaints of pain or loss of function. **Conclusions:** A 17 year old quarterback was diagnosed with a patellar OCD lesion after observation of knee effusion with no knee injury. The athlete was able to return to football after having his knee joint aspirated and injected with steroids. The athlete was able to complete his senior season with no problems. He never had a return of the effusion. He is currently working out and conditioning 3-4 days a week, but he has not decided if he will be playing football again.

Dislocation of Right Knee With ACL and PCL Avulsion, MCL Tear, Menisci Tears, and Tibial Plateau Fracture in a Collegiate Football Athlete

Sanders JT, Martinez RE, Odai ML, Felton SD: Florida International University, Miami, FL

Background: This level 4 case report is on a 21 years old male collegiate offensive lineman, with no prior injuries to the lower extremity. During a game, the athlete was rushed by an opponent and awkwardly fell as another athlete landed on the lateral portion of his knee. The athlete reported two pops, one on contact and another as he fell. There was no on-field evaluation. Due to obvious deformity, the athletic trainers protected the leg and transported the athlete to the sideline in order to proceed with the injury protocol. On the sideline, the team physician reduced the knee, splinted it, and transported the athlete to the emergency room. Obvious gross deformity required the athletic trainers to continuously check for distal pulses and sensation in the patient's lower extremity during transport. Neurovascular structures were not compromised. **Differential Diagnosis:** A knee dislocation was obvious during initial observation. The severity of the ligamentous and bone damage was unknown until MRIs and X-rays were ordered. **Treatment:** Immediate treatment included the reduction and splinting of the knee. X-ray and MRI findings revealed: ACL and PCL avulsions from the femur, a torn MCL, tears in both menisci, and a lateral tibial plateau fracture. All structures were repaired via surgical intervention. Post-surgical rehabilitation was difficult due to multiple injuries in the knee. All ranges of motion (ROM) of the knee were severely limited and painful. As a result, initial interventions focused on decreasing pain and increasing ROM. Once pain was modulated the patient began ROM exercises, with an emphasis on knee extension. A standard ACL rehabilitation protocol was followed that focused on

regaining muscular strength, power and endurance and restoring neuromuscular control and balance. Sport specific exercises, plyometric training, and patient feedback were also included and used in making return to play decisions.

Uniqueness: The combination of the injuries makes this case unique. Follow up studies on the O'Donoghue triad (ACL, MCL, menisci) determined that lateral meniscal involvement was more common but failed to identify cases where both medial and lateral menisci were involved. There is also limited, if any, research that looks at rates of concomitant injuries in the knee from a single mechanism of injury. Additionally, despite lateral tibial plateau fractures with associated ACL ruptures being relatively common, multiple ligamentous ruptures are not. **Conclusions:** This case reviewed the on-field assessment and the recovery process of an acute traumatic knee injury. Keeping the patient calm, employing an emergency action plan, and having an excellent medical staff was key in managing this traumatic injury. Decision making, and communication were vital in the management of this injury. Rehabilitation protocols were specific to this patient's injuries and limitations, allowing him to fully recover and return to play nine months post injury. This case can be effective in teaching athletic trainers how to manage a traumatic knee injury.

Lateral Meniscus Transplant and Osteochondral Allograft Transplant in an Olympic Ski Racer

Volz JD, DePhillipo NN, Martin BM, LaPrade RF: The Steadman Clinic, Vail CO; Steadman Philippon Research Institute, Vail, CO

Background: Due to the critical function of the menisci, meniscal tears should be repaired whenever possible due to the detrimental consequences of post-traumatic osteoarthritis and dysfunction associated with meniscectomy. This level 3 CASE study describes an Olympic ski racer who presented with recurrent knee swelling, pain, and inability to ski 1-year status-post partial lateral meniscectomy and subsequent early-onset of osteoarthritis. The patient underwent a lateral meniscus allograft transplant and concomitant osteochondral allograft transplant(OATS) which allowed return to full activities and competition in Olympic level ski racing. **Patient:** 21 year-old male, Olympic level ski racer presented one year status-post left knee ACL reconstruction with a hamstring autograft and partial lateral meniscectomy. After returning to skiing he reported lateral knee pain after a suspected valgus mechanism. His knee ROM was full and strength was equal bilaterally. His Lachman's was a 1+ with a solid end point, otherwise he was ligamentously stable. MRI showed a medial meniscal tear, lateral meniscal tearing with a flap formation and lateral positioning, and a full thickness chondral defect of the lateral femoral condyle. **Intervention or Treatment:** A diagnostic arthroscopy was performed which demonstrated lateral meniscus deficiency corresponding with a previous subtotal partial meniscectomy and a full thickness defect of the posterior aspect of the lateral femoral condyle. There was also a complex medial meniscus tear that was repaired. The patient underwent the next staged surgery 5 months later which consisted of a lateral meniscus allograft transplant and an OATS to the lateral femoral

condyle. Postoperative therapy began immediately after surgery and focused on knee ROM, edema control, and quadriceps activation exercises. He was nonweight bearing for a total of 8 weeks and slowly weaned off of crutches until week 12 postoperatively. The patient avoided all impact activities for a total of 7 months and began his return to skiing protocol at 1-year postoperatively. He was able to pass a functional sports test at 14 months postoperatively and returned to full competition. **Outcomes or Other Comparisons:** The patient was able to return to high level downhill skiing competition. He successfully returned to Giant Slalom and Super G and finished as a top competitor in the combined event at the United States National Championships. He represented the US Olympic Team at the 2018 Winter Games finishing in the top 30 in three different events. **Conclusions:** A concomitant OATS and lateral meniscal allograft transplant surgery provides a viable surgical option for athletes to return to previous level of activity. The meniscus should be repaired at all costs with primary tears because a meniscectomy has been associated with early-onset of osteoarthritis and failure to return to preinjury levels in elite athletes. **Clinical Bottom Line:** The return to high impact activity after an OATS or meniscal transplant is contraindicated in much of the current literature, especially in sports involving impact in knee flexion such as downhill skiing. However, this case shows that proper surgical intervention, with careful recovery / rehab and return to sport, patients are certainly capable of returning to high level competition in high impact sports after major surgical intervention such as an OATS and total meniscus transplant.

Free Communications, Poster Presentations: Lower Extremity Injury Risk

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Improvements in Perceived Self-Efficacy Toward Injury Prevention Program Participation Following a Multi-factorial Intervention Based on the Health Belief Model: A Pilot Study

Gabriel EH, McCann RS, Cramer RJ, Hoch MC: Mercer University, Macon, GA; Old Dominion University, Norfolk, VA; University of Kentucky, Lexington, KY

Context: The effectiveness of injury prevention programs (IPPs) is highly limited by the lack of adherence within users. The Health Belief Model (HBM) has been used to understand, predict, and influence participation in preventative health behaviors. There is potential that an intervention grounded in the HBM could lead to improvements in attitudes towards IPP participation. Therefore, the purpose of this study was to determine if an intervention based on the HBM could improve attitudes towards IPPs within club sport participants. **Methods:** This study utilized a repeated-measures design in a field setting. Twenty-six club sports participants volunteered to participate in this study (M/F = 12/14; Age = 19.88 ± 1.88 years; Height = 172.42 ± 10.25 cm; Mass = 77.18 ± 13.66 kg). The participants completed the Health Belief Model Scale (HBMS) to assess attitudes towards IPPs on three occasions (Pre-Measure, Post-Measure, Follow-up). The HBMS contains 9 subscales (susceptibility, consequences, fear of injury, benefits, barriers, community led self-efficacy, individual self-efficacy, general health cues, external health cues) and has demonstrated acceptable internal consistencies (0.80-0.95). Positive scores on all of the subscales except barriers were associated with an increased likelihood of participation in an IPP. Following the pre-measure collection, the participants completed the intervention consisting of 1) educational

information on the risk of sustaining a lower extremity injury, negative consequences of sustaining a lower extremity injury, benefits of IPPs, barriers of IPPs and strategies to overcome those barriers, 2) feedback on a lower extremity injury screening risk session serving as a cue to action, and 3) demonstration and participation in the 11+ IPP. Participants continued to complete the 11+ IPP over a 6-week period and compliance was monitored. The HBMS was administered 2 weeks and 6 weeks after the intervention to investigate changes in attitudes. Total scores and associated means and standard deviations were calculated for each subscale of the HBMS and separate repeated measures ANOVAs were used to examine changes in attitudes over time. Alpha was set at $P < 0.05$ for all analyses. Partial eta squared was used to determine the magnitude of change and was interpreted as small ($0.06 > \eta^2 \geq 0.01$), moderate ($0.14 > \eta^2 \geq 0.07$), or large ($\eta^2 \geq 0.15$). **Results:** Significant improvements with large effect sizes were detected in the individual self-efficacy subscale from pre-test (0.73 ± 4.48) to post-test (2.93 ± 4.30 ; $P = 0.05$; $\eta^2 = 0.18$) and pre-test to follow-up (3.20 ± 3.49 ; $P = 0.04$; $\eta^2 = 0.20$). Similar improvements were also identified in the community led self-efficacy subscale from pre-test (4.40 ± 2.75) to post-test (6.07 ± 3.43 ; $P = 0.02$; $\eta^2 = 0.24$) and pre-test to follow-up (7.07 ± 2.05 ; $P = 0.001$; $\eta^2 = 0.44$). No other significant changes in HBMS subscales were identified ($P > 0.05$). **Conclusions:** The intervention based on the HBM led to improvements in individual and community led self-efficacy indicating an enhancement in the participants' confidence in their ability to participate in an IPP. Future research should investigate the effectiveness of individualized interventions to improve attitudes towards and adherence to IPPs.

Exposure to Movement Challenges is Not Adequate to Ensure the Development of High-Quality Movement Patterns

Peck KY, Houston MN, Miraldi SFP, Eckard TG, DiStefano LJ, Padua DA, Marshall SW, Cameron KL: Keller Army Community Hospital, United States Military Academy, West Point, NY; University of North Carolina, Chapel Hill, NC; University of Connecticut, Storrs, CT

Context: The Landing Error Scoring System (LESS) has been shown to identify athletes with poor movement quality which puts them at risk for lower extremity injury. Injury prevention programs have been created with the goal of improving movement quality and reducing injury rates. Understanding what factors contribute to the attainment of high-quality movement patterns may inform strategies for developing and enhancing these programs. The purpose of this study was to determine if there are more organic experiences, outside of injury prevention programs, occurring throughout the development of young athletes that cause them to adopt high-quality movement patterns as measured by the LESS. **Methods:** Subjects were 1801 (428 females) cadets (height = 175.91 ± 8.71 cm, mass = 75.46 ± 13.32 kg, BMI = 24.26 ± 3.05) enrolled in a prospective cohort study at a United States Service Academy. Upon entry into the academy, participants completed the LESS and a baseline questionnaire. The questionnaire asked about their activity level and previous experiences in physical fitness, sports, conditioning programs, and injury prevention programs. Specifically, participants were asked to complete the Marx Activity Rating Scale (MARS) and the 3-Point Sport Specialization Classification. Data were also collected on sport participation at the academy, sex, height, and weight. Height

and weight were used to calculate body mass index (BMI). A backward multiple linear regression model was used with LESS score as the outcome variable. Predictor variables included sex, BMI, plyometric training participation (yes=496, no=1,303), injury prevention program participation (yes=71, no=1,725), the MARS, the 3-Point Sport Specialization Classification, and current sport level (intercollegiate=713, intramural=1,088). All selected predictor variables were either associated with LESS scores in previous studies or theorized to contribute to higher quality movement patterns. Alpha was set a priori at $p < 0.05$. **Results:** Sex ($p < 0.001$) and participation in an injury prevention program ($p = 0.016$) were the only significant predictors of LESS Score ($R^2 = 0.023$). On average, females had LESS scores 0.67 (95%CI: 0.45, 0.89) points worse than males; cadets who had participated in an injury prevention program had LESS scores 0.61 (95%CI: 0.11, 1.10) points better than those who did not. All other predictor variables were eliminated from the final model ($p > 0.05$). Results were similar for models utilizing p-value cutoff values of 0.15 and 0.25, though sport level was retained in the former with intercollegiate athletes scoring 0.18 (95%CI: 0.01, 0.38) points better on the LESS ($p = 0.064$). **Conclusions:** These results suggest that experiences previously thought to contribute to the development of high-quality movement patterns do not appear to be associated with better LESS scores. Further research is needed to determine what foundational experiences are important for cultivating high-quality movement patterns in young developing athletes.

Ankle Sprain Prevention in Football Players Using Hip Strengthening and Balance Training: A Numbers Needed to Treat Analysis

Gribble PA, Kosik KB, Amponsah G, Griskowitz E, Koesling D, Madaleno J, McCann RS, McMurtrie J, Terada M: University of Kentucky, Lexington, KY; University of Louisville, Louisville, KY; Old Dominion University, Norfolk, VA; James Madison University, Harrisonburg, VA; Ritsumeikan University, Shiga, Japan

Context: Because ankle sprains are the most common injury reported in football, it is important to implement effective prevention strategies. Previous investigation in high school football athletes has shown the utility of balance training protocols to reduce ankle sprain rate. Reduced hip strength has been suggested as a risk factor for ankle sprains, but hip strengthening has had little implementation as part of a preventative protocol, particularly in football athletes. Therefore, the purpose of this study was to determine the effectiveness of an ankle sprain prevention protocol focused on balance training and hip strengthening among collegiate football athletes. **Methods:** Using a cohort design, Division I collegiate male football players ($n = 519$) cleared for full participation volunteered. Players were on teams pre-selected to participate in an exercise based Prevention program ($n = 292$) or serve as a Control group ($n = 227$). Players on designated teams in the Prevention group performed supervised 10-minute sessions 3 times/week for 8 weeks prior to the competitive season that emphasized static postural control and hip strength using elastic resistive bands. The players on the teams in the Control group did no prevention exercises prior to the season. All players in the study received prophylactic ankle supports for practice and games. As part of a larger study,

certified athletic trainers collected player demographic information and recorded time-loss injuries (absence from at least one game or practice) to the ankle or knee during team practice or games in the fall competition season. Knee injuries or other foot injuries ($n = 23$) were eliminated from this analysis, allowing an exploration of the distribution of players that did or did not sustain a time loss ankle sprain in the Prevention ($n = 287$; Age = 19.85 ± 1.33 yrs; Height = 188.42 ± 6.65 cm; Mass = 107.14 ± 23.21 kg) and Control ($n = 209$; Age = 19.74 ± 1.34 yrs; Height = 186.61 ± 7.04 cm; Mass = 103.57 ± 18.82 kg) groups. Using a 2x2 contingency table of this distribution, Relative Risk Reduction (RRR), Absolute Risk Reduction (ARR), and Numbers Needed to Treat (NNT) were calculated to evaluate the potential success of the Prevention program at reducing ankle sprains. **Results:** The Control group presented with a 9.1% ankle sprain event rate ($n = 19$) and the Prevention group presented with 6.9% ankle sprain event rate ($n = 20$). These distributions yielded a RRR=24.2%, ARR=2.2%, and NNT=45.45. **Conclusions:** A low dosage ankle sprain prevention program focused on hip strengthening and balance training was associated with a >2% decrease in ankle sprain rate compared to the Control group. The NNT suggests that in a typical Division I football roster of approximately 90 players, the prescribed prevention protocol could be successful at reducing injury occurrences by 2 ankle sprains/team. Continued work is needed to determine if a larger dosage of Prevention before the season and/or regular maintenance of the Prevention program during the season would be more effective.

Exploring the Relationship Between Weight-Bearing Dorsiflexion and Lower Extremity Injury Rates in Collegiate Football Athletes: A Clinical Case Series

Gordon JR, Dolan KE, Hummel C, McKeon PO: Ithaca College, Ithaca, NY

Background: A 2 cm asymmetry in the weight bearing lunge test (WBLT) has been considered an appropriate cutoff score for identifying athletes with a pathological weight-bearing dorsiflexion (DFROM) asymmetry. It remains unclear whether this cutoff score of asymmetry is actually clinically meaningful. **Patient:** Sixty-eight collegiate football players aged 18-22 were examined using the WBLT at the beginning of the 2018 season to determine whether weight-bearing DFROM asymmetries were related to lower extremity injury rates from the previous season. **Intervention or Treatment:** To measure the WBLT, the athletes were instructed to touch their knee to the wall in front of them, while keeping their heel on the ground. The athlete's foot was moved further away from the wall with every successful trial until they could no longer perform the test correctly. The location of the last distance before heel lift off was recorded as the athlete's final WBLT measurement. The final WBLT was measured to the closest 0.5 cm. All recorded lower extremity injuries from the previous year beginning in August of 2017 during preseason until the start of the next preseason in August of 2018 were reviewed. Lower extremity injury was defined as any orthopedic pathology sustained to the foot, ankle, lower leg, knee, thigh, or hip that was reported to the athletic training staff. Lower extremity injury history data falling within the accepted timeframe of this study was obtained via the electronic record keeping system, SportsWare, managed by the head athletic trainer of the football team. The WBLT measurements from athletes who did and did not sustain lower extremity injuries

from the previous year were examined to determine if a relationship existed between these variables. **Outcomes or Other Comparisons:** Forty-four out of 68 (65%) of athletes sustained lower extremity injuries in the previous season. Of the forty-four injured athletes, 13 (30%) demonstrated an asymmetry ≥ 2 cm. The most common lower extremity injuries associated with ≥ 2 cm WBLT asymmetry involved the ankle and knee joints; there were 18 ankle injuries (41%) and 17 knee injuries (39%). Of the 35 ankle and knee injuries, 12 (34%) had a ≥ 2 cm WBLT asymmetry. In the uninjured group, 8 of the 24 athletes who did not sustain an injury during the previous season (33%) also presented with a WBLT asymmetry ≥ 2 cm. **Conclusions:** There was an equal trend of asymmetry in the injured and uninjured groups. Previous history of injury could not be used as an explanatory factor for WBLT asymmetries in these athletes. The proportion of athletes with WBLT asymmetries ≥ 2 cm were similar in both the injured and uninjured groups. **Clinical Bottom Line:** Based on the trends uncovered in this clinical case series, previous history of lower extremity injury does not explain WBLT asymmetries in collegiate football players. However, these asymmetries may be explored prospectively as baseline measurements into the future season to accurately assess an outcome if a new injury is sustained and rehabilitation is initiated. It currently remains unknown whether there may be a trend that football players with a WBLT asymmetry greater than 2 cm have increased risk of sustaining a lower extremity injury during the season. Due to the high intensity and physical nature of football, the ankle and knee are commonly injured, possibly contributing to the increase in prevalence of these injuries in this case series. Further research needs to be conducted to establish a prospective, causative relationship between site of injury and weight-bearing dorsiflexion asymmetry.

Exploring the Effects of Limb Dominance and Injury History on Weight-Bearing Dorsiflexion Asymmetry: A Clinical Case Series.

Dolan KE, Gordon JR, Hummel C, McKeon PO: Ithaca College, Ithaca, NY

Background: Mounting evidence suggests that weight-bearing dorsiflexion asymmetries are associated with increased risk of suffering a lower extremity injury. The purpose of this case series was to establish the normally-occurring weight-bearing dorsiflexion asymmetry in collegiate football players through the use of the Weight Bearing Lunge Test (WBLT), in order to determine whether weight-bearing dorsiflexion is an important outcome measure for athletic trainers to utilize in clinical practice. **Patient:** Sixty-seven Division III collegiate football players, aged 18-22, were evaluated for weight-bearing dorsiflexion asymmetry during off-season spring training. **Intervention or Treatment:** Leg dominance, defined as the preferred kicking leg, and lower extremity injury history were collected. All athletes were assessed with the WBLT using the knee to wall principle to the nearest 0.5cm. To perform this test, athletes were given the goal of touching the wall with their knee while keeping their heel in contact with the floor. If the athlete was successful in keeping heel and knee in contact with the respective surfaces, the test leg was moved away from the wall. The final WBLT was collected as the last measured trial before the heel came off the ground and recorded to the nearest 0.5 cm. To evaluate trends in weight-bearing dorsiflexion asymmetry, athletes were stratified into four groups: 1) those with no history of lower extremity injury, 2) those with a bilateral history of injury, 3) those with a history on the dominant leg, and 4) those with history on the non-dominant leg. Asymmetry was defined as the difference between dominant and non-dominant limbs. Positive asymmetry values indicated more dorsiflexion on the dominant limb whereas negative values corresponded to greater dorsiflexion on the non-dominant limb. **Outcomes or Other Comparisons:** To compare the outcomes

across groups, the mean asymmetry with a corresponding 95% confidence interval (CI95%) was calculated for each group. All asymmetry values are reported as the mean asymmetry \pm CI95%. Athletes with no previous history of lower extremity injury (55% of the whole) demonstrated an average dorsiflexion asymmetry of 0.4 ± 3.06 cm. Athletes with bilateral injury history (15% of the whole) demonstrated an average asymmetry of 0.7 ± 3.34 cm. Athletes with previous history of injury on the non-dominant side (17% of the whole) had an average asymmetry of 0.8 ± 3.14 cm. Athletes with dominant sided previous history of injury, (13% of the whole) had an asymmetry of -0.1 ± 1.37 cm. The CI95% of all groups overlapped, which indicated no potentially meaningful differences among the groups. **Conclusions:** Lower extremity injury history and limb dominance did not appear to be explanatory factors for weight-bearing dorsiflexion asymmetry in collegiate football players. The wide CI95% across each of the groups indicated that there was high variation in asymmetry. In 3 of the 4 groups, there was a systematic bias of the dominant side having greater asymmetry than the non-dominant, except for the dominant sided injured group. Future exploration of dorsiflexion asymmetry should center on evaluating the relationship between a baseline asymmetry score and future injury risk, prospectively. **Clinical Bottom Line:** There was not a definitive relationship among lower extremity injury history, limb dominance and weight-bearing dorsiflexion asymmetry when measured by the WBLT at the start of a collegiate football season. These factors did not help identify individuals with a pathological weight-bearing dorsiflexion asymmetry. The information from this case series can be helpful for athletic trainers in using the WBLT as an outcome measure with collegiate football players, with normally-occurring asymmetry ranging up to 3 cm. There is a need to prospectively explore the effects of lower extremity injury and rehabilitation on weight-bearing dorsiflexion in collegiate football players.

Relationship Between Dorsiflexion Asymmetries and Lower Extremity Injuries in Collegiate Women's Lacrosse Players: A Clinical CASE Series

Kleinberg J, Cosby A, Albrecht J, McKeon PO, Hummel C: Ithaca College, Ithaca, NY

Background: Reduced weight-bearing dorsiflexion is a modifiable risk factor that can contribute to sustaining lower extremity injury such as ankle sprain, ACL sprain, plantar fasciitis, patellofemoral pain syndrome, and tendinopathy. The weight bearing lunge test (WBLT) is a functional test that measures the amount of weight-bearing dorsiflexion a person has. Healthy adults have been found to have side-to-side asymmetries in weight-bearing dorsiflexion of up to 1.5 cm. However, it has also been found that any asymmetry exceeding 2 cm is considered to be potentially indicative of pathological impairments. Identifying dorsiflexion asymmetries can help clinicians in the prevention and treatment of injury.

Patient: All members of a Division III NCAA Collegiate Women's Lacrosse team were screened for injury history at the start of their season. If they had any history of ankle injury, they were asked to indicate which side was affected. All athletes were also assessed on the WBLT in accordance to the knee-to-wall principle. Athletes faced a wall and placed the test limb in line with a tape measure that was perpendicular to the wall. Their test foot was then moved away from the wall as far as possible to allow the knee to touch the wall without lifting the heel. The WBLT was performed on both legs of all athletes and the maximum distance from the wall for each ankle was recorded. To examine potential WBLT asymmetries, the absolute difference between the right and left WBLT values was calculated.

Intervention or Treatment: In order to explore the potential clinical meaningfulness of WBLT asymmetries, athletes were separated into two groups: those who sought athletic training services for lower body injuries since the WBLT assessment during the season, and those who did

not. **Outcomes or Other Comparisons:** During the competitive lacrosse season, 16 of the 29 athletes sought care from the athletic trainers for lower body injuries. The injuries reported included low back pain, ankle sprain/strain, plantar fasciitis, and medial tibial stress syndrome. When examining the dorsiflexion asymmetry values from those athletes who reported to the athletic trainers (WBLT Asymmetry: 1.6 ± 1.0 cm) compared to those who have not complained of injury (0.8 ± 0.6 cm), there was a higher level of asymmetry in those who sought out care. In order to assess the magnitude of this asymmetry, we calculated a Hedges' g effect size (ES) with a 95% confidence interval (CI) between the asymmetry differences reported above. This analysis revealed an ES of 0.9 with a 95% CI ranging from 0.2 to 1.7, suggesting a potentially meaningful difference between groups. **Conclusions:** WBLT outcome measures taken at the start of the season in combination with the information about those who sought out athletic training services during the season for LE injuries revealed a trend for larger weight-bearing dorsiflexion asymmetries in the injured group. Of the 16 injured athletes, 63% (10/16) had weight-bearing dorsiflexion asymmetries equal to or greater than 1.5 cm. Only 15% (2/13) of those who did not seek out care had this level of asymmetry. This finding supports current literature that links weight-bearing dorsiflexion asymmetries with lower body injury risk. **Clinical Bottom Line:** The results of our clinical CASE series support the findings of previously published literature. Our findings suggest there is a meaningful difference in the magnitude of dorsiflexion asymmetries in women's lacrosse players who sustained lower extremity injury compared to those who did not. The WBLT appears to be a good clinical tool to identify athletes with dorsiflexion asymmetries who may be at greater risk of injury. By tracking injury trends in combination with sensitive outcome measures such as the WBLT, it may be possible to reduce injury risk.

Free Communications, Poster Presentations: Movement and Outcomes After ACL

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday,

June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;

Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Influence of Graft Type on Lower Extremity Functional Test Performance After Anterior Cruciate Ligament Reconstruction

Houston MN, Peck KY, Roach SP, Goss DL, Posner MA, Haley CA, Svoboda SJ, Cameron KL: Keller Army Community Hospital, United States Military Academy, West Point, NY

Context: Injury to the Anterior Cruciate Ligament (ACL) is a common cause of knee instability. To restore knee stability and function and facilitate return-to-activity, patients typically undergo ACL reconstruction (ACLR). Both autografts and allografts are used to reconstruct the ACL; however, it is unclear whether graft source affects lower extremity (LE) functional test performance post-ACLR. Additionally, we do not know how ACLR patients perform on these types of tests compared to healthy populations. Therefore, the aim of this study was to compare LE functional test performance between ACLR graft types and to determine the magnitude of difference between normative samples and ACLR patients on these tests. **Methods:** A cross-sectional

design was used to compare functional test performance following ACLR by graft type. Seventy cadets (21 females) entering a US Service Academy with a history of unilateral ACLR agreed to participate. Prior to basic training, participants completed the Balance Error Scoring System (BESS), Landing Error Scoring System (LESS), Lower Quarter Y-Balance Test (LQYBT), and Single Leg Hop Test (SLHT). Separate Kruskal-Wallis tests were used to compare all outcomes by graft type (bone-patellar tendon-bone (BTB) autograft, hamstring autograft, allograft) ($p<0.05$). If significant, Mann-Whitney U-tests were performed to determine where differences occurred with an adjusted p-value ($p<0.017$). Cohen's D effect sizes (ES) were calculated to compare normative values reported in the literature to the ACLR patients in the current study. ES were interpreted as small (>0.2), medium (>0.5), and large (>0.8). Descriptive statistics were calculated as mean \pm standard deviation. **Results:** No differences in demographic characteristics or time since injury (26.5 \pm 16.5mos) or surgery (24.4 \pm 15.4mos) were observed between graft types. Furthermore, no differences were detected for BESS, LESS, or LQYBT scores by graft type. For the

SLHT, the allograft group demonstrated significant deficits in comparison to the BTB (dominant $p=0.008$, non-dominant $p=0.014$) and hamstring (dominant: $p<0.001$, non-dominant: $p<0.001$) groups; however, no differences were detected between the BTB or hamstring (dominant: $p=0.145$, non-dominant: $p=0.101$) groups. Table 1 includes descriptive statistics for each test by group and collectively, Kruskal-Wallis p-values, and ES for the normative value comparisons. A large magnitude of difference was identified between the ACLR group and normative values for the BESS and SLHT. **Conclusions:** Following ACLR, patients with allografts appear to display deficits on the SLHT compared to autograft patients. Although graft type did not appear to influence other LE functional tests, a small effect was observed between the normative values and the ACLR patients for the LESS and large effects for the BESS and SLHT. With many of these tests associated with increased LE injury risk, these gaps between the healthy populations and the ACLR patients who have returned-to-activity are concerning. Thus, individuals with an ACLR may require additional rehabilitation to prevent injury.

Table 1. Comparison of Lower Extremity Functional Test Performance by Graft Type

	n	BTB (n=32)	Hamstring (n=25)	Allograft (n=11)	p-value	ACLR Groups Combined	Normative Values	Cohen's D
BESS	68	26.19 \pm 11.13	26.04 \pm 9.31	24.91 \pm 6.86	0.973	25.93 \pm 9.77	12.57 \pm 6.06 ^a	1.64
LESS	56	4.37 \pm 2.19	4.29 \pm 1.57	3.40 \pm 0.89	0.631	4.25 \pm 1.85	4.92 \pm 1.67 ^b	0.38
LQYBT	67	95.40 \pm 8.11%	99.12 \pm 13.05%	94.14 \pm 9.64%	0.769	96.58 \pm 10.48%	96.9 \pm 8.6% ^c	0.03
SLHT-Dom	66	117.58 \pm 59.50%	142.34 \pm 52.30%	57.76 \pm 28.68%* [^]	0.001	117.89 \pm 59.53%	177.5 \pm 34.5% ^d	1.23
SLHT-Non-Dom	66	116.55 \pm 58.04%	143.41 \pm 53.28%	59.84 \pm 26.88%* [^]	0.001	118.13 \pm 58.93%	175.2 \pm 35.2% ^d	1.17

*Bone-patellar tendon-bone (BTB) and Allograft groups are significantly different ($p<0.017$)

[^]Hamstring and Allograft groups are significantly different ($p<0.017$)

^a Ozinga et al. 2018, *J Athl Train*

^b Padua et al. 2009, *Am J Sports Med*

^c Teyhen et al. 2014, *Mil Med*

^d Onate et al. 2018, *J Athl Train*

Synthetic Model Knee and Lachman Test Accuracy: The Role Years of Experience, Profession, and Given Integrity Fulfill

Brady MP, Gnacinski SL, Newman N, Melcher N: Drake University, Des Moines, IA

Context: Positive patient outcomes after an anterior cruciate ligament (ACL) injury begin with accurate assessment, commonly achieved using the Lachman test. Previous research indicates the Lachman test is the most accurate clinical assessment method for ACL integrity. A recently developed synthetic model knee (see figure 1) capable of mimicking intact, partially torn, and completely torn ACLs was validated using a motion capture system, and was ecologically validated and deemed an appropriate teaching tool for learning or mastering the Lachman test. The objective of this study was to determine if years of clinical experience, profession, and the given model ACL integrity were related to the frequency of Lachman test correct response. **Methods:** Applied cross-section study. Athletic training professional meetings, athletic training education classrooms, and orthopedic surgeons' offices. Five orthopedic surgeons, 30 certified athletic trainers, and 23 athletic training students were recruited for this study. Orthopedic surgeons were employed in orthopedic surgeons' offices. Certified athletic trainers were employed in collegiate or high school settings, physical therapy clinics, or orthopedic surgeons' offices. Athletic training students were enrolled in CAATE - Accredited bachelor's programs, were in the 2nd or 3rd year of their athletic training education program, and had successfully completed a lower body injury assessment course. To assess if years of clinical experience, profession, and given ACL integrity were related to participant correct responses, a Chi-square test of independence was conducted

for each variable. **Results:** Years of clinical experience and Lachman test correct responses were significantly related, Chi squared (4) = 9.924), $p=0.42$. Profession was independent of correct response rate, Chi squared (2) = (.779), $p=.677$. The given synthetic model knee integrity was significantly related to Lachman test correct responses, Chi squared (2) = (42.481), $p<.001$. **Conclusions:** In this study, years of experience was significantly related to correct and incorrect responses, profession of participants was independent of correct response, and the given ACL integrity was significantly related to correct and incorrect responses. Clinicians and students in this study were most accurate in detecting the intact ACL (75-76% correct), followed by the completely torn ACL (75-76% correct), and were least accurate in detecting the partially torn ACL (46% correct). Participants with less than 5 years of experience and athletic training students had fewer correct responses (60.0-63.5% correct), regardless of synthetic model knee integrity, than participants with more than 5 years of experience (70.0-90.0% correct). This study provides secondary support for the use of synthetic model knees in clinical educational settings, specifically for the purpose of learning the Lachman test. Results of this study also indicate the importance of repetitive experience with the Lachman test to improve diagnostic accuracy, thereby supporting the need for synthetic model knees in clinical educational programs.

Quadriceps Strength is Greater in Individuals With Greater Single Limb Squat Depth at Time of Return to Sport Following ACL Reconstruction

Hoffman EH, Garrison JC, Goto S, Hannon JP, Bothwell J, Bush CA: Texas Health Sports Medicine, Fort Worth, TX; Fort Worth Orthopedics, Fort Worth, TX; Orthopedic Specialty Associates, Fort Worth, TX

Context: Quadriceps strength and single limb squat (SLS) function are often considered important variables for determining readiness for safe return to sport (RTS) following anterior cruciate ligament reconstruction (ACL-R). The International Knee Documentation Committee Subjective Knee Evaluation Form (IKDC) is a patient-reported measure of knee function. These variables are commonly used as components of RTS decision making following ACL-R. The aim of this study was to compare quadriceps strength and IKDC scores at time of RTS following ACL-R in individuals demonstrating "good" squat depth versus those demonstrating "poor" squat depth during a SLS. **Methods:** Cross-sectional study design within a health-system based outpatient sports medicine center. One-hundred twelve participants (age 16.0 ± 1.7 yrs., height 171.1 ± 10.2 cm, weight 71.3 ± 14.8 kg) were assessed for quadriceps strength, lower extremity biomechanical performance during a SLS, and self-reported function on the IKDC at time of RTS following ACL-R. Peak isokinetic quadriceps strength was measured at $60^\circ/\text{sec}$ on an isokinetic dynamometer, normalized to body weight (BW), and averaged across five trials. Peak knee flexion angle was assessed during the descent phase using an 8-camera infrared motion capture system while participants performed five consecutive SLS. Peak isokinetic quadriceps strength was assessed on the surgical and non-surgical limbs. Participants were divided into 2 groups based upon SLS depth of the surgical limb. "Good" squat depth (GSD)

was classified as greater than the median knee flexion angle of 72.4° while “poor” squat depth (PSD) was classified as anything < 72.4°. Descriptive data were used to determine the median SLS depth. Three independent t-tests were used to compare group (GSD and PSD) differences between the surgical and non-surgical limbs for quadriceps strength and IKDC scores. Alpha level was set at $p < 0.05$. **Results:** The average peak knee flexion angle on the surgical limb was 78.2±5.3° for the GSD group and 64.8±5.9° for the PSD group. The GSD group demonstrated significantly higher quadriceps strength (GSD = 1.6±0.4 BW) than the PSD group (PSD = 1.4±0.4 BW, $p = 0.012$) on the surgical limb. There were no significant quadriceps strength differences between groups on the non-surgical limb (GSD = 2.0±0.6 BW, PSD = 1.9±0.5 BW, $p = 0.218$). IKDC scores were not significantly different between the GSD (91.9±7.5) and PSD (90.5±7.9) groups ($p = 0.303$). **Conclusions:** Participants with GSD demonstrate greater quadriceps strength on the surgical limb than those with PSD. Although self-reported IKDC scores did not differ between groups, SLS performance may provide clinicians with insight into underlying quadriceps strength at time of RTS following ACL-R.

Effects of Anterior Cruciate Ligament Reconstruction on Patellofemoral Joint Stress and Lower Extremity Biomechanics at 12 Weeks Post-Surgery and at Time of Return to Sport in Adolescent Females

Goto S, Bothwell JM, Bush CA, Grondin AN, Hannon JP, Garrison JC: Texas Health Sports Medicine, Fort Worth, TX; Fort Worth Orthopedics, Fort Worth, TX; Orthopedic Specialty Associates, Fort Worth, TX

Context: Patellofemoral pain (PFP) is a common complication following anterior cruciate ligament reconstruction (ACL-R) and could develop into patellofemoral osteoarthritis. Although prevalent, the underlying mechanics is not well recognized. The purpose of this study was to examine kinematic and kinetic differences that are associated with PFP development between ACL-R limb and contralateral limb at 12-week post-surgery and at time of return to sports in adolescent females. **Methods:** Cohort study design was used in the clinical laboratory setting. Twenty-five adolescent females who completed 12 weeks post-operative (ACL-12wk) and return to sport assessments (ACL-RTS) participated in this study (Age=15.56 ± 1.16 yrs; Ht=164.70 ± 8.38 cm; Mass=65.24 ± 9.34 Kg). Eight three-dimensional cameras (120Hz) and two forceplates (1200Hz) collected kinematics and ground reaction forces, respectively while participants performed five consecutive single-leg squats at velocity of 60 beats per minute at each time point in order of uninvolved side (UnInv) and involved side (Inv). Data were low-pass filtered with cutoff frequency of 12Hz. Middle three squats were used for data analysis. Peak knee extension moment (KEM), peak hip adduction (HAD) angle, and patellofemoral joint stress at 45 degrees of knee flexion (PFJS-45) were calculated during the descent phase of single-leg squat.

Frontal plane knee impulse was also calculated by integrating area under the frontal plane knee moment curve during descent phase. All variables were averaged across three trials. Separate two (12wk vs RTS) by two (Inv vs UnInv) repeated measures of ANOVA were performed. With significant interaction, paired t-tests were performed ($\alpha \leq 0.05$). **Results:** For KEM, there was a significant interaction in KEM ($p < 0.001$). Post hoc test demonstrated that RTS-Inv was significantly less than RTS-UnInv ($p < 0.001$), 12wk-Inv was significantly less than 12wk-UnInv ($p < 0.001$), and RTS-Inv was significantly greater than 12wk-Inv ($p < 0.001$) (RTS-Inv = -0.080 ± 0.023, RTS-UnInv = -0.098 ± 0.026, 12wk-Inv = -0.069 ± 0.015, 12wk-UnInv = -0.104 ± 0.016). There were significant main effects of side for HAD angle ($p = 0.002$). Involved side was significantly greater than UnInv side (Inv=9.84 (SE 1.53) degree, UnInv=4.79 (SE 1.01) degree). There was also a main effect of time in PFJS-45. RTS was significantly greater than that of 12wk (12wk=4.84 (SE 0.28) MPa, RTS=5.42 (SE 0.33) MPa). No significant interaction or main effect were observed in frontal plane knee impulse ($p > 0.05$). **Conclusions:** The Inv limb demonstrated reduced KEM compared to the UnInv limb at each time point although Inv-KEM improved from 12wk to RTS. Additionally, Inv limb presented greater HAD angle compared to the UnInv limb over time. These variables have been associated with PFP development. A focus in increasing KEM while decreasing HAD angle during SLS throughout the course of rehabilitation for ACL may help to reduce development of PFP.

Sensory Reweighting in ACL Reconstructed Patients: Analysis of a Single Leg Triple Jump Proprioceptive Task

Grooms DR, Dattilo A, Simon JE, Yom J, Chaudhari AM, McNally MP, Onate JA: Ohio University, Athens, OH; Ohio State University, Columbus, OH

Context: The risk of anterior cruciate ligament (ACL) re-injury remains high when returning to sport despite advances in surgical reconstruction and rehabilitation. Sensorimotor deficits caused by neurological sensory reweighting for motor control after ACL injury may be an under-recognized factor contributing to re-injury risk. The objective of this study was to quantify sensory reweighting following ACL injury via a novel proprioceptive single leg triple jump task. **Methods:** This cohort study took place in a biomechanics research laboratory. Sixteen individuals who previously had an ACL reconstruction (8 males, 8 females; 25.5 ± 1.37 years, 1.70 ± 0.13 m, 75.6 ± 19.2 kg) were recruited for this study, however, one participant was unable to complete the single leg triple jump under all conditions and was excluded from analyses. Therefore, fifteen individuals were used for analysis (7 males, 8 females). Inclusion criteria were: 18 to 39 years old, underwent an ACL tendon graft reconstruction, and currently physically active. Participants completed a Tegner activity survey indicating their current levels of activity (Tegner score: 6.0 ± 1.5). The mean time interval after reconstruction was 23 ± 18 months. Single leg triple jump capability was measured using a Vicon Motion Capture system (Oxford, UK). All subjects performed a single leg triple jump on each leg with eyes open and blindfolded to assess the relative visual contribution to the task. Participants were instructed to jump as high as possible on a single leg three times in a row and attempting to land in the same initial footprint

(minimize excursion). Center of mass excursion was quantified from the start of the first jump till the final third jump landing. Paired samples t-tests were used to assess (1) the difference between sides for the change score of center of mass (CoM) excursion between full vision and blind vision for the sagittal plane, and (2) the difference between sides for the change score of CoM excursion between full vision and blind vision for the frontal plane. Alpha was set at 0.05 a priori. **Results:** The CoM frontal plane excursion change score from full vision to blind vision was significantly increased on the involved leg (left) (42.72 ± 42.40 cm; $p=.027$) relative to the uninvolved leg (right) (9.28 ± 24.72 cm). Participants did not show a difference in sagittal plane excursion on the involved leg (left) ($.58 \pm 18.90$ cm; $p=.463$) in comparison to the uninvolved leg (right) (-2.82 ± 17.50 cm). **Conclusions:** These data suggest the single leg triple jump may be beneficial in identifying sensorimotor deficits and sensory reweighting post ACLR for frontal plane full body control. This finding emphasizes the importance of rehabilitating the sensorimotor system to address potential functional deficits from injury.

Kinematic and Kinetic Differences During the Y Balance Test™ in ACL Reconstructed Individuals

Decker MN, Ruhde L, Trowbridge C, Ricard MD: University of Texas, Arlington, TX

Context: The Y Balance Test™ (YBT) is a reliable and valid assessment of dynamic balance used with ACL reconstructed individuals (ACLR) throughout rehabilitation and at return to sport assessment. At these time points, reduced YBT reach distances and composite scores have been identified in ACLR limbs. However, limited data exists for the associated kinematic and kinetic variables during YBT assessment, especially in ACLR individuals. The purpose of this study was to determine if ACLR individuals several years post reconstruction demonstrate distance or composite score differences, as well as kinematic and kinetic differences between their involved and uninvolved limbs during the YBT. **Methods:** A cross-sectional study design was used, and data was collected in a university biomechanics laboratory. Twelve recreationally active females ($n=7$) and males ($n=5$) (age= 24.7 ± 3.6 yrs, mass= 76.1 ± 12.3 kg, height= 168.7 ± 10.1 cm) volunteered. All participants had a previous history of a unilateral ACLR with an average time of 7 ± 3.1 years post reconstruction. Participants completed one testing session, in which they performed the YBT while being recorded using Vicon 3D motion analysis capture software and an AMTI force plate. Mean \pm SD of maximum reach distance (YMRD) and YBT composite scores (YCOMP) were calculated in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions for involved and uninvolved limbs. Kinematic and kinetic variables analyzed at YMRD for each reach direction were hip angle (HANG), hip moment (HMOM), knee angle (KANG), knee moment (KMOM), and minimum center of mass (mCOM). Paired samples t-tests were performed

to determine the mean differences between involved and uninvolved limbs. Alpha was set a priori at 0.05. **Results:** Significant differences were found for YMRD in the PL direction between the involved (86.8 ± 12.9 cm) and uninvolved (90.9 ± 10.7 cm) limbs ($p=0.01$). No significant differences were found for YMRD in the ANT and PM reach directions. YCOMP scores between the involved ($90.9 \pm 7.2\%$) and uninvolved limbs ($92.7 \pm 6.2\%$) were also significantly different ($p=0.05$). A significant difference ($p=0.02$) was found for HANG during the PL reach, with the involved limb demonstrating less flexion ($81.1 \pm 17.7^\circ$) than the uninvolved limb ($90.1 \pm 22.9^\circ$). No other significant differences were found for HANG, HMOM, KANG, KMOM, and mCOM in any of the YBT directions. **Conclusions:** Differences between YCOMP scores and PL YMRD demonstrate dynamic balance asymmetries of the involved limb in ACLR individuals several years after reconstruction. The decreased YMRD and HANG during the PL reach of the involved limb suggests that altered dynamic stability exists during a task that requires rotary stability. The involved limb also demonstrated decreased YCOMP scores, however the values for both limbs were below the accepted 94% mark, which may indicate a predisposition for re-injury or contralateral injury. Dynamic balance training should be emphasized in ACLR individuals several years post reconstruction in an effort to reduce injury risk and limit limb asymmetries.

Can Lower Extremity Assessment Protocol Be More Efficient to Detect Deficits After Anterior Cruciate Ligament Reconstruction?

Jun H, Jeon H, Cheo JH, Kim B, Lee SY: Dong-A University, Busan, South Korea; Yonsei University, Seoul, South Korea; Yonsei Institute of Sports Science and Exercise Medicine, Seoul, South Korea

Context: Lower Extremity Assessment Protocol (LEAP) is one of many different evaluating tools for deficits after the anterior cruciate ligament reconstruction (ACLR) and is consist of a set of 12 tests in strength, balance, landing posture, and functional task. Although this protocol has been used to provide comprehensive information for patient and clinicians, it is not clear whether this protocol includes redundant tests or not. We hypothesized that this protocol could be more efficient to assess deficit after the ACLR. The purposes of this study were 1) to examine a relationship between each battery of tests, and 2) to reduce many individual tests into a fewer number of dimensions.

Methods: This study is a descriptive design in a laboratory setting. A total of 15 subjects [12 males & 3 females (Age: 27.86 ± 4.1 yrs, Height: 172.56 ± 4.81 cm, Mass: 75.51 ± 13.03 kg, Tegner activity score: 5.73 ± 1.16 , IKDC: 61.46 ± 13.62 , Time from surgery: 27.1 ± 14.03) who had a history of ACL reconstruction participated in this study. Each subject performed both isokinetic and isometric knee flexion/extension using CON-TREX® (Physiomed AG, Schnaittach, Germany), postural control on AccuSway (AMTI, Boston, MA), drop and jumping using landing error scoring system (LESS), and four functional hopping on both involved and non-involved legs. The dependent variables include Isokinetic extension 90 degree/sec, Isokinetic flexion 90 degree/sec, Isokinetic extension 180 degree/sec, Isokinetic flexion 180 degree/sec, Isometric quad for 30 sec,

Isometric_hamstring for 30sec, single leg balance, functional single hop, functional triple hop, functional cross-over, functional 6m hop, and LESS. We performed factor analysis over all 12 individual tests for grouping similar variables into dimensions. Then, regression analysis was used to confirm which dimension is useful to predict the IKDC. **Results:** Factor analysis with varimax rotation resulted 12 different tests of the LEAP were categorized into 3 factors: 1) strength, 2) functional, and 3) balance and LESS. Regression analysis showed only balance_LESS was found to be significant predictors of IKDC ($b= .05$, $SE = .02$, $t(12) = 2.33$, $p = .04$). Also, functional task was eliminated by multicollinearity (Variance Inflation Factor= 18807.31, $p = .21$). **Conclusions:** Our result suggests that clinicians may consider utilizing one of the most powerful measurements in balance with LESS to assess deficits after the ACLR. However, further research requires more participants in order to confirm its validity for a specific standard. In addition, the regression equation can be performed over 12 measurements with a large sample size to examine which measurements can be eliminated.

Comparison of Drop Jumping in Individuals Following ACL Reconstruction With Quadriceps Tendon and Patellar Tendon Autografts

Hunnicuttl JL, Slone HS, Gregory CM, McLeod MM: Emory University, Atlanta, GA; Medical University of South Carolina, Charleston, SC; College of Charleston, Charleston, SC

Context: Altered biomechanics (e.g., ground reaction forces) during drop jumps have been demonstrated in individuals following ACL reconstruction (ACLR), however less is known regarding differences in graft types, particularly involving the quadriceps tendon (QT) autograft. The QT autograft is becoming increasingly popular, as it offers a unique soft-tissue option with larger and stronger anatomical area from which to harvest the graft. The purpose of this study is to compare vertical ground reaction forces (vGRFs) during a drop jump in individuals with QT versus bone-patellar tendon-bone (BPTB) autografts. The hypothesis was that individuals with QT autografts would demonstrate more symmetrical vGRFs during landing and push-off phases. **Methods:** This cohort study included 25 active individuals with a history of primary, unilateral ACLR with QT (n=14) or BPTB (n=11) autografts (24±8 years; 17 males; 10±5 mo. post-ACLR; Tegner Activity Level=7±2; IKDC=80±11). Following practice trials, participants completed three trials of drop jumping off a 20 cm box onto an instrumented treadmill with two separate embedded force plates. Participants were instructed to keep their hands on hips while they dropped off the box, landed with each foot on separate force plate, and then completed a maximal vertical jump. Kinetic data were collected at 1000 Hz. Peak vGRFs for each limb during landing phase of drop jump and push-off phase of rebound jump were normalized to body weight and averaged for analyses. Limb symmetry indices of vGRFs were expressed as a

percentage of the surgical limb over the nonsurgical limb. Given the small sample size, nonparametric Wilcoxon rank-sum tests were used to compare differences in limb symmetry indices (dependent variable) between QT and BPTB autograft groups (independent variable). **Results:** The QT and BPTB autograft groups were similar on demographic variables (age = 25.9 ± 9.8 vs. 20.7 ± 5.3 years, p = 0.297; mass = 83.2 ± 16.2 vs. 75.2 ± 13.9 kg, p = 0.208; BMI = 25.0 ± 4.5 vs. 23.8 ± 3.7 kg/m², p = 0.381; months since surgery = 10.8 ± 5.8 vs. 9.0 ± 4.8 months, p = 0.389). Contrary to the hypothesis, there were no significant differences between QT and BPTB autografts for limb symmetry (%) of vGRF during landing phase (78.8 ± 20.0 vs. 78.5 ± 22.5, p = 0.870) or push-off phase (89.3 ± 10.9 vs. 83.7 ± 12.7, p = 0.352). **Conclusions:** Individuals with QT autografts demonstrate similar limb symmetry in vGRFs during drop jumping compared to individuals with the more-standard BPTB autograft. Clinicians can feel more confident about outcomes following ACLR with QT autografts, but should note that deficits in vGRFs of the surgical limb were present in both autograft groups.

Demographic and Surgical Factors Influence Readiness for Sport During the First 2 Years After ACL Reconstruction

Kuenze C, Bell DR, Grindstaff TL, Lisee C, Birchmeier B, Triplett A, Pietrosimone B: Michigan State University, East Lansing, MI; University of Wisconsin, Madison, WI; Creighton University, Omaha, NE; University of North Carolina, Chapel Hill

Context: Psychological readiness for sport, including fear of re-injury and knee-related confidence, is known to influence the likelihood of return to sport among young individuals following ACL reconstruction (ACLR). It is not well understood how demographic (sex, age, and BMI) and surgical (graft source) factors contribute to psychological readiness for sport. Therefore, the purpose of this study was to evaluate the effect of demographic and surgical factors on psychological readiness for sport among individuals within two years of ACLR. **Methods:** Two hundred twelve participants (Sex = 72M/141F, Age = 19.4±3.3 years, time since surgery = 10.7±5.3 months) between the ages of 13 and 30 years old with a history of ACLR within the past 24 months (range = 5 to 24 months) were enrolled in this multi-site cross-sectional laboratory study. Participants were included if they had a history of ACLR (unilateral, bilateral, multiple) with or without meniscal procedure. Participants were excluded if they had undergone multiple ligament reconstruction (e.g., MCL, PCL) or articular cartilage procedure at the time of the most recent ACLR. Participants completed the ACL Return to Sport After Injury Scale (ACL-RSI) to assess psychological readiness for sport and the International Knee Documentation Committee subjective knee evaluation form (IKDC) to assess patient-reported knee function. Participants were categorized based on demographic (sex: M/F; age: <18 years old, ≥18 years old; BMI: <25.0, ≥25.0) and surgical (graft source: hamstring autograft, patellar

tendon autograft) information collected from each participant using a standardized health history form. ACL-RSI score was compared between demographic and surgical categories using separate ANCOVAs while controlling for age and time since surgery.

Results: Participants under 18 years of age (N= 53) reported significantly higher ACL-RSI scores (age<18 years = 74.7±19.7, age≥18 years= 62.5±23.5, p= 0.004) when compared to older participants. Participants with BMI less than 25.0 (N= 138) reported significantly higher ACL-RSI scores (BMI<25.0= 68.3±22.9, BMI≥25.0= 60.6±22.9, p= 0.03) when compared to individuals with BMI of 25.0 or greater. ACL-RSI score did not significantly differ between groups based on sex (male= 68.2±22.1, female= 64.2±23.7, p= 0.39) or ACLR graft source (hamstring autograft= 68.0±22.2, patellar tendon autograft= 61.1±24.4, p= 0.09). **Conclusions:** Time since surgery has been consistently described as a primary determinant of change in ACL-RSI score following ACLR. Based on our findings, it appears that demographic factors, independent of time since surgery, may also play a role in determining psychological readiness for sport after ACLR. The results of this investigation indicate that patient-specific demographic (older age and greater BMI) factors, but not surgical factors, may contribute to elevated risk for persistent psychological barriers to return to sport.

Quadriceps Strength and Plyometric Characteristics Predict Hop Performance after ACL Reconstruction

Birchmeier TB, Lisee C, Geers B, Kuenze C: Michigan State University, East Lansing

Context: Single-leg hop distance and limb symmetry are indicators of lower extremity function after ACL reconstruction (ACLR); however, current assessments do not account for the movement strategy used to complete the task. Quadriceps weakness is associated with poor outcomes following ACLR. Plyometric loading occurs during repetitive hopping tasks when individuals decelerate an eccentric load followed by a concentric contraction to generate movement. Difficulty completing successive hops, as in the triple hop task, may indicate a deficit in plyometric characteristics which would require specific intervention to overcome during rehabilitation. Therefore, the purpose of this study is to assess whether knee extension strength and plyometric characteristics during a single-leg landing task predict single-leg hop performance after ACLR. **Methods:** Fifty-two individuals (Sex = 35 females/17 males; age = 22.94 ± 50 years; BMI = 24.63 ± 3.91; months post-surgery = 37.6 ± 23.7) enrolled in this descriptive laboratory study. Inclusion criteria were: 18-24 years old; undergone ACLR; cleared for unrestricted physical activity. Participants attended two testing sessions 9.0±7.1 days apart. Session one consisted of single-leg drop vertical jump (DVJ) kinematics and kinetics assessed using a 10-camera motion capture system and an embedded forceplate. Data was used to calculate DVJ height, amortization time, and Reactive Strength Index (RSI). Amortization is the time to transition from eccentric loading to concentric contraction during plyometric loading. The RSI (jump height/ground contact time) quantifies plyometric performance. Three trials of the single hop (% leg length) and triple hop for distance (% leg length) were

also completed. In session two, participants completed two maximal voluntary isometric knee extension contractions (MVIC) during which peak knee extension torque (Nm*kg⁻¹), average rate of torque development (RTD; Nm*kg⁻¹*s⁻¹), rate of torque development 0-100ms after the initiation of the contraction (RTD100; Nm*kg⁻¹*s⁻¹), and rate of torque development 100-200ms (RTD200; Nm*kg⁻¹*s⁻¹) after the initiation of the contraction were assessed. Pearson's product-moment correlation coefficients were used to investigate relationships between knee extension strength, DVJ outcomes, and hop performance variables. To predict normalized single hop distance and normalized triple hop distance, separate multivariable linear regression models with forward entry were created using knee extension MVIC, RTD variables, and plyometric characteristics. Significantly correlated predictor variables were entered into models. Variation inflation factor analysis was used to assess multicollinearity. A priori alpha level was established at p<0.05. **Results:** Jump height, peak knee extension torque, and RTD200 predicted 60.9% of the variance in single hop distance (R²= 0.609, p<0.001). Peak knee extension torque, RSI, RTD200, and RTD100 predicted 61.8% of the variance in triple hop distance (R²= 0.618, p<0.001). **Conclusions:** The results indicate distance and limb symmetry are not the only metrics needed to be assessed during single-leg hop tasks. Three of four predictors of triple hop performance were dependent on rate of force production. Triple hop may provide information about the patient's ability to absorb and react to plyometric loading.

Joint Position Sense in ACL Reconstructed Patients Across Open and Closed Chain Tasks

Hall SR, Bodkin SG, Vela L, Hart JM: University of Virginia, Charlottesville, VA

Context: Proprioceptive deficits may in part contribute to poor outcomes following ACL reconstruction (ACLR). Prior studies have used non weight-bearing (NWB) tasks to evaluate proprioceptive deficits in patients with ACLR through measures of joint reposition sense (JPS). Weight bearing (WB) tasks may be a more functionally relevant method for identifying deficits in patients with ACLR. The purpose of this study was to compare JPS in WB and NWB conditions between patients with ACLR vs healthy controls and to determine associations between JPS and strength and patient reported outcomes.

Methods: A total of 16 individuals (8 ACLR: 22.98±2.77years, 167.6±7.1 cm, 71.0±13.1 kg, 71.0±13.1 months post-ACLR; 8 Healthy: 23.29±2.82 years, 172.2±6.0 cm, 66.7±14.2 kg) participated. We recorded isokinetic knee extension peak torque (90°/sec) and patient reported outcomes (KOOS). JPS was assessed by measuring subjects' error in reproducing standard joint angles (60°, 45°, and 30° of knee flexion) in WB and NWB conditions. During NWB conditions participants reproduced angles starting from fully flexed knee position (concentric contraction) and from a fully extended position (eccentric contraction) while seated in a chair. During WB conditions, patients reproduced joint angles during bilateral and unilateral squat eccentrically. We measured joint angles using an electrogoniometer on the reconstructed limb and matched control (non-dominant) limb in healthy controls. JPS was defined as the absolute error in joint angle when subjects perceived they had achieved the reference angle. Separate 2x2x3 ANOVAs were used for NWB: Group (ACLR, Healthy) by contraction mode (eccentric, concentric) by Position (30,45,60°), and WB: Group

by squat type (single limb, double limb) by Position. Post hoc comparisons were performed where appropriate. Pearson r correlations were used to determine associations among the variables. Alpha level was set at 5%. **Results:** There were no differences in any of the NWB measures of JPS between groups (P=.55). On average, patients with ACLR demonstrated worse JPS (6.74±1.9°) during WB compared to Healthy controls (4.29±1.8°, P=.022). A strong, negative correlation was observed between peak knee extensor torque and WB JPS (r=-.738, P=.037) for ACLR participants. A strong, negative correlation was observed between open chain JPS and KOOS symptoms (r=-.707, P=.05) for ACLR participants. A strong, negative correlation was observed between time since surgery and joint repositioning error within ACLR participants (r=-.833, P=.005) for ACLR participants. **Conclusions:** Proprioceptive deficits were observed in patients with ACLR during WB tasks but not during NWB tasks. Associations with strength, patient reported outcomes and time since surgery indicate potential for clinical relevance of measuring proprioception during WB tasks in patients recovering from ACLR.

Jump Landing Time to Stabilization After Return to Sport Following ACL Reconstruction

Hayes R, Onate JA, Simon JE, Jamison ST, Chaudhari AM, McNally MP, Yom J, Grooms DR: Ohio University, Athens, OH; Ohio State University, Columbus, OH; TrueMotion, Boston, MA; Tampa Bay Rays, St. Petersburg, FL

Context: Dynamic postural control may be altered in individuals with anterior cruciate ligament reconstruction (ACLR) even after return to sport. Time to Stability (TTS) is a measure of postural stabilization after landing from a jump and may provide improved insight into motor control deficits associated with injury. The purpose of this study was to determine if TTS is different in those who have ACLR and returned to sport relative to healthy controls. **Methods:** This study was a cohort study that enrolled 30 individuals. Fifteen ACLR (8 female, 21.7±2.7 years, 1.7±0.1m, 70.4±15.8kg, Tegner 7.2±1.3), and matched controls (8 female, 23.2±3.5 years, 1.7±0.1m, 68.7±14.3 kg, Tegner 6.8±1.5). Healthy controls were matched to ACLR participants based on age, weight, sex and activity level. Participants performed a unilateral anterior jump landing with each limb in a biomechanics laboratory. The participants were asked to jump, hit an overhead target with their hand, land on one leg, place their hands on their hips while trying to regain postural control as quickly as possible. A strain-gauge force platform (model 4060 NC; Bertec Inc, Columbus, OH) was used to calculate and document ground reaction forces. During the jump-landing procedures, a Vertec (Sports Imports, Columbus, OH) was utilized to estimate the vertical jumping heights. TTS was calculated over a 10-second landing window, starting with initial force plate contact. Paired samples t-tests were used to assess (1) TTS between the ACL group involved knee and matched control group knee

(based on limb dominance) and (2) TTS between the ACL group uninjured knee and matched control group knee (Bonferroni corrected alpha of $<.02$) To determine the influence of time from surgery on TTS we also completed a Pearson correlation on months from surgery date, relative to the time of testing and the four resultant TTS metrics with alpha set at 0.05 a priori. **Results:** The paired samples t-test demonstrated a slower TTS on the uninjured side for those with ACLR (3.48 ± 0.53 s), compared to matched control knees (2.95 ± 0.49 s, $p=.02$), with no difference for the injured side (ACLR: 3.06 ± 0.45 s, control: 3.09 ± 0.60 , $p=.87$). There was no correlation time from surgery (38.1 ± 27.2 months) and TTS ($r=.42$, $p=.12$). **Conclusions:** TTS can detect functional deficits in the “healthy” side after ACLR and return to play, potentially indicating contralateral changes due to the unilateral injury and/or recovery process. Alternately, the ACLR group may focus on stabilizing their injured knee quickly and not put as much effort into rapid stabilization of the uninjured knee as they consider it to be “healthy”. The decreased stability on the uninjured side indicates a need to ensure both restored injured side function and optimal uninjured side performance.

Relationship Between Hamstrings Strength Indices and Self-Reported Knee Function After ACL Reconstruction

Sherman DA, Kuenze C, Garrison CJ, Hannon J, Bothwell J, Bush CA, Ingersoll CD, Norte GE: The University of Toledo, Toledo, OH; Michigan State University, East Lansing, MI; Texas Health Sports Medicine, Fort Worth, TX

Context: Hamstrings muscle function is a drastically underrepresented variable in the context of recovery from anterior cruciate ligament reconstruction (ACLR). The first nine months of recovery is characterized, in part, by hamstrings weakness and high reinjury risk. Understanding the best metric of muscle function to predict normal self-reported knee function will be valuable to clinical rehabilitation in this critical period. Therefore, our purpose was to determine if there is a relationship between hamstrings strength and self-reported knee function in the first nine months after surgery and determine which metric best predicts normal function. **Methods:** The data from 256 patients with a history of primary, unilateral ACLR (131 female, age: 17.1 ± 3.3 years, height: 172.4 ± 12.2 cm, mass: 73.6 ± 17.6 kg, time from surgery: 3.9 ± 1.8 months) were used in this multi-site retrospective analysis. International Knee Documentation Committee (IKDC) Subjective Knee Evaluation scores and bilateral isokinetic quadriceps and hamstrings peak torque (PT) at $60^\circ/\text{second}$ were recorded. Hamstrings strength was evaluated using the involved limb (Nm/kg), hamstrings-to-quadriceps ratio (H:Q, %), and limb symmetry index (LSI, %). We operationally defined normal knee function as IKDC scores \geq the 15th percentile of the participant-specific age- and gender-matched population. Pearson’s r correlation coefficients were used to determine the relationship between hamstrings PT and IKDC. Receiver operating characteristic curve

analyses were used to identify cutoff values that maximized the ability of the selected hamstrings strength indices to discriminate between normal and abnormal knee function. The area under the curve (AUC), sensitivity, specificity, and odds ratios were calculated with 95% confidence intervals (CI). **Results:** Greater hamstrings PT was associated with higher IKDC scores ($r = 0.428$, $P < .001$). A PT value of 0.85 Nm/kg demonstrated fair discrimination in knee function (AUC: 0.72 [95% CI: 0.64-0.80], $P < 0.001$, sensitivity = 0.79, specificity = 0.58) and displayed 5.15 [95% CI: 2.25-11.30] times higher odds of reporting normal function. A H:Q ratio of 81.0% demonstrated poor discrimination in knee function (AUC: 0.60 [95% CI: 0.51-0.71], $P = 0.026$, sensitivity = 0.60, specificity = 0.55) and displayed 0.84 [95% CI: 0.39-1.82] times lower odds of reporting normal function. A LSI of 63.6% demonstrated poor discrimination in knee function (AUC: 0.60 [95% CI: 0.51-0.69], $P = 0.038$, sensitivity = 0.64, specificity = 0.55) and displayed 2.72 [95% CI: 0.80-9.27] times higher odds of reporting normal function. **Conclusions:** Greater hamstrings PT was associated with higher knee function, supporting the need to address this impairment during the early post-operative period after ACLR. Involved limb hamstrings PT was the best metric evaluated to discriminate normal self-reported knee function. Future research investigating which clinical metrics best predict optimal knee function after ACLR will guide evidence-based intervention research and clinical practice.

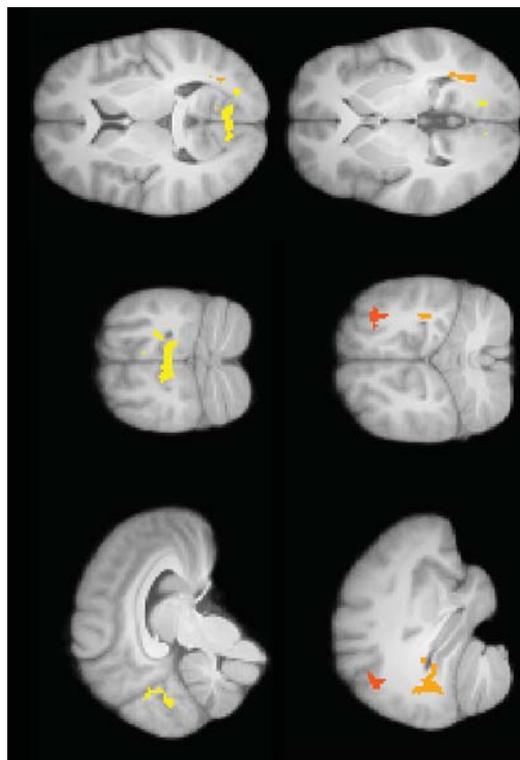
Neural Activity Differences for Combined Hip-Knee Motor Control in ACL Reconstructed Individuals

Criss CR, Onate JA, Grooms DR:
Ohio University, Athens, OH; Ohio State University, Columbus, OH

Context: The risk of anterior cruciate ligament (ACL) re-injury remains high when returning to sport despite advances in surgical reconstruction and rehabilitation. The high re-injury risk is in large part due to continued deficits in neuromuscular control that is potentially secondary to changes in neural activity, but limited evidence exists pertaining to the neural activity for multi-joint action after ACL injury. Thus, our purpose is to determine if differences in neural activity for combined hip-knee movement exists in ACL reconstructed (ACLR) individuals relative to matched healthy controls. **Methods:** Thirty individuals were enrolled in this cross-sectional neuroimaging laboratory study. Participants were matched on height, mass, extremity dominance, history, and current physical activity level. Fifteen left ACLR (23.7.6±3.20 years,

1.80±0.08 m, 83.0±19.8 kg, Tegner activity level 6.75 ± 2.0, 42±36 months post-surgery) and 15 matched healthy controls (24.6±2.08 years, 1.74±0.06 m, 80.5±12.55 kg, Tegner activity level 6.75 ± 2.0) participated. The functional neuroimaging data were collected on a 3T Siemens Magnetom scanner with a sixteen-channel head coil with ninety whole brain gradient-echo scans every 3 seconds with a slice thickness of 2.5 mm for 55 transversal slices. Before the functional run, an anatomical 3-D high-resolution T1 scan was taken for anatomical registration. The movement task was block designed consisting of four repeated 30-second cycles of unilateral left (involved) knee and hip extension/flexion while lying supine in the MRI scanner (similar to a heel slide movement). Brain activation patterns during movement were contrasted with an interspersed rest condition. An Independent Component Analysis – based strategy for Automatic Removal of Motion Artifacts (ICA-AROMA) was used to de-noise and reduce motion-induced signal variations within the data set. Results are reported as z-scores, indicative of the likelihood of activation, with higher being more likely and p-value

indicating the probability of finding activation when there was none. The two groups were compared with a general linear model second-level mixed-effects paired analysis a priori threshold at $z=3.1$ and alpha level of $<.05$ cluster corrected for multiple comparisons. **Results:** Participants with ACLR exhibited increased activation in three defined clusters (Figure): 1) the bilateral intracalcarine cortex and lingual gyrus ($z=6.73$, $p=.01$), 2) occipital fusiform gyrus, white matter optic radiation ($z=4.12$, $p=.01$), 3) lateral occipital cortex, angular gyrus, and the superior parietal lobule ($z=5.26$, $p=.04$) for hip-knee motor control relative to controls. **Conclusions:** Brain activation for combined knee and hip motion is altered in patients with ACLR. The ACLR brain activation profile may indicate increased attention, spatial cognition and orientation, and a visual-motor strategy to engage hip movement. Future sensorimotor targeted rehabilitation strategies should attempt to target this neural processes, specifically, clinicians may integrate multi-joint exercises with visual-motor dual-tasking to potentially rectifying the neuroplastic effects of injury.



Free Communications, Poster Presentations: Muscle Recovery

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;
Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Post-Exercise Cooling Modified Muscle Performance and Soreness Perception

Doeringer JR, Colas M, Khan IA:
Nova Southeastern University,
Fort Lauderdale, FL

Context: Context: It is a common trend for athletes to prophylactically use cold-water immersion (CWI) 24-hours before a game, in hopes of improving performance and after for preventing soreness. Objective: To assess the effects of pre- and post-cooling for exercise on muscle performance or pain perception. Design: Cross-Sectional. Setting: Research Laboratory. **Methods:** Patients or Other Participants: Ten males (20.40 ± 1.10 yrs, 180.34 ± 6.40 cm, 84.77 ± 8.47 kg) and 10 females (22.90 ± 2.66 yrs, 166.30 ± 8.10 cm, 63.50 ± 8.40 kg) enrolled in the study. Interventions: The subjects were pseudo-randomly assigned to a CWI or control group. The CWI group were immersed up to their iliac crest at roughly 10°C for 15 minutes. Muscle performance measures included flexibility, strength, power, agility, and speed for the lower extremity. The sit and reach test was used for muscle flexibility, the 1-RM Squat was used for strength, the Vertec Jumping System was used to assess power production, 5-10-5 pro-agility shuttle test was used for agility measurement, and 10m dash was used for measuring speed. All subjects performed the same HIIT protocol which consisted of five exercises, performed for 60 seconds each. The timeline for data collection included: 1) baseline measurements of dependent variables as well as administration of CWI for treatment group; 2) then 24-hours later involved repeating baseline measurements, performing a High Intensity Interval Training (HIIT) protocol, and receiving CWI; 3) the third session 48-hours after initial baseline testing involved repeating

all measurements. Main Outcome Measures: The independent variables were group (ice immersion vs. control) and time (Baseline, 24-hours, and 48-hours). The dependent variables were muscle performance measures and Pain Likert Scale. **Results:** Results: A 2 [group] x 3 [time] mixed design ANOVA with repeated factors with gender as a covariate revealed a significant interaction for group x time for strength [(CWI: Baseline (173.4 ± 90.48); 24-hours (181.1 ± 93.57); 48-hours (183.0 ± 92.78)]; [(Control: Baseline (186.1 ± 75.52); 24-hours (178.4 ± 70.69); 48-hours (174.5 ± 64.76)]; P=0.024), agility [(CWI: Baseline (6.25 ± 0.85); 24-hours (6.27 ± 0.81); 48-hours (6.17 ± 0.84)]; [(Control: Baseline (6.11 ± 0.54); 24-hours (6.15 ± 0.76); 48-hours (6.16 ± 0.70)]; P=0.04), and pain [(CWI: Baseline (1.0 ± 1.63); 24-hours (2.25 ± 1.18); 48-hours (3.35 ± 1.73)]; [(Control: Baseline (0.2 ± 0.63); 24-hours (2.7 ± 1.7); 48-hours (5.1 ± 1.68)]; P=0.019). A Post-Hoc Independent Sample T-test revealed significant differences at 24-hours for strength (P=0.001), 48-hours for agility (P=0.03), and 48-hours for pain (P=0.001). There were no significant difference in flexibility, power, and speed between the CWI and control groups. **Conclusions:** Conclusions: The use of pre-cooling demonstrated significant improvement in strength at 24-hours which was sustained at 48-hours. The combination of pre- and post-cooling prevented soreness and facilitated significant improvements for agility from 24-hours to 48-hours.

Muscle Soreness From Eccentric Exercise Does Not Modify Neural Excitability

Needle AR, Mackall JM, Merritt EK, van Werkhoven H:
Appalachian State University,
Boone, NC; Southwestern
University, Georgetown, TX

Context: Recent evidence has highlighted neurological changes occurring following ligamentous injury, believed to contribute to deleterious outcomes among patients. These neurological changes are often reported to be secondary to sensory aberrations related to acute injury (i.e. pain, swelling); however, the heterogeneous nature of ligamentous injury has made it difficult to directly understand the acute effects of injury on neural function. A more homogenous model of injury, such as muscle damage may allow for a better understanding the neural effects of acute injury. Therefore, we aimed to determine the effects of triceps surae muscle damage on cortical and reflexive excitability to the lower leg. **Methods:** Eight healthy, untrained individuals (22.4±2.7yrs, 82.6±19.8kg, 176.3±6.9cm) with no musculoskeletal injuries within 6 months, no surgeries to the legs, and no history of ligament injury volunteered for this study. Participants reported for 3 total testing sessions consisting of 4 measurement points: before muscle damage (Pre), immediately following damage (Post), 24-hours following damage (24), and 72-hours after damage (72). On the first day of testing, after initial measurements, participants were damaged through performing 10 sets of 10 eccentric contractions of the triceps surae, moving from 20 degrees plantarflexed to 10 degrees dorsiflexed at 10 degrees/second. At each time point, participants were assessed for reflexive excitability using the Hoffmann reflex (H-reflex), and cortical excitability

using transcranial magnetic stimulation (TMS) over the lower extremity representation of the motor cortex. Muscle activation was recorded from the tibialis anterior, lateral gastrocnemius, and soleus; and outcome measures included the H:M ratio (%Mmax) from H-reflex, motor evoked potential (MEP) size at 90, 110, and 130 percent of resting motor threshold, and cortical silent period (ms) from the soleus from TMS. A visual analog scale was used to describe pain (0-10 scale). Differences in variables were assessed across time-points, with muscle and/or stimulation intensity used as factors when appropriate, using analyses of variance ($\alpha=0.05$). **Results:** No time effects were present for the H:M ratio ($F=0.273$, $p=0.845$), MEP size ($F=0.546$, $p=0.656$), or cortical silent period ($F=2.080$, $p=0.139$). Similarly, no interaction effects were observed for muscle or stimulation intensity, when appropriate. This occurred despite a statistically significant increase in resting pain, that reflected greatest pain at 24 hours ($F = 4.280$, $p = 0.012$; Pre: 0.80 ± 0.65 ; Post: 1.34 ± 0.87 ; 24: 2.21 ± 1.44 ; 72: 1.20 ± 0.93). **Conclusions:** Our results suggest that, while eccentric exercise is able to elicit pain in the triceps surae group, this did not lead to changes in neural excitability. Muscle damage has previously been used to generate sensory aberrations within the central nervous system; however, it appears to not do so at a level consistent with what has been seen in patients with ligamentous injury.

Is the Lack of Finger Flexor Strength an Indicator of A2 or A4 Pulley Injury in Rock Climbers?

Iruetagoiena-Urbieta X, Rodríguez-López ES, Webster KA, De la Fuente-Ortiz de Zarate J, Romero-Pérez AG, Guodemar-Pérez J: Camilo José Cela University, Madrid, Spain; Boston University, Boston, MA; Clínica Pakea-Mutualia, San Sebastián, Spain

Context: A2 and A4 pulley ruptures are the most prevalent rock-climbing related injuries. Flexor digitorum profundus and superficialis strength measurement has been researched in the fields of physiology, performance and post-surgery, but never as a diagnostic tool in pulley injuries. The purpose of this study was to determine whether A2 or A4 pulley pathology causes finger flexor strength decrease and also to establish the relationship between such strength decrease and the tendon-bone distance of A2 or A4 ring finger pulley with diagnostic ultrasound measurements. **Methods:** A cross-sectional study was conducted in 58 flexor pulleys (A2 or A4) of the 4th digit of rock climbers; half of them were diagnosed pathologic and half were healthy. The tendon-bone distance of A2 or A4 4th digit pulley was measured using diagnostic ultrasound at 21MHz frequency. Additionally, flexor digitorum strength was measured in three types of climbing crimp grips (one finger, open and closed), comparing the pathological finger with the healthy finger. To determine ultrasonographic values, we utilized the most published measurement protocol, which compares the absolute value of tendon-bone distance to the relative value, which is based on comparing the tendon-bone distance of the injured pulley with the sound side. Statistical analysis was conducted using T test, Pearson correlation, and simple linear regression. **Results:** The fingers diagnosed with pulley pathology had significant strength decreases compared

to non-pathological fingers on the one finger crimp ($p<0.001$), and open crimp ($p=0.001$) grips. The tendon-bone ultrasonographic distance of the pulley was significantly correlated with one finger crimp strength decrease ($r=0.436$, $p=0.006$), while open and close crimp grips were not significantly correlated with ultrasonographic measurements ($p>0.05$). However, the strength decrease was only correlated with the absolute value and not with the relative one, even if the both type of values correlated between them ($r=0.428$, $p=0.007$). **Conclusions:** Finger flexor digitorum strength is significantly decreased in fingers with A2 and A4 pulley pathology. When evaluating A2 and A4 pulley rupture in rock climbers, finger flexion strength decrease using one finger crimp grip can assist in initial diagnosis, as it was significantly correlated to pulley pathology seen on diagnostic ultrasonography.

The Use of Blood Flow Restriction Treatment on a Patient With Weakness of the Vastus Medialis Oblique: A Clinical Case Study

Eiroa DC, Felton SD, Rodriguez R: Florida International University, Miami, FL; Florida Atlantic University, Boca Raton, FL

Background: This was a Level 3 case study focused on the treatment and impending recovery of a football patient that had undergone ACL reconstruction of his left knee that continued to present with chronic quadricep, specifically vastus medialis oblique weakness. Blood flow restriction therapy (BFR) is an emerging course of treatment used on postoperative patients to help develop muscle strength when persistent chronic quadriceps and hamstring weakness is apparent despite traditional conservative therapy methods. Recently research has suggested that the use of BFR with light training loads at 20-30% of the 1RM can produce significant gains in muscle strength and size. **Patient:** Athlete was a 24-year-old, football player with 17 years of experience. The patient had prior medical history of anterior cruciate ligament repair and a complete lateral meniscectomy of the left knee two years prior. General quadriceps weakness had been continued to be treated through exercise prescription since return to participation. Two years following, the athlete had not regained full strength and was still experiencing episodes of swelling and ongoing pain. Athlete has full AROM and PROM. Strength of the left quadriceps is rated at 4+/5 as compared bilateral. Neuro = normal and no other orthopedic problems noted except for the left quadriceps girth difference and strength production. **Intervention or Treatment:** Blood flow restriction treatment is usually applied to patients who are recently post-operative. It has been suggested the application of BFR assists in gaining muscle mass with the same effects of high-intensity exercises provides or doing a one rep max. Application procedure for the treatment requires the cuff to be applied to the patient onto the upper

quadriceps. Followed the restriction of blood is adjusted to 80%. The patient will then start with 1 set of 30 repetitions followed by 3 sets of 15, in between sets the patient takes 30 second break. The BFR was applied to this patient every two days a week along with the combination of exercises. On the other three days of rehabilitation, the patient was progressed to perform corrective exercises with the use of other modalities. The BFR was applied on alternative days. Following the week of rehabiliation, the patient had a recovery day, the use of massage, Graston, Hivamat, lymphedema pumps, and Game Ready. **Outcomes or Other Comparisons:** As a result of the application of BFR, the patient rated outcomes demonstrated that there was a decreased level in pain and discomfort in comparison to the previous traditional treatments applied on the athlete. Measures of swelling have decreased along with the patient's ability to participate in practice and competition. In addition, athlete's strength is now measured at 5/5 and no further complaints. **Conclusions:** The was a Level 3 exploration case with concentration on the successful use of blood flow restrictions on a division one offensive linemen who has a noticeable weaker left leg, specifically the vastus medialis oblique. Muscular atrophy is expected after a patient undergoes an invasive surgery much like the one presented in this case. Blood flow restriction therapy may be used on throughout the recovery and rehabilitation period. The course of treatment has been effective by allowing the athlete to fully participate in competition and practice. The athlete has also reported of having less pain and the patients girth measurements have improved. **Clinical Bottom Line:** The use of Blood flow restriction (BFR) therapy appears to enhance muscle mass and strength and should be considered by athletic trainers treating patients with chronic muscular weakness due to the reported low risk of adverse responses.

The Impact of a Post-Practice Recovery Lab in the Availability Rate of a Professional Soccer Club

Korte G, Richards SG, Liu K: University of Evansville, Evansville, IN; FC Dallas, Frisco, TX

Background: Implementation of an injury prevention program is important to keep injury rates low throughout a season. There are many existing injury prevention programs, however, there is limited evidence in passive recovery protocols. In this Level 2 CASE study, the availability rate of a professional soccer club was calculated from 2014-2018. Availability rate is defined as the average percent of players available to compete due to injury status. **Patient:** This case series consisted of a professional soccer club with a roster of 33 male athletes ranging 17 to 33 years old. The professional soccer club competitive season runs from March to December, depending on playoff standings. During each of the documented seasons from 2014-2018, all injuries were recorded. The most prevalent soft tissue injuries were hamstring strains, ankle sprains, and MCL sprains. **Intervention or Treatment:** This professional soccer club implemented a post-practice Recovery Lab to prevent soft tissue injuries at the beginning of the 2015 season. Everyday after training, athletes were required to participate in the Recovery Lab that consisted of three types of passive treatments. The first component is intermittent compression boots, which provide sequential compression in different chambers starting distally in the foot and moving proximally towards the hip. The pressure was set to modulate a pumping sensation to increase venous return of the lower extremities. The theory of intermittent compression is to increase the body's reabsorption rate of elements that cause muscle fatigue and soreness. Athletes were placed in the compression boots for 30 minutes with their legs elevated. The second component is working with a certified massage therapist. Utilizing Physmodo MAPS (Physmodo, Plano, TX), inefficiencies

within the athlete's mobility, activation, posture, and symmetry were identified as the athlete performs three body weight squats. With the limitations identified, the massage therapist would perform a deep tissue massage on the target muscles. Depending on the results of MAPS and subjective complaints, each massage would last between 10-20 minutes. After the massage, the athletic training staff would address individual treatment therapies as needed. Lastly, all athletes would sit in a cold tub immersion from the waist down for 10 minutes. Therefore, combining all three elements, each post-practice Recovery Lab would take about an hour. **Outcomes or other Comparisons:** To get the availability rate for each game, the total number of players was subtracted from the number of unavailable players due to injury and then divided by the total number of players. This gave the percentage of availability each game. The availability rate for the season was then calculated by adding the availability rate of each game and divided by the total number of games played that season. To be counted as unavailable, the athlete had to be injured and not available to dress for the match. In 2014, prior to the implementation of the Recovery Lab, the availability rate was at its lowest at 84.1%. When the Recovery Lab was implemented in 2015, availability rates started to increase. The availability rate was 85.5% in 2015, 92.9% in 2016, 95.2% in 2017, and 91.1% in 2018. **Conclusions:** Not all injuries are preventable, but athletic trainers are continuously searching for methods to decrease injuries. This study shows that a passive recovery protocol as a means of injury prevention increased the availability rates of athletes in a professional soccer club. While time and resources may be limited to many athletic trainers, a variation of a passive recovery protocol can be easily implemented at all levels. **Clinical Bottom Line:** A post-practice passive recovery injury prevention protocol can be useful in decreasing the number on injuries that limit athletes from participating in sport.

Free Communications, Poster Presentations: Non-Acute Upper Extremity Case Studies

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM;

Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Radiocapitellar Plica Syndrome: Non-Operative Treatment in an Adolescent Artistic Gymnast

Frank SM, Gubanich PJ: Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Background: The formation of synovial plicae, especially in the knee, has been well described in the literature. Less commonly, the plica can become inflamed and painful (knee plica syndrome) with a reported prevalence of 2.1% in adolescent female athletes. Plica syndrome can also occur at the elbow but is rare and easily misdiagnosed due to symptoms that mimic other common elbow injuries. There is no true consensus regarding the diagnosis and treatment of this pathology, but findings indicate that operative care outperforms conservative care. Evidence regarding best practice for elbow plica syndrome is extremely sparse in adolescent overhead athletes and absent in gymnasts. We present a Level 3 CASE Study on radiocapitellar plica syndrome.

Patient: A 16-year-old female gymnast presented to the sports medicine clinic with a three-week history of left posterior elbow pain. The patient reported no specific trauma, however her upper extremity biomechanics were recently altered due to a right wrist injury. Her main complaints were sharp pain, repetitive clicking, and an inability to fully extend the elbow. Upon examination, she presented with painful terminal elbow extension and initial radiographs were normal. MRI was obtained and revealed a prominent posterolateral synovial plica measuring up to 6 mm in length and 2 mm in thickness posteriorly. The patient was diagnosed with radiocapitellar plica syndrome.

Intervention or Treatment: Rest from gymnastics and formal physical therapy were initiated. The family was referred to an orthopaedic surgeon if conservative care failed. Symptoms persisted

for approximately four weeks, but upon initiation of an iontophoresis treatment regimen (1.5mL dexamethasone) twice-per-week, symptoms improved. After one month of iontophoresis and traditional rehabilitation, the patient reported being symptom-free. She made a full return to gymnastics approximately 11-weeks from initial visit. No reoccurrence of symptoms has been reported.

Outcomes or Other Comparisons:

The clinical findings of our patient were similar to other reported cases in the literature: pain over the radiocapitellar joint line, sharp pain with terminal extension, end range extension deficit, and painful snapping or locking. However, our patient's symptoms resolved with conservative care which contradicts research suggesting surgical resection is the preferred treatment, producing excellent outcomes of greater than 90%. Additionally, previous known cases of elbow plica syndrome in adolescents were resolved with surgical resection. To our knowledge, only one study examined overhead athletes (throwers and golfers) and none included gymnasts.

Conclusions: We present a case of radiocapitellar plica syndrome in an adolescent gymnast with full resolution of symptoms via conservative care. While plica syndrome is a known entity, the combination of our patient's age (16), affected joint (elbow), chosen sport (artistic gymnastics), and treatment plan (non-operative) is unique among the reported literature. Although uncommon, plica syndrome should be part of a complete differential diagnosis when faced with posterior elbow pain, clicking/snapping sensations, and pain upon full extension, especially in athletes who perform repetitive overhead tasks. Athletic trainers are in a unique position to recognize symptoms of elbow plica and make appropriate referrals. Health care professionals should be wary to label elbow pain as standard tendinitis; advanced evaluation may be necessary to

diagnose the true source of pain. Lastly, though the literature demonstrates successful treatment of symptomatic plica syndrome by surgical resection, this case suggests that a period of conservative care is warranted, especially in the adolescent population. **Clinical Bottom Line:** Plica syndrome should be considered as part of a thorough examination of new elbow pain. Despite indications that surgical intervention is more successful, this case offers fresh evidence to support the non-operative approach. Further research on radiocapitellar plica syndrome is needed in adolescent overhead athletes to determine best practice in this unique demographic.

Radiocapitellar Osteoarthritis in an Adolescent Following a Radial Neck Fracture

Montgomery AL, Leyrer A, Martin BM, Viola RW: The Steadman Clinic, Vail, CO; Steadman Philippon Research Institute, Vail, CO

Background: Displaced radial neck fractures have been reported to occur in 5-10% of pediatric elbow fractures. One complication that can occur is a malunion, which can result in poor elbow arthrokinematics. This may lead to radiocapitellar degenerative joint disease (DJD), which is a rare complication of an isolated radial neck fracture. Outcomes associated with these injuries commonly result in loss of forearm rotation, severely impacting an individual's ability to participate in athletics. This Level 3 CASE study aims to further investigate a unique occurrence in which a multi-sport adolescent developed radiocapitellar arthritis following the malunion of a radial neck fracture. **Patient:** A 14 year old multi-sport, female athlete injured her right elbow performing a back handspring on a trampoline. Initially, she was diagnosed with a radial neck fracture and treated conservatively in a cast for two weeks. Surgical intervention of a radial head transcapsular pinning occurred 6 weeks post-injury. Two years post-injury, the patient had continuous radial-sided pain and was evaluated by an athletic trainer in the orthopaedic setting. The patient had a chief complaint of pain and elbow stiffness that

had been worsening and restricting her ability to participate in sports. Upon physical exam, the patient presented with 140° elbow flexion, 65° pronation, 60° supination, and lacked 15° of elbow extension. The patient was tender to palpate over the medial and lateral epicondyles and radial head. The patient had instability with valgus stress and posterolateral rotatory instability. Strength assessment was equal compared bilaterally. Neurovascular exam was unremarkable. Plain radiographs (Figure 1.) revealed evidence of radial neck malunion and arthritic changes at the radiocapitellar joint. An MRI obtained at the time of evaluation reported a radial neck malunion and radiocapitellar DJD with capitellar cartilage thinning. Further evaluation by a physician confirmed a diagnosis of radiocapitellar DJD and radial neck malunion. **Intervention or Treatment:** The patient was not a candidate for osteochondral allograft repair because the capitellar cartilage was well preserved. The patient underwent a staged procedure including a diagnostic arthroscopy preceding a radial head excision and interosseous membrane reconstruction using semitendinosus tendon allograft. A radial head prosthesis was attempted; however, given the angulation of the radial neck malunion, the prosthesis could not be appropriated with the capitellum and was not used. The patient followed a splinting and physical therapy protocol for 4 months before being cleared to progressively return to full activity. **Outcomes or Other Comparisons:** The literature suggests that patients can develop significant physiological and functional

complications following surgery to correct fractures of the radial head or neck. An adolescent developing DJD is an unusual complication. Literature has described poor functional outcomes associated with a chronic radial neck angulation of >20°, comparable to the patient in this case. Patients with complications that impair function and cause pain are often treated with a radial head excision.³ In cases involving severe radial head fractures or complications associated with the radiocapitellar joint, patients may be treated with an implant arthroplasty.⁵ Radial head arthroplasty is not often seen in pediatric and adolescent patients. ADDIN CSL_CITATION {"citation-Items":[{"id":"ITEM-1","itemData":{"author":{"dropping-particle":"","family":"Kruppa, Christiane; Konighausse, Matthias; Schildhauer, Thomas A.; Dudda","given":"Marcel","non-dropping-particle":"","parse-names":false,"suffix":""}}, {"container-title":"Injury","id":"&-->"}]} **Conclusions:** This case illustrates how ROM, patient comfort, and elbow joint function can be impacted by malunion of the radial neck in an adolescent. Athletic trainers are increasingly serving the pediatric and adolescent populations. Adequate education, early differential diagnosis, and appropriate referral by the athletic trainer is critical to providing these young patients with the best possible outcomes. **Clinical Bottom Line:** Controversy remains regarding the management of radial neck fractures. The literature suggests adolescent patients presenting with minimally displaced radial neck fractures may require earlier surgical intervention to avoid complications.



Figure 1. Oblique view of the right elbow showing A) malunion, B) radial head impaction, C) proximal radioulnar joint arthritis, and D) radial neck impaction defect with loose body.

Musculocutaneous Nerve Injury in a Collegiate Baseball Pitcher

Vineyard AP, Gallucci A, Imbus S, Garrison JC, Conway JE: Baylor University, Waco, TX; Texas Health Sports Medicine, Fort Worth, TX

Background: A 23-year-old Division 1 NCAA collegiate baseball pitcher presented with vague anterior arm pain following a pre-season game. The athlete described the pain as an “intense stretch” of his right arm that occurred during his last pitch. Initial evaluation revealed tenderness over the right distal bicep. Range of motion assessments of the shoulder and elbow were within normal limits bilaterally. Diminished bicep strength was noted (4/5 with manual muscle break testing). All shoulder and elbow orthopedic tests to rule out various conditions including shoulder impingement, labral pathologies, and instability were unremarkable. A follow-up examination was performed the following day identifying marketable decreased sensation along the athlete’s right lateral antebrachial cutaneous nerve distribution. Therefore, an electromyography (EMG) test was conducted which confirmed a right upper and mid-brachial plexus stretch injury with primary involvement of the musculocutaneous nerve. **Differential Diagnosis:** Traction injury of the musculocutaneous nerve, second-degree strain of the bicep musculature, or thoracic outlet syndrome involvement. **Treatment:** The athlete was initially treated with an oral steroid and removed from all throwing activities. The athlete began a comprehensive rehabilitation program that emphasized strengthening the shoulder musculature in an effort to restore bicep musculature strength. However, exercises that caused excessive stress on the biceps such as eccentric focused contractions and exercises involving abduction and extension were avoided to minimize stretching of the musculocutaneous nerve. Additionally, exercises utilizing blood flow restriction (BFR) were introduced on the uninvolved side in an effort to reduce deficits in bicep musculature strength by enhancing hypertrophy factors seen with the use of BFR. This method utilized the idea of the cross-education theory which postulates that strength

training of the uninjured extremity results in bilateral strength increases likely through neural adaptation mechanisms specifically with eccentric contractions. A month later, a second EMG study revealed significant reduction of neuropathy findings. However, observed deficits in strength and atrophy of the right bicep musculature continued to be present. Therefore, the athlete was allowed to begin flat-ground throwing activities but was restricted from progressing to mound throwing until this deficit had improved. Rehabilitation continued and inclusion of BFR and progressive resistance exercise of the involved arm were added due to diminished neuropathy findings. The athlete was eventually progressed to mound throwing and returned to full activity three months following initial injury. **Uniqueness:** Literature regarding musculocutaneous nerve injuries amongst the athletic population is scarce, with only several clinical cases being reported amongst adult and adolescent baseball and softball pitchers. Available documented reports reveal vague initial pain patterns, lack of deficits in range of motion, manual muscle testing, and positive shoulder orthopedic exams with the increased observance of sensory and motor deficits usually occurring several days or weeks following initial injury evaluation. Overstretching of the musculocutaneous nerve may occur in the pitching motion at time of ball release due to the traction force placed through the arm as it attempts to decelerate thus placing excessive stress on the anterior shoulder including increased stress through the bicep musculature.^{8,9} The amount of shoulder abduction, horizontal abduction, and elbow torque reached prior to ball release has been shown to impact the amount of traction force placed through the arm. **Conclusions:** Due to vague reports and inconclusive findings upon an initial evaluation of this condition, the initial presentation may be mistaken for other conditions such as biceps brachii strain. Further documentation and literature regarding this condition may be of value to clinicians for awareness and conclusive diagnosis.

How Can the Absence of the Pectoralis Major Muscle Affect Pitching Biomechanics?

Kirk TC, Craddock JC: Florida Gulf Coast University, Fort Myers, FL

Background: This level 4 clinical case report involves 24-year-old (76 inches and 214 lbs) male Minor League right handed pitcher. His medical history includes grade I right rotator cuff muscle strains, and sternoclavicular ligament sprain. The athlete comes into the athletic training room often reporting soreness and tightness in his R rotator cuff muscles, along with some supporting scapular muscular tightness. Initial evaluation reveals an abnormality of the athlete’s chest wall on the right side. Also, his right shoulder sits higher than the left side, at rest. Following observations, it is noted the athlete has an absence of the right pectoralis major muscle but reports no pain. following palpations, the athletic trainer determines the athlete’s pectoralis minor and subclavian muscle are present, only the pectoralis major is missing. Further palpation of the shoulder and back reveals myofascial trigger points in the rhomboids, levator scapulae, infraspinatus, descending trapezium, subscapularis, and teres minor. Full active range of motion and strength bilaterally with shoulder flexion, extension, adduction, abduction, internal rotation, and external rotation. Empty can test (-), clunk test (-), Hawkins-Kennedy’s test (-). Following the evaluation, the athlete noted he was born without his pectoralis major muscle on his right side. **Differential Diagnosis:** Muscular atrophy, pectoralis major avulsion, a rare birth defect causing the absent pectoralis major. **Treatment:** A biomechanical analysis was performed to determine what muscles were compensating for the lacking pectoralis major muscle during the pitching motion. A plan was established to strengthen the compensating muscles and relieve his trigger points. The pectoralis major is most active during the arm cocking phase and the arm acceleration phase of the throwing

motion. During the arm cocking phase, the pectoralis major, anterior deltoid, and subscapularis contract concentrically to horizontally adduct the shoulder. It was determined that the subscapularis and latissimus dorsi were compensating during the arm acceleration phase creating a muscle length and trigger point phenomenon. Due to the absent pectoralis major, the subscapularis and latissimus dorsi must produce more force to perform the same action. Treatment began with deep tissue massage of the compensating muscles followed by therapeutic cupping if necessary, to release tension in the muscle fibers. Static stretching, along with a pin and stretch, or active release technique, can be used to stretch the fibers. To strengthen the compensating muscles, the athlete can perform a weekly shoulder program. The focus was to strengthen the rotator cuff muscles and supporting scapular muscles. A progressive resistance exercise program was initiated for the RTC.

Uniqueness: Poland Syndrome is a rare birth defect that typically affects one side of the body. The effects consisting of; the absence of the pectoralis muscle on one side, and occasionally webbing of the fingers or toes are associated. It is more common in men than women, and more common on the right side than the left. According to the National Human Genome Institute, Poland Syndrome ranges from one to seven thousand, to one and one hundred thousand people affected. For a pitcher to have this syndrome and make it to the minor league level is even more rare and impressive.

Conclusions: This case highlights the stages of pitcher's motion and the muscles activated during each stage. This case further highlights the rarity of Poland Syndrome in the sports world and what it is. This case also demonstrates how to treat and strengthen the muscles used by baseball pitchers.

Thumb Pain in a Division I Collegiate Football Student Athlete: A Case Report

Matthis K, Joseph C: University of Central Florida, Orlando, FL

Background: The subject is a 20 year old Division I football safety who sustained a hyperextension, hyperabduction injury to his left thumb during an in-season game. After a sideline evaluation, a thumb spica tape job was used to limit the amount of valgus force applied to the thumb. He returned to participation for the remainder of the game. **Differential Diagnosis:** Ulnar Collateral Ligament (UCL) sprain, UCL tear, proximal phalanx fx, joint effusion, Stener lesion. **Treatment:** Post-game, he had considerable laxity over the UCL of his left thumb. There was mild pain and swelling over the ulnar side of the metacarpophalangeal (MCP) joint and thenar eminence. A fluoroscopic exam was completed and was negative for fracture. He was given a custom splint and instructed to wear it at all times. An MRI showed the UCL was torn from the distal attachment and retracted within the adductor aponeurosis in keeping with a Stener lesion. There was a bony contusion within the first metacarpal head, but no evidence of fracture. Due to slippage of the distal UCL attachment superficial to the adductor aponeurosis, surgical intervention was required for proper healing. Surgery was scheduled for the beginning of the team's bye week, which was 16 days post-injury. During that time, the student athlete was instructed to keep his thumb splinted and limit movement during activities of daily living. He played in two football games after the initial injury with his thumb taped and splinted. The surgical plan was to debride the distal attachment of the UCL from the adductor aponeurosis and reattach it using a Fiberwire suture. Once completed, an internal brace was created by taking the suture tape, which was in the anchor distally, and adding a second anchor just proximal to the insertion on the metacarpal head.

The suture tape, placed in this anchor, was screwed down. Due to the internal brace, the joint only needed to be immobilized for the first five days in order for the incision site to heal. **Uniqueness:** In an unaffected thumb, the adductor aponeurosis lies superficial to the UCL. When the UCL is torn by an abducted motion of the first metacarpophalangeal, the adductor aponeurosis can get in the way of the torn UCL fragment when the thumb is returned to a neutral position. This is called a Stener lesion. This injury requires surgical intervention as the adductor aponeurosis acts as a blockage for a displaced tear from healing. This case is unique because it uses Internal Brace augmentation, a new technique used to repair multiple ligament injuries in the body. This technique was developed in April 2015 but was not widely practiced until October 2017. It was used for this case, allowing for early motion of the MCP joint. This technique allows for more aggressive physical therapy days after surgery due to the immediate added strength of the ligament. When compared to the typical ligament-only repair, the MCP joint is casted for at least 4 weeks. This athlete began ROM exercises and was able to participate fully while wearing a short arm cast only five days post-surgery.

Conclusions: The student athlete suffered from a UCL tear and Stener lesion. He had surgery 16 days post-injury during the team's bye week in order to reconstruct the UCL and create an internal brace. He was able to start regaining ROM and fully participating in practice five days post-surgery. He was casted and permitted to play in the football game ten days after surgery. At 4 weeks post-surgery, strength and ROM exercises are progressing well and he continues to participate in a small orthoplast thumb splint.

Free Communications, Poster Presentations: Quality of Life And General Health

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

The Influence of Sleep and Heart Rate Variability on the Occurrence of Injuries, Illnesses, and Missed Participation Days in NCAA Collegiate Swimmers

Armwald BC, Adams MW, Vairo GL, Hamilton D, Miller SJ: Pennsylvania State University, University Park, PA; University of North Carolina, Greensboro, NC

Context: Athlete populations are at an increased risk of suffering an injury or illness due to their high level of physical activity. Additionally, athletes often do not attain adequate recovery following their training and/or competition sessions. Recent innovations in wearable technology have allowed researchers to track recovery metrics such as sleep and heart rate variability (HRV). Few studies have explored the relation between sleep, HRV, and adverse health events in collegiate athletes. The purpose of this study was to utilize an objective method of sleep and HRV detection to discern the influence of these variables on the occurrence of injuries, illnesses, and missed participation days

in 11 NCAA Division 1 swimmers (Males= 8, Females= 3, Age= 20 ± 1 years). It was hypothesized that reduced sleep and low levels of HRV would increase an athlete's odds of suffering an injury, illness, and/or missed participation day when considered along with covariables including training load. **Methods:** A wrist-worn activity monitor (WHOOP, Boston, MA) was used to measure sleep (hours), resting heart rate (beats/minute), and HRV (milliseconds) in subjects 24 hours a day for 157 days during their season. Training load was quantified using total swimming distance (yards). The main outcome variables included total injuries, total illnesses, and total missed participation days all of which were calculated using electronic medical records. Descriptive statistics (means, 3-day and 7-day moving averages, and standard deviations) as well as stepwise logistical regression were used to discern the influence of independent variables on each outcome variable. **Results:** Ten athletes completed data collection and were used for analysis. Average total sleep was 6.51 (± 0.23) hours, and average HRV was 78.08 (± 7.54) ms. Regression analysis

identified total sleep as a significant predictor of illnesses (OR= 0.70, 95% CI= 0.55-0.89, P< 0.01) and missed days (OR= 0.74, 95% CI= 0.61-0.90, P< 0.01). 3-day and 7-day moving averages for total sleep prior to an illness were calculated at 6.21 ± 0.33 and 6.41 ± 0.33 hours respectively and prior to a missed day were 6.28 ± 0.52 and 6.20 ± 0.48 hours respectively. Total swimming distance (OR= 0.99, 95% CI= 0.99-0.99, P< 0.001) and resting heart rate (OR= 1.08, 95% CI= 1.05-1.11, P< 0.001) were also identified as significant predictors of missed days. HRV was not a significant predictor of any outcome (see Figure 1). **Conclusions:** Swimmers with higher average total sleep had lower odds of suffering an illness and missing a participation day while HRV had no influence on these variables. These results may be useful in helping clinicians make evidence-informed decisions regarding athlete training and recovery to reduce the risk of adverse health events. Additional research with greater sample sizes is necessary to confirm these findings.

Logistical Regression Model Summary with Missed Participation Days as Response Variable					
Independent Variable	b	se	z-ratio	P-value	OR (95% CI)
(Intercept)	-5.87	1.58	-3.71	<0.001***	0.29 (0.57-1.25)
Total Sleep	-0.29	0.10	-3.07	<0.01**	0.74 (0.61 – 0.90)
Swimming Distance	-1.0e-02	1.99e-04	-5.24	<0.001***	0.99 (0.99-0.99)
RHR	0.08	0.01	6.00	<0.001***	1.08 (1.05-1.11)
Logistical Regression Model Summary with Illnesses as Response Variable					
Independent Variable	b	se	z-ratio	P-value	OR (95% CI)
(Intercept)	-1.24	0.79	-1.58	0.11	0.29(0.05-1.25)
Total Sleep	-0.36	0.12	-3.00	<0.01**	0.70 (0.55-0.89)
Swimming Distance	-6.73e-05	<0.001	-1.46	0.14	1.00 (0.99-1.00)

OR= odds ratio, se= standard error, df= degrees of freedom

* Significant at $P \leq 0.05$

** Significant at $P \leq 0.01$

*** Significant at $P \leq 0.001$

Figure 1. Stepwise Logistical Regression Model Summaries for Illnesses and Missed Participation Days Outcome Variables.

Lower Extremity Injury and Health Related Quality of Life in Both Current and Former Track and Field Athletes

Penilla KD, Pickerill ML, Kipp LE, Fraser M: Disneyland Resort, Anaheim, CA; Colorado State University, Pueblo, CO; Texas State University, San Marcos, TX

Context: Health Related Quality of Life (HRQoL) increases with higher physical activity levels in the general population. Athletes, even with their high physical activity level, have lower HRQoL compared to non-active individuals. Within the sport of Track & Field (T&F), despite high risk potential and reporting of chronic lower extremity injury, little information regarding HRQoL is known. The purpose of this study was to evaluate effects of chronic lower extremity injuries on HRQoL and function in current and former Division I T&F athletes. **Methods:** We used a cross-sectional design and administered an online survey through Qualtrics. Participants included 126 current or former Division I T&F athletes recruited via personal communication (current athletes) or an electronic mail database (former athletes). Forty-seven current (mean age=20.2 yrs. (+1.42); gender F=27 M=20) and 79 former (mean age=38.7yrs. (+13.46); gender F=37 M=42) athletes participated. Of all participants, 47 identified as injured and 79 as non-injured athletes. The online survey contained four sections: Demographic information, Injury demographic information, the 36 item-Short Form (SF-36) survey (HRQoL), and the Lower Extremity Functional Scale (LEFS). Statistical analyses included measures of central tendency (frequency, mean + SD) and non-parametric Mann-Whitney and Kruskal-Wallis tests. **Results:** Current athletes, regardless of injury status, reported significantly lower SF-36 mental status sub-scale scores than former athletes ($p = 0.02$, $U=1408$, $d=-0.46$). Injured athletes, regardless of participation status, reported significantly lower

scores for all measures when compared to non-injured counterparts: SF-36 physical status score (PS) ($p < 0.001$, $\chi^2=25.037$), SF-36 mental score (MS) ($p = 0.007$, $\chi^2=7.57$) and LEFS score ($p < 0.001$, $\chi^2=37.143$). Comparison of between-group effects for SF-36 PS indicated large effect differences between former injured and current non-injured athletes ($d=-1.04$, $r=-0.46$) and former injured and former non-injured athletes ($d=-0.84$, $r=-0.39$) with former injured athletes reporting lower scores in both cases. Large effects emerged for LEFS between-group differences between current injured and current non-injured athletes ($d=-1.20$, $r=-0.51$), and former injured and current non-injured athletes ($d=-1.36$, $r=-0.56$), with the injured groups reporting lower scores. **Conclusions:** Chronic injury regardless of participation status was associated with lower HRQoL and lower LEFS scores. Former athletes experiencing symptoms from injury during NCAA eligibility report significantly lower HRQoL physical measures and LEFS scores when compared to former athletes that were not injured or not experiencing symptoms. Overall current and former Division I T&F athletes in our study report lower HRQoL scores when compared to the general population using age stratified data. T&F as a non-contact sport has high risk for chronic lower extremity injury which negatively impacts HRQoL. Athletic trainers working with T&F athletes should take into account HRQoL as part of the rehabilitation program and provide patient education regarding HRQoL and chronic lower extremity injuries common in the sport.

A Comparison of Physical Literacy and Landing Strategies Between Low-Resourced and High-Resourced Communities

Zuk EF, Evanovich J, Burland JP, Beltz EM, Root HJ, DiStefano LJ: University of Connecticut, Storrs, CT; Emory & Henry College, Emory, VA; A.T. Still University, Mesa, AZ

Context: Physical literacy is a growing concept throughout the United States. In order to be physically active, children must develop physical literacy, which is the competency to control their body, and the confidence and motivation to be active. There is a critical need to identify children with low physical literacy and/or at risk for sustaining musculoskeletal injuries and factors associated with proper development. Socioeconomic status of children's living communities may influence opportunities for physical activity and motor development, but this has not been examined in relation to physical literacy in the United States. The purpose of this study was to evaluate physical literacy competency and landing strategies in youth between a low-resourced community and a high-resourced community. **Methods:** This was a cross-sectional study design including 245 male and female children (high-resourced, $n=102$; low-resourced, $n=143$; age, 9 ± 2 years; height, 142.7 ± 14.5 cm; mass, 41.5 ± 14.4 kg). High-resourced (HIGH) and low-resourced (LOW) categories were determined by the published need for free or reduced lunch for each community (LOW: $>50\%$ free/reduced lunch; HIGH: $<49\%$ free/reduced lunch). Physical literacy competency tasks, which examine fundamental movement skills, were assessed using the validated PLAYfun assessment tool and divided into five domains: locomotor, balance, upper extremity object control, lower extremity object control and running. Each consisted of discrete tasks. Each task was measured using a 100-point visual analog scale (100= proficient, 0= not competent). The average total score across all tasks within each domain was calculated for 5 separate composite competency scores. Landing technique was assessed using the Landing Error Scoring

System (LESS). The average total LESS score across 3 trials were calculated for a single LESS score per participant. Analyses of variance were used to compare physical literacy competency in each domain (locomotor, balance, upper extremity object control, lower extremity object control and running) and LESS scores between high and low-resourced communities. An alpha level was set at 0.05. **Results:** There was a significant difference for locomotor ($p < 0.004$, HIGH= 99±9 points; LOW=90±30 points), balance ($p < 0.001$, HIGH= 98±14 points; LOW=86±35 points) and lower extremity object control ($p < 0.001$, HIGH= 76±43 points; LOW=56±50 points) between high-resourced and low-resourced communities. LESS scores between high-resourced and low-resourced communities also significantly differed ($p < 0.009$, HIGH= 6.9±1.8; LOW=7.6±1.9). **Conclusions:** Children in low-resourced communities demonstrate lower competency during fundamental movement skills and a jump-landing task, which is associated with increased risk of musculoskeletal injury. These differences may be attributed to fewer opportunities for skill development and emphasize the need for interventions within low-resourced communities. Competency is only one aspect of physical literacy so future research should evaluate if socioeconomic status impacts comprehensive physical literacy factors.

Generalized Joint Hypermobility and Quality of Life

Marchetti DP, Mansell JL, Tierney RT, Russ AC: King's College, Wilkes-Barre, PA; Temple University, Philadelphia, PA

Context: Generalized Joint Hypermobility (GJH) can impact various aspects of a patient's health, including injury and joint pain. It is suggested that GJH can lower quality of life (QOL). The purpose of this analysis is to determine if athletes with GJH experience a difference in QOL compared to athletes without GJH. **Methods:** A database search was conducted in June of 2018. Relevant resources were found utilizing CINAHL, PubMed, EBSCO host, Cochrane, MEDLINE, and Sport Discus. The following search terms were utilized: "joint hypermobility" AND "quality of life". The inclusion criteria included level 4 evidence or higher, generic or disease-specific patient-reported measures of QOL and included athletes as participants. Participants with GJH had to have a Beighton Score ≥ 4 out of 9. Titles were reviewed for relevance, then abstract, then full text. Articles were included based on their ability to answer the research question and matching clinical outcome measures. QOL scores were compared across studies and 95% confidence intervals (CI) were calculated. STROBE Checklist for cross sectional studies and the Critical

Appraisal Skills Programme tool for case-control series was used to assess validity. **Results:** The search of the literature resulted in 50 studies. Upon review, 3 relevant studies were found; 2 cross sectional studies and 1 case control study. In the first cross sectional study, the Peds QL was used to assess QOL. The GJH group reported a QOL of 70.6 ± 18.3 (95% CI 62.8, 78.4), while the healthy group was 82.7 ± 13.2 (95% CI 82.21, 83.19). In the second study, QOL was assessed by the RAOS-Child. The GJH group reported a QOL of 225.8 ± 48.9 (95% CI 111.6, 340) and healthy group's QOL was 232.5 ± 170.1 (95% CI 154.45, 310.55). In the final study, the WOSI was used to assess QOL. The GJH group reported a QOL of 77.2 ± 13.9 (95% CI 72.12, 82.28) and healthy group's QOL was 81 ± 14.5 (95% CI 75.71, 86.29). The two cross sectional studies scored 18/22 and 19/22 on the STROBE Checklist. The third study scored an 8/11 on the Critical Appraisal Skills Programme tool. **Conclusions:** Findings were inconsistent across studies. At this point in time there is not sufficient evidence to support the generalization that those with GJH have a lower QOL than those without GJH. It is still important for clinicians to collect QOL data in order to best practice patient centered care. The Strength of Recommendation is B due to limited patient-oriented outcomes and inconsistencies.

Study	Groups	Mean QOL Score	95% Confidence Interval
Nicholson et al ³	GJH	70.6 (18.3)	62.8 to 78.4
	No GJH	82.7 (13.2)	82.21 to 83.19
Schmidt et al ⁴	GJH	77.2 (13.9)	72.12 to 82.28
	No GJH	81 (14.5)	75.71 to 86.29
Frydendal et al ⁵	GJH	225.8 (248.9)	111.6 to 340
	No GJH	232.5 (170.1)	154.45 to 310.55

Current Evidence in Mental Health: Medication Use in Neurocognitive Performance

DeRollo JM, Russ AC, Tierney RT, Mansell J: Modesto Junior College, Modesto, CA; Temple University, Philadelphia, PA

Context: There are between 1.6 and 3.8 million sport-related concussions annually and baseline testing is considered a best practice with regards to concussion. It is important for healthcare professionals to know how medication, such as those used in treating depression, ADHD and other common mental health pathologies, affects baseline testing and concussion presentation. The purpose of this review was to determine if medication influences neurocognitive performance in student-athletes.

Methods: PubMed, Google Scholar and Science Direct were searched in July of 2018 using the Boolean phrase: neuro* OR neurocog* AND sport* AND athlet* AND depress* OR ADHD AND drug* OR medic*. Titles were reviewed for relevance, then abstract, then full text. Articles were included based on their ability to answer the research question and matching clinical outcome measures. Only studies from the previous five years with student-athletes aged 10-25 were considered. Outcome measures were representative of baseline ImpACT test for three different groups; a control group; patients with ADHD but undedicated (ADHD/No Medication); and patients with ADHD using medication (ADHD/Medication). The Strobe Checklist for cohort studies is the appraisal used to address internal and external validity of the retrospective studies. **Results:** The search returned 33 articles and 3 were selected for inclusion. In the first study, athletes treated for ADHD had significantly better baseline visual motor speed scores ($p = 0.025$, $r = -0.134$) than athletes with untreated ADHD. Athletes reporting a history of untreated ADHD performed worse on all baseline ImpACT neurocognitive measures and reported greater total symptom scores

than matched controls ($p \leq 0.01$). The second study showed that athletes with untreated ADHD performed worse compared to the medication group and the control group on the Visual Motor Speed composite ($d = .32$ to $.42$). The control group performed better than those with untreated ADHD ($d = .33$). In the last study, athletes who used medication had significantly lower visual motor speed scores ($p = 0.030$) and slower reaction times ($p = 0.04$) than those who were not. STROBE = 19, 19 and 20. **Conclusions:** Medication in those diagnosed with ADHD appeared to improve performance on the ImpACT. Clinicians need to account for mental health history and medication use when conducting baseline and concussion assessments. The Strength of Recommendation is B due to consistent lower quality evidence. Future studies should utilize verification of medical histories and medication compliance.

Effects of Aquatic Therapy on Functionality [Gait & Balance] and Quality of Life Among Patients With Parkinson's Disease: A Systematic Review

Teets AL, Liedel BM, Troy J, Berry DC: Saginaw Valley State University, University Center, MI

Context: Gait pattern disruptions in patients with Parkinson's Disease (PD) diminishes functionality (i.e., gait, balance) and reduces their quality of life (QoL). Identifying alternative and innovative interventions, including aquatic therapy (AT), may positively impact PD patients to improve functionality and QoL. The study aimed to systematically review, evaluate, and summarize the literature to determine the effects of aquatic-based therapies (ABT) on functionality and QoL in patients with PD. **Methods:** Articles were identified from: CINAHL Complete, ProQuest Research Library, PubMed, Medline, and Cochrane Library, from January 2008-to-August 2018. Search terms: ["aquatic" AND "parkinsons"], resulting in 45 articles. Following initial screening (duplicates=30, title, abstract), 14 articles were reviewed for possible inclusion: (1) peer-reviewed, randomized-controlled trials, (2) patients with PD (>18 y.o.), (3) full-report, (4) English-language, and (5) at least one outcome measuring functionality or QoL. Two reviewers independently assessed studies' level of evidence (LOE) and quality using the Oxford Center for Evidence-Based Medicine (2011) and Physiotherapy Evidence Database (PEDro) scale. Data of interest: interventions (type), main outcome descriptive and inferential statistics. **Results:** Five articles met inclusion criteria (LOE=2). PEDro scores ranged from 3-8 (max=10; average=71.89). Pooled sample size=177, average age=70.365.68. All articles examined functionality and QoL. The ABT intervention, Ai Chi versus land-based therapy (LBT), demonstrated significant improvements in VAS score (4.00.9 vs 5.51.5, $p < 0.001$, $d = 1.21$),

“Five-Times Sit-to-Stand” test (14.33.2 vs. 18.04.1, $p=0.001$, $d=1.0$), and “Get-Up and Go” test (8.82.4 vs. 11.42.7, $p<0.001$, $d=1.01$). Conventional-ABT compared to obstacle-ABT demonstrated improved outcomes; however, obstacle-ABT scored significantly higher on the Freezing of Gait Questionnaire (FOG) (posttest: 8.73.3 vs. 6.22.1, $F=18.4$, $p<0.0001$, $d=0.90$) and TUG score (posttest: 17.12.9 vs. 13.81.9, $F=22.3$, $p<0.0001$, $d=1.3$). An ABT walking group versus LBT demonstrated improved gait stride length (0.9 vs. 0.70.2, $p<0.05$, $d=1.0$), speed (0.7 vs. 0.60.2, $p<0.05$, $d=0.49$), and cadence (93.0 vs. 77.325.5, $p<0.05$, $d=0.75$). While comparing ABT+LBT to ABT-alone, only the ABT+LBT resulted in a significant difference in FOG scores ($t=3.619$, $P=0.007$). The ABT-alone group’s FOG score improved, but was insignificant ($t=1.202$, $p=0.274$). No other outcomes were significant ($p>0.05$). Finally, ABT demonstrated a significance difference in QoL utilizing the Unified Parkinson’s Disease Rating Scale (UPDRS) (T1=17.5 (IQR=8.75-21.25); T2=13 (IQR=5.25-16.25)) compared to usual care (T1=16.5 (IQR=10.25-21.25); T2=16.5 (IQR=11.25-21.75)), $p=0.01$). The ABT group’s FOG score exhibited a lower post-test value (T2=3.5 (IQR=1-9)) compared to usual care (T2=6.5 (IQR=3.5-12.75)), $p=0.17$). **Conclusions:** Results moderately-to-strongly suggest that patients with PD benefit from ABT to improve functionality and gait. Further studies should examine large-scale sample sizes, lengthen study duration and follow-up, and examine “on” and “off” PD states. When LBT becomes unfeasible and unsafe, ABT programs provide an empowering alternative intervention to improve functionally and QoL. Clinicians should be educated on appropriate ABT intervention strategies to improve PD patient outcomes.

Outcome Measures for Rural Healthcare Clinics, Primary Care Providers or Clinics, and Hospitals Associated With an Accountable Care Organization

Aiken ME, Mansell JL, Russ AC, Tierney RT: Chowan University, Murfreesboro, NC; Temple University, Philadelphia, PA

Context: Rural health providers face several challenges, including financial struggles, quality of care, and not being able to provide adequate healthcare services to the population. Accountable Care Organizations (ACOs) may serve as a solution by increasing patient outcomes, quality of provider care, and decreasing costs. The purpose of this review is to determine if rural healthcare clinics (RHC), rural primary care clinics, or rural hospitals associated with an ACO or utilizing accountable care reforms improve population health and quality of care and decrease healthcare costs. **Methods:** The following databases were searched in July of 2018: CINAHL, Medline, History of Science, Technology, and Medicine, Chicano Database, eBook Clinical Collection (EBSCOhost). Search terms included “rural health clinics,” “accountable care organizations,” “patient outcomes,” and “population health.” Articles published from 2008-2018 were reviewed. The search terms were entered in the databases and produced several hundred results. If a title seemed relevant, the abstract was reviewed to determine inclusion. Articles chosen for appraisal were studies that examined any patient outcomes in rural clinic ACOs, studies that examined cost effectiveness of rural clinic ACOs, and studies that examined quality of care in rural clinic ACOs. One investigator extracted data using STROBE checklists to determine study quality. A Strength of Recommendation Taxonomy grade of “B” was given to each article. The investigator obtained descriptive measurement data from the studies appraised which included: study participants, inclusion criteria, exclusionary factors, outcome measures,

results, and level of evidence. Included articles reported 95% confidence intervals and percent increase in the results. **Results:** Three articles were included for appraisal. Infant mortality rates in a rural hospital utilizing accountable care reforms decreased from 18.3 per thousand to 12.5 per thousand. Further, 15 out of 97 rural ACOs earned shared savings totaling \$41.6 million. Finally, rural ACOs scored higher than urban ACOs on quality of care measurements. **Conclusions:** There is Level B evidence to support improved quality of care and patient outcomes and decreased costs for rural health provider services associated with an ACO. However, there remains little research examining this emerging phenomenon. Future research should include comparisons between ACO and non-ACO associated rural clinics.

Athletic Trainers' Familiarity and Assessment of Patient Barriers to Rehabilitation Adherence

Picha KJ, Heebner NR, Abt JP, Usher EL, Capilouto GJ, Uhl TL: A.T. Still University, Mesa, AZ; University of Kentucky, Lexington, KY

Context: Non-adherence to rehabilitation is a common behavior demonstrated by athletes following injury. Non-adherent behaviors include poor attendance for rehabilitation sessions, failure to complete recommended exercises, and/or not following prescribed activity modifications. Non-adherence is related to poor patient outcomes. Barriers to patient adherence have been identified, and tools to assess these barriers are available. However, athletic trainers' (ATs) familiarity with and assessment of patient barriers is unknown. The purpose of this study was to evaluate ATs' familiarity with and assessment of patient barriers to rehabilitation adherence. **Methods:** This was a cross-sectional, survey-based study. The survey was distributed to a sample of ATs via email by the National Athletic Trainers' Association. The survey consisted of

10-15 questions based on answering logic that evaluated familiarity and assessment of patient barriers to rehabilitation adherence using various question formats including Likert-scale, multi-select items, and rank-order. Responses were reported as frequency counts and percentages. One question provided respondents with a matrix of eight barriers to rank order (1-most common to 8-least common) in response to the question: "Clinically, how often do you observe the following patient barriers to completing their prescribed exercise?" A Friedman test and Wilcoxon sign-rank test were used to determine if and where differences in ranks existed between barriers. Seven pairwise comparisons between the barriers were performed, therefore an adjusted p-value was used ($p < 0.007$). **Results:** Out of 2,000 ATs invited to complete the survey, 80 ATs (39 males, 40 females, 1 unreported; age=39.4±13.4 years; athletic training experience=15.2±12.3 years) started and completed the survey yielding a completion rate of 100%. Ninety percent (n=72/80) of respondents reported familiarity with patient barriers to rehabilitation adherence. Respondents reported "lack of time" and "forgetting" as the two most

common barriers observed in clinical practice. Seventy-six percent (n=61/80) of respondents indicated they assessed patient barriers to rehabilitation adherence. Assessment through verbal discussion with patients was most common for all barriers. Table 1 displays barriers and method(s) of assessment used by ATs. The most common reason ATs reported they did not assess barriers was lack of knowledge about how to assess (n=9/19, 47%), lack of time (n=7/19, 37%), and lack of knowledge about how to apply information (n=6/19, 32%). **Conclusions:** Assessment of patient barriers to rehabilitation adherence is most commonly done through verbal discussion with patients; however, this method has not been identified as reliable or valid for objectively collecting patient perspectives. Because lack of knowledge is a primary reason clinicians do not evaluate barriers to rehabilitation adherence, efforts to educate ATs on effective methods of assessment and strategies for implementation are needed. Using assessment tools to identify barriers to rehabilitation adherence in athletic healthcare may assist in creating athlete-specific strategies to overcome barriers and improve adherence.

Table 1. Frequency of Methods Used to Assess Adherence Barriers by Athletic Trainers

Barrier	Verbal Discussion n (%)	Observation of the Patient n (%)	Patient Self-Report Questionnaires n (%)	I do not Assess this Barrier n (%)	Other Method n (%)
Anxiety/Depression	50 (63)	22 (28)	12 (15)	4 (5)	2 (3)
Forgetting to complete exercise	56 (70)	25 (31)	2 (3)	0 (0)	1 (1)
Helplessness/lack of independence	39 (49)	21 (26)	8 (10)	12 (15)	0 (0)
Increased pain during exercise	55 (69)	38 (48)	16 (25)	0 (0)	1 (1)
Low self-efficacy/lack of confidence	46 (58)	28 (35)	6 (8)	5 (6)	0 (0)
Sedentary/low levels of activity at baseline	30 (38)	26 (33)	11 (14)	17 (21)	1 (1)
Lack of social support	43 (54)	12 (15)	3 (4)	15 (19)	2 (3)
Lack of time	60 (75)	13 (16)	3 (4)	0 (0)	0 (0)

* Respondents could select all methods used

Examination of Self-Reported Physical Activity Levels in Individuals With and Without a History of Lower Extremity Injury

Birtzer BA, Powden CJ: Indiana State University, Terre Haute, IN

Context: It is proposed that individuals with a history of Lower Extremity (LE) injury may suffer from long-term consequences regarding function, physical activity levels, and overall health. Despite the vast amounts of research into LE pathology and physical activity's relation to long-term health, few studies have been conducted to examine the relationship between the two. The objective of this study is to determine the effect of LE injury history on physical activity levels. **Methods:** This study utilized a cross-sectional web-based survey design. One hundred seven young adults with (Male=35, Female=72, Age=24.9±5.08) or without a history of LE injury participated. All participants were free from injury at the time of survey completion. A Delphi panel and pilot testing were used to validate the survey tool designed to assess general demographic information and LE injury history (Back, hip, knee, lower leg, ankle, foot/toe). Physical activity levels were examined using: Godin Leisure-Time Exercise Questionnaire (GLTEQ), and the NASA-Physical Activity Status Scale (NASA-PASS). Injury history was grouped into history of LE, knee, lower leg, ankle, and foot/toes injury categories. Dependent variables were GLTEQ-Total, GLTEQ-Strenuous, GLTEQ-Moderate, GLTEQ-Mild, and NASA-PASS. Independent t-tests were used to evaluate differences in physical activity variables between injury history groups. Alpha was set at $p < 0.05$. **Results:** The GLTEQ-Total scores were significantly greater in those with a history of LE injury (33.85 ± 4.52 , $p = 0.004$) and lower leg injury (61.67 ± 33.95 , $p = 0.010$) compared to those with no history (No LE = 32.12 ± 38.93 , No lower leg = 38.32 ± 37.24). No other significant differences were identified for GLTEQ-Total for other injury

history group comparisons ($p > 0.059$). GLTEQ-Strenuous scores were significantly greater in those with a history of LE injury (3.05 ± 2.51 , $p = 0.001$) and lower leg injury (3.95 ± 2.50 , $p < 0.001$) compared to those with no history (No LE = 1.47 ± 2.11 , No lower leg = 1.89 ± 2.27). No other significant differences were identified for GLTEQ-Strenuous for other injury history group comparisons ($p > 0.073$). GLTEQ-Moderate scores had no significant differences for any injury history group comparisons ($p > 0.081$). GLTEQ-Mild scores had no significant differences for any injury history group comparisons ($p > 0.208$). NASA-PASS scores were significantly greater in those with a history of LE injury (6.38 ± 3.15 , $p < 0.001$), knee injury (6.65 ± 3.05 , $p = 0.004$), lower leg injury (7.71 ± 3.00 , $p < 0.001$), ankle injury (6.07 ± 2.96 , $p = 0.012$), and foot/toe injury (6.50 ± 3.48 , $p = 0.001$) when compared to those with no history (No LE = 3.84 ± 2.37 , No knee = 4.69 ± 2.94 , No lower leg = 4.55 ± 2.76 , No ankle = 4.56 ± 3.02 , No foot/toe = 4.49 ± 2.62). **Conclusions:** Contrary to previous literature, the results indicated that those with a history of LE injury participate in greater amounts of physical activity. Included participants' age may be the cause of contradictory results as the young age may limit the time needed for health detriments to develop after injury that could cause reductions in physical activity levels. Future research should explore physical activity and injury trends throughout the lifespan.

Examination of Hormonal Contraceptive Use and Mental Health Risks in Female Student-Athletes

Weber SR, Finnegan O, Torres-McGehee TM: University of South Carolina, Columbia, SC

Context: Female student-athletes are at a higher risk for the prevalence of mental health disorders following an athletic injury, change in life stressors, or performance failures when compared to men. Females are using oral contraceptives as a method of birth control or medical management of their menstrual cycle. However, little research has focused on mental health outcomes such as depression and eating disorders in female student-athletes using oral contraceptives. Therefore, the primary goal of this study was to identify relationships between oral contraceptive use and the risk of depression, eating disorders, and low self-esteem in female collegiate student-athletes. **Methods:** A cross-sectional study examined female collegiate student-athletes ($n = 1306$; age: 19.9 ± 1.4 years; height: 168.2 ± 8.0 cm; weight: 63.9 ± 10.9 kg) from 23 colleges or universities across the United States and from a variety of sports (e.g., basketball, soccer, volleyball, track, etc.). As a part of a larger online study, the independent variable was contraceptive intake (yes or no), and dependent variables were risks for depression, eating disorders, and low self-esteem. Participants completed a demographic survey (e.g., menstrual cycle background, contraceptive use, sport type, etc.). The Center for Epidemiologic Studies Depression Scale assessed depression risk; Eating Attitudes Test assessed eating disorder risks, and the Rosenberg Low Self-Esteem Scale assessed low self-esteem. Basic descriptive statistics, crosstabulations, and Chi-square analysis were used. **Results:** The overall prevalence for depression and low self-esteem was 28.9% ($n = 376$) and 9% ($n = 118$) respectively with no differences with contraceptive use ($\chi^2(1) = 0.010$, $p = 0.922$; $\chi^2(1) = 0.656$, $p = 0.418$). Overall eating

disorder risk was estimated at 24.4% (n=319), with significant differences between female student-athletes not using contraceptives compared to those that used contraceptives (13.9%, n=181 vs. 10.6%, n=138; $\chi^2(1) = 4.59$, $p = 0.032$). Frequencies for eating disorder pathogenic behaviors among female student-athletes revealed: 11.8% (n=154) engaged in binge eating, 7.3% (n=96) used laxatives, diet pills or diuretics to control weight, and 5.5% (n=72) vomited to control their weight.

Conclusions: Although we did not find any relationship between contraceptive use and a risk for depression and low self-esteem, there was a mild, protective effect for oral hormonal contraceptive use and eating disorder risk. This may indicate that those who are taking oral contraceptives were slightly less likely to have a risk for an eating disorder; which may be due to the regulation of hormones and blocking the 'anorexic effect' of different gonadal hormones. Future research should focus on the type of contraceptive and mental health risk and include other mental health disorders such as anxiety.

**NASA Task Load Index –
Measuring Patient Experience
With Novel Exercise**

Newsham KR, Gutekunst DJ: Saint Louis University, St. Louis, MO

Context: Patients experience exercises in multiple contexts, yet outcomes commonly reported are limited to strength, motion, and/or functional gains. There is limited information on how patients perceives the workload of an exercise. The National Aeronautics and Space Administration Task Load Index (NASA-TLX), validated and widely utilized in industry to understand the perceived mental and physical workload of work-related tasks, was employed with research participants performing a novel exercise. The NASA-TLX measures 6 dimensions (Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration) on a 21-point scale (very low – very high). The purpose of this study was to understand how patients perceived intrinsic foot muscle (IFM) exercises and explore construct validity of the NASA-TLX with therapeutic exercises.

Methods: Eighteen participants (18-30 years) with IFM dysfunction were instructed in an IFM exercise progression as part of a randomized controlled trial. Exercises were introduced and progressed over four-weeks, with 3 supervised sessions/week. The NASA-TLX was embedded in this study. Participants were provided descriptors of dimensions on the NASA-TLX and completed the survey immediately after supervised sessions with attention to performance of specific exercises. Sub-scale scores were recorded; unweighted totals (raw TLX) were calculated. Descriptive analysis was performed. **Results:** The introduction of a new exercise was associated with elevated NASA-TLX scores (Day 1 and Day 8); scores decreased as participants mastered the techniques. A radar chart of mean scores demonstrates changes on various dimensions over time (Figure 1). For the initial exercise (isolated great toe extension), Effort (mean 13.9 +3.4) and Mental Demand (mean 11.4 +4.59) were rated highest. The scores for all dimensions decreased over the first week, except for Physical Demand, which was essentially unchanged. Perceived workload measured

2 weeks after the exercise was introduced was substantially reduced (Mental 4.3 +4.6; Physical 3.7 +3.8; Temporal 3.2 +2.6; Performance 4.6 +3.8; Effort 4.6 + 3.9; Frustration 2.8 +2.9) A reduction in performance score indicates improved performance. The raw TLX for Great Toe Extension was 53.8 (+14.58) on Day 1; 39.3 (+20.23) on Day 5; and 23.3 (+20.67) at Day 15. On Day 8, the Short Foot Exercise was introduced with corresponding increases in perceived workload (Mental 11.2 +4.5; Physical 9.5 +5.1; Temporal 5.9 +3.3; Performance 9.3 +3.5; Effort 12.3 +4.9; Frustration 8.1 +5.3; raw TLX 56 +23.0). These scores decreased over the course of one week, with significant reductions within two weeks (Mental 5.7 +3.6; Physical 4.8 +3.1; Temporal 3.8 +2.6; Performance 5.1 +2.7; Effort 6.9 +4.6; Frustration 4.6 +4.4; raw TLX 31 +18.2) **Conclusions:** Introduction of IFM exercises created a high perceived workload that decreased as the participant gained familiarity and confidence in exercise execution. Our study provides evidence of construct validity for the NASA-TLX for individuals learning a novel exercise.

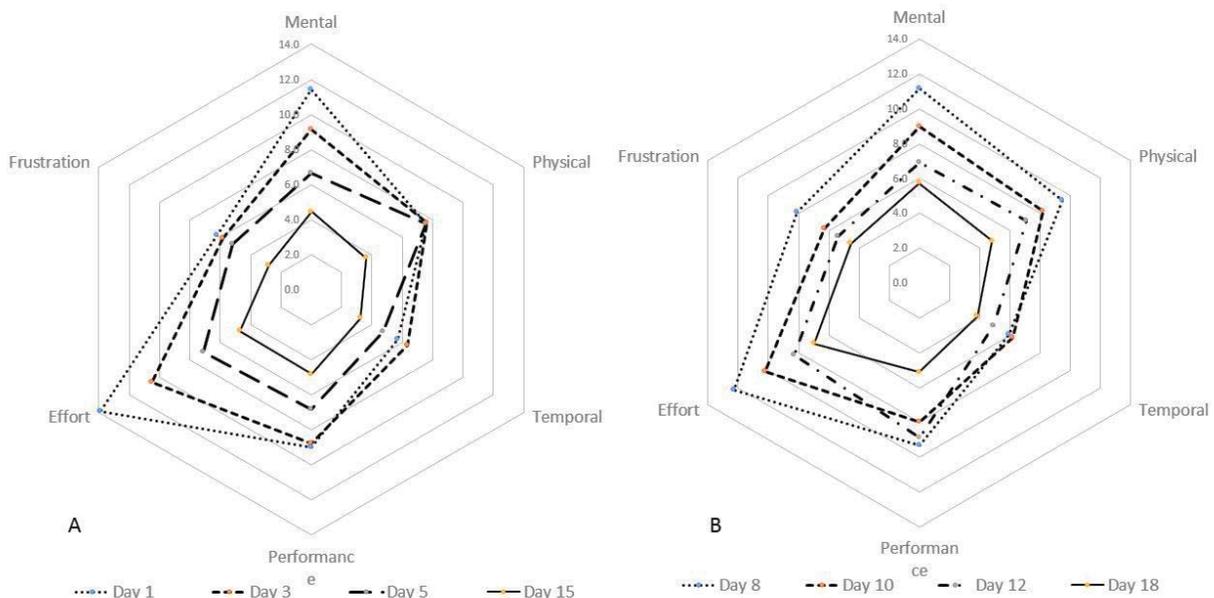


Figure 1. NASA-TLX Dimensions clockwise from top Mental, Physical, Temporal, Performance, Effort, Frustration (A) Great Toe Extension introduced Day 1; (B) Short foot exercise introduced Day 8

Free Communications, Poster Presentations: Reliability and Diagnostic Accuracy - "How Reliable Is It?"

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Intra and Inter-Rater Reliability of Two New Single Leg Sit to Stand Tests

Waldhelm A, Gubler C, Bushheister D, Bartz-Broussard J, Sullivan K, Witte C: University of South Alabama, Mobile, AL

Context: The single leg sit-to-stand test (SLSTST) is a functional test used to assess quadriceps strength. The original SLSTST has been used to diagnosis lumbar nerve root impingement/radiculopathy specifically at the L3 and L4 level. Unfortunately, the original SLSTST uses only one repetition and may not be challenging enough to identify quadriceps weakness in individuals with athletic injuries or as a return to sport assessment. Therefore, the objective of the study is to determine the intra and inter-rater reliability of the two new SLSTSTs. **Methods:** Twenty-two healthy college-aged individuals (12 males, age: 22.5 years \pm 1.37, height: 1.72 m \pm 0.09; weight: 70.2 kg \pm 11.0) participated in the study. A repeated measures research design was used and data was collected in an exercise science research laboratory. There were two testing session held three to seven days apart and two second-year physical therapy students served as the examiners. The objective of the first SLSTST was for the participant to perform as many single leg sit-to-stand repetitions they could in thirty seconds, while the second test measured how quickly the subjects could perform five sit to stand repetitions. Both lower extremities were tested and Intraclass Correlation Coefficients (ICC) were used to analysis the data. **Results:** Both SLSTSTs were found to have good to excellent intra-rater and excellent inter-rater reliability. The 30-second SLSTSTs had intra-rater ICCs ranged from 0.92 to 0.94 and inter-rater ICC = 0.99 on the

right and 0.98 on the left. The intra-rater ICC ranged from 0.87 to 0.94 and the inter-rater ICC = .99 on both legs for the five repetition SLSTST. **Conclusions:** This study determined the two new SLSTSTs introduced had good to excellent intra-rater and inter-rater reliability. The two new SLSTSTs are extremely reliable, but more research is needed to determine if they can be used to identify quadriceps weakness in individuals with recovering from an athletic injury or as a return to sport assessment.

Inter-Session Reliability and Responsiveness of Weight-Bearing Dorsiflexion Asymmetries

Sharpe NM, Rinehart C, Robison H, Kupiec M, Carlson J, Quintana L, Meilun R, McKeon PO, King D: Ithaca College, Ithaca, NY

Context: The Weight Bearing Lunge Test (WBLT) is a clinical test used to examine weight-bearing dorsiflexion range of motion (DFROM). A 2 cm side-to-side WBLT asymmetry has been linked to a pathological deficit in weight-bearing DFROM. While this is currently clinically accepted, there is limited evidence to substantiate it. **Objective:** The purpose of this study was to examine the normally-occurring WBLT asymmetry across two testing sessions in healthy, young adults and establish the reliability and responsiveness of the asymmetry estimate. **Methods: Study Design:** Reliability study. **Setting:** Research laboratory. **Participants:** Twenty-two healthy adults (17 females, 5 males, age: 18.9 \pm 1.0 years, height: 119.8 \pm 9.3 cm, mass: 71.3 \pm 16.2 kg) participated in the study. Prior to participating, all participants provided written informed consent and reported they were free of lower extremity injury and health issues that would affect DFROM. **Intervention:** Participants performed the WBLT using the knee to wall principle in which they faced a wall and aligned their test foot parallel to a tape measure that was perpendicular to the wall. Their test foot was moved away from the wall to find the furthest distance that the knee could touch without lifting the heel in a lunge position. WBLT distance was measured from the most distal point of the great toe to the wall to the nearest 0.5cm. Participants performed three trials on each limb. The means of the three trials

for each limb were used for analysis. Main Outcome Measures: To calculate the normally-occurring WBLT asymmetry for each session, the left WBLT mean was subtracted from the right for each participant. To examine the intersession reliability of the asymmetry estimate, an intraclass correlation coefficient (ICC_{2,3}) was calculated. From the ICC, the standard error of measure (SEM) was calculated to estimate the error in the asymmetry estimate between sessions. From the SEM, the minimum detectable change (MDC_{95%}) was calculated ($SEM \times 2.1/2 \times 1.96$) to estimate the largest likely asymmetry that may exist between sessions in the healthy, young adult population. **Results:** For session 1 (right WBLT: 10.6±3.4cm, left WBLT: 9.9±3.5cm, asymmetry: 0.7±1.7cm) and session 2 (right WBLT: 10.5±3.5cm, left WBLT: 10.4±3.7cm, asymmetry: 0.2±1.5cm) demonstrated a small systematic bias toward the right limb having greater WBLT compared to the left. The reliability of the asymmetry estimate (ICC_(2,3))=0.72, SEM=0.8cm, MDC_{95%}=2.2cm) indicated that there was good agreement between sessions. **Conclusions:** WBLT asymmetry within sessions was small (0.2-0.7cm). As well, there was good agreement across sessions. Based on the MDC_{95%}, the largest likely asymmetry that may exist due to error between sessions within a healthy, young adult population is approximately 2cm. Clinically, these findings serve to verify the current estimates of a 2cm cutoff score for potentially meaningful deficits in weight-bearing DFROM due to injury. Participants in the healthy, young adult population are unlikely to have asymmetries greater than 2 cm.

Reliability and Responsiveness of the Star Excursion Balance Test

Rinehart C, Sharpe N, Robison H, Kupiec M, Carlson J, Quintana L, Meilun R, McKeon PO, King D: Ithaca College, Ithaca, NY

Context: The Star Excursion Balance Test (SEBT) is a common clinical outcome tool used to assess dynamic postural control of the lower extremity. Estimates of intra- and inter-rater reliability have been established, but the responsiveness over time is needed to understand the anticipated day-to-day performance changes. Objective: The purpose of this study was to examine the reliability and responsiveness of SEBT performance over two sessions in a group of healthy, young adults. **Methods:** Study Design: Reliability Study. Setting: Research Laboratory. Participants: Twenty-two healthy adults (17 females, 5 males, age: 18.9±1.0 years, height: 119.8±9.3 cm, mass: 71.3±16.2 kg) participated. All subjects provided informed consent and confirmed that they had no lower extremity injuries or health problems that would affect balance prior to participating in the study. Interventions: All subjects participated in two testing sessions, separated by at least two days, where they performed three trials reaching in three SEBT directions; anterior (ANT), posterolateral (PL) and posteromedial (PM) on each limb. Each subject performed at least three practice trials for each direction on each limb before testing. The mean of the three trials for each direction was used for analysis. Main Outcome Measures: Because there were no differences between right and left limbs, SEBT scores from both limbs were pooled to create an unbiased performance estimate for each participant for each session. To examine the intersession reliability, intraclass correlation coefficients (ICC_{2,3}) were calculated from the pooled limb scores for the SEBT-ANT, SEBT-PL, and SEBT-PM directions. From the ICC, the standard error of measure (SEM) was calculated to estimate the responsiveness of the

three reach directions between sessions. From the SEM, the minimum detectable change (MDC_{95%}) was calculated ($SEM \times \sqrt{2} \times 1.96$). The MDC_{95%} provides an inferential estimate of the largest error that is likely going to be present in the healthy, young adult population between testing sessions. **Results:** The SEBT-ANT (session 1: 58.2±5.6 cm, session 2: 58.0±5.7 cm, ICC_(2,3) = 0.95, SEM = 1.3 cm, MDC_{95%} = 3.5 cm), SEBT-PL (session 1: 66.2±9.56 cm, session 2: 66.30±8.7 cm, ICC_(2,3) = 0.94, SEM = 2.2 cm, MDC_{95%} = 6.1 cm), and SEBT-PM (session 1: 75.3±9.4 cm, session 2: 73.4±7.5 cm, ICC_(2,3) = 0.87, SEM = 3.0 cm, MDC_{95%} = 8.4 cm) directions demonstrated strong intersession reliability estimates with small SEMs. **Conclusions:** The SEBT demonstrated excellent reliability and responsiveness when performing multi-session testing. The amount of change anticipated in the healthy, young adult population appears to be the smallest in the SEBT-ANT (MDC_{95%} = 3.5 cm) and largest in the SEBT-PM (MDC_{95%} = 8.4 cm). Clinically, these findings can be used to establish cutoff scores for potentially meaningful changes in SEBT performance due to factors such as injury and rehabilitation in the healthy, young adult population.

The Diagnostic Accuracy of Residency Trained Athletic Trainers for Shoulder and Knee Pathologies

Pecha FQ, Wetherington JJ, Nicoletto TS, Lam KC: St. Luke's Sports Medicine, Boise, ID; A.T. Still University, Mesa, AZ

Context: The evaluation of musculoskeletal conditions is a primary component of routine athletic training clinical practice. Yet, there is limited data describing the diagnostic accuracy (DA) of athletic trainers. Our objective was to determine the DA of residency trained athletic trainers (RTATs) for shoulder and knee pathologies within a sports medicine clinic. **Methods:** Eleven RTATs prospectively collected patient data from 2014-2018 in a sports medicine clinic. RTATs had a master's degree in a healthcare-related field, completed a Commission on Accreditation of Athletic Training Education accredited athletic training residency program, and had 1-5 years of certified experience. Patients arrived at the clinic complaining of shoulder or knee issues and were initially evaluated and diagnosed (ICD-9/-10 code) by a RTAT. After the completion of the RTAT evaluation, an orthopedic physician entered the exam room and performed a separate evaluation determining if the patient needed magnetic resonance imaging (MRI) for further evaluation. Following the MRI, a fellowship trained radiologist provided an outcome report which included a diagnosis. The orthopedic surgeons and radiologists were blinded to the initial diagnosis recorded by the RTAT. Diagnoses provided by the RTAT initial evaluation and the MRI outcome reports were paired by patient and compared for agreement. Descriptive statistics were used to summarize study findings, with DA defined as the percent agreement between the diagnoses reported by the RTAT and MRI outcome report. **Results:** A total of 122 patients reported to the sports medicine clinic complaining of shoulder (n=61, male=38, female=23) and knee (n=61,

male=28, female=33) problems. RTATs demonstrated 82.0% (100/122) DA across all conditions when compared to MRI outcome reports. The most common diagnoses recorded by the RTAT were labral (45.9%, n=28/61) and rotator cuff (41.0%, n=25/61) pathology for the shoulder, and medial meniscal tear (42.6%, n=26/61) and anterior cruciate ligament sprain (26.2%, 16/61) for the knee. When analyzing DA per body region, RTATs demonstrated 93.4% (57/61) and 70.5% (43/61) DA for shoulder and knee injuries, respectively. For common shoulder conditions, RTATs demonstrated 92.9% (26/28) and 96.0% (24/25) DA for labral and rotator cuff pathologies, respectively. For common knee conditions, RTAT demonstrated 65.4% (17/26) and 87.5% (14/16) DA for medial meniscal tears and anterior cruciate ligament sprains, respectively. The most common diagnoses missed by the RTAT were lateral (54.4% missed, 6/11) and medial (34.6% missed, 9/26) meniscal tears. **Conclusions:** Our findings suggest that RTAT demonstrate good DA when evaluating shoulder and knee pathologies in an orthopedic clinic and similar DA when compared to other healthcare providers. Our results also indicate that RTAT are more accurate in evaluating shoulder than knee pathologies. These findings suggest that RTAT can be an important member of a team-based approach to patient care within the orthopedic setting, particularly during the evaluation process.

The Intra-Rater Reliability of a Battery of Closed Chain Physical Performance Measures for the Upper Extremity

Marant DJ, Coulter CB, Olds M, Sciascia AD, Hoch JM, Uhl TL: University of Kentucky, Lexington, KY; Flawless Motion, Auckland, New Zealand; Eastern Kentucky University, Richmond, KY

Context: Increased rate of shoulder injuries have been reported in the latter stages of sporting events¹. However, previous research on closed kinetic chain (CKC) physical performance measures in the upper extremity have not examined an endurance component in the measure². We created four physical performance measures to assist clinicians in decision-making for return to sport following a shoulder injury. We hypothesize the intra-rater reliability of these four upper extremity physical performance measures will exceed an intraclass correlation coefficient (ICC) >0.85 for three raters. **Methods:** This was a quasi-experimental design carried out in a clinical laboratory setting.

Thirty-three healthy subjects, with no history of shoulder injury or surgery, volunteered from a collegiate community (19 Male, 16 Female; Age:24±6years; Height:177±99cm; Weight:78±19kg; Arm Length:77±4cm). Subjects completed a series of four CKC upper extremity physical performance measures on two separate days in a randomized order, which remained consistent across days. All performance measures were performed continuously for one minute, with a two-minute rest between tests. One examiner recorded the trial and all three examiners were blinded and independently counted the repetitions. The four tests were: 1) Single Arm Line Hop Test: the participant balanced on their knees with their right hand on the right side of a 3.8cm strip of tape. While the hips were extended, they hopped their hand over the tape and then back to perform one repetition. 2) Push-Up Claps: the participant started in a standard push-up position on their toes and performed an explosive push-up to clap their hands while in flight and returned to the position for one repetition. 3) Side Hold Rotations:

the participant started in a side plank position with the elbow straight and opposite arm extended and horizontally abducted with the top foot in front. The participant then rolled onto their toes to roll the body as a plank with hips parallel with the floor, crossed the top hand over the stabilizing hand, then returned to the starting position for one rotation. 4) CKC Upper Extremity Stability Test: the participant started with their hands on the outside of tape 91.4cm apart. While they maintained the plank position, they reached one hand across to tap the supporting hand, and then returned the moving hand to the start position. Statistical analysis was performed using the ICC function in SPSS v24 (IBM, Armonk, NY) and the standard error of measurement and MDC₉₀ was calculated in excel. **Results:** There was excellent intra-rater reliability for all three raters (ICC=0.96-0.99) (Table). **Conclusions:** This test battery is easily performed in the clinical setting and is consistent between raters. The low MDC values (< 4 repetitions) indicate that these tests are responsive to detect improvement in performance.

Table for Reliability: Comparison of 3 Raters

	Rater 1 Mean(SD)	Rater 2	Rater 3	ICC	SEM	MDC ₉₀
L Single Arm Line Hop	23(9)	22(9)	22(9)	0.99	1	2
R Single Arm Line Hop	22(8)	22(8)	22(8)	0.98	1	2
L Side Hold Rotations	18(6)	18(6)	17(6)	0.98	1	2
R Side Hold Rotations	17(6)	17(5)	17(6)	0.96	1	2
Push-up Claps	14(10)	14(10)	14(10)	0.98	1	3
CKCUEST*	25(17)	25(17)	24(17)	0.99	2	4

*Closed Kinetic Chain Upper Extremity Stability Test

SD= standard deviation; ICC= intraclass correlation; SEM= standard error of measurement; MDC₉₀= minimal detectable change with a 90% confidence interval

Test-retest Reliability of a Digital Version of the Foot and Ankle Ability Measure

Burcal CJ, Johnston M, Rosen AB:
University of Nebraska, Omaha, NE

Context: Patient-reported outcomes (PRO) are a useful tool that provide an athletic trainer with pertinent information about their patients' health-related quality of life and perceived disabilities. Digital versions of PROs are efficient methods of obtaining such outcomes, as they eliminate the time required to grade and score the instrument. With the recent shift towards using electronic medical records (EMR) in medical practice and the implementation of these EMR systems in athletic training, it is imperative that digital adaptations of PROs are validated. Therefore, the aim of this investigation was to assess for the test-retest reliability of a digital version of the Foot and Ankle Ability Measure activities of daily living (FAAM) and sports (FAAM-S) compared to the original paper version. **Methods:** We collected data from a convenience sample of 50 university students. Participants reported to the research laboratory and completed two methods of administration (MOA) of the FAAM and FAAM-S: paper and digital. Participants were randomized via coin-flip to complete the paper or digital MOA first. Participants took a 5-minute break after completing the first MOA and then completed the second MOA. To allow for an assessment of the responsiveness and validity across a range of scores, data was removed from 22 participants as they had a score of 100% on the FAAM or FAAM-S for both limbs. We conducted two separate reliability analyses on the limb with the lowest score for the remaining 28 participants (11 male, 17 female; age: 25.89 ± 6.65 yr; mass: 73.91 ± 17.28 kg; height: 172.91 ± 10.36 cm). Random-effects intra-class correlation coefficients (ICC) were calculated for absolute agreement between the two MOA using SPSS version 24. **Results:** Both the FAAM and FAAM-S were shown to be highly reliable

with average ICC values above 0.9. The FAAM had an ICC estimate of 0.921 (95% CI: 0.830, 0.963), and the FAAM-S had an ICC estimate of 0.971 (95% CI: 0.937, 0.987). However, our participants on average did not have a high level of disability as indicated by the scores on the PRO. Scores on the FAAM were $91.48 \pm 9.48\%$ for the paper MOA and $90.22 \pm 10.30\%$ for the digital MOA. Scores on the FAAM-S were $81.69 \pm 19.52\%$ for the paper MOA and $81.73 \pm 18.04\%$ for the digital MOA. **Conclusions:** A digital version of the FAAM and FAAM-S is reliable when compared to the originally validated paper MOA. It is common in both clinical practice and research to utilize digital MOA for PROs and other survey-based assessments (e.g. inclusion criteria). These preliminary results from a convenience sample reflect the feasibility and accuracy of using digital MOA for assessing foot and ankle function. Caution must be noted as the digital MOA of PROs should be validated in specific patient populations prior to use as a clinical decision-making tool.

Reliability of a Clinical Assessment Tool for Measuring Scapular Mobility

Silverson OA, Cascia NG, Hettrich CM, Heebner NR, Uhl TL: University of Kentucky, Lexington, KY

Context: Abnormal positioning of the scapula has been linked to shoulder pathology. Quantitative measures of scapular position can provide clinicians with objective values to identify mobility impairments. Currently, scapular mobility can be measured accurately and reliably in the clinical setting using an electronic inclinometer for the motion of scapular upward rotation. Measuring scapular internal rotation and posterior tilting is limited due to orientation restrictions with respect to gravity. The objective of this study was to investigate the reliability of a new electric goniometer using an inertial measurement unit that removes the dependence on gravity for measuring scapular mobility in the three orthogonal planes during scapular and humeral motions. We hypothesized that the intra-rater reliability

of a single examiner on the same day will exceed Intraclass Correlation Coefficient (ICC(1,3)) of 0.80 with a standard error of measure (SEM) less than 5° of error. **Methods:** This is a repeated measure design carried out in a clinical laboratory setting, to evaluate intra-rater reliability. The right scapula of 17 healthy participants (9 females, 8 males; age: 28±15 years; height: 1.7±0.12 m; mass: 73± 18 kg) was measured by a single rater during a single testing session. Three trials of each motion were recorded. The motions included were: scapular shrug, protraction, and retraction occurred with arms at side, and humeral elevation to 120° in the scapular plane were performed in an upright sitting posture using the EasyAngle electric goniometer (Melog AB, Stockholm, Sweden). The start and end positions of the scapula for each of the motions were recorded to determine the excursion of scapular rotation in three planes: frontal, sagittal and transverse. The motions of positive direction for each orthogonal plane were: scapular downward rotation, internal rotation,

and posterior tilt. The average of three trials for each motion was assessed for intra-rater reliability ICC(1,3) (p<0.05). For each position, SEM and minimal detectable change with 90% confidence boundary (MDC90) was calculated. **Results:** Overall the reliability for both start and end positions were excellent with ICC values all greater than 0.83 and SEM not exceeding 3°. (Table) **Conclusions:** Based on the ICC(1,3) values for intra-rater reliability, the use of the EasyAngle to measure static scapular position proves to be a reliable device when used by a single rater in the same session. The responsiveness of this goniometric evaluation is consistent with previous studies of scapular and glenohumeral measures. Objective measurement of scapular position and excursions can provide clinicians with quantified values that will advance scapular assessment relating to shoulder pathology. Future investigation of this goniometric measurement device should focus on the reliability between raters and across days.

Table: Intra-rater reliability within a single session: ICC(1,3)

Plane of Rotation	Scapular Motion	Start Position				End Position			
		Mean (SD)	ICC	SEM	MDC ₉₀	Mean (SD)	ICC	SEM	MDC ₉₀
Downward Rotation (+)	Shrug	0 (3)	0.91	1	2	-25 (11)	0.95	2	6
	Elev 120*	2 (5)	0.85	2	5	-25 (8)	0.83	3	8
Internal Rotation (+)	Retraction	33 (6)	0.93	2	4	10 (9)	0.95	2	5
	Protraction	33 (5)	0.85	2	5	46 (5)	0.86	2	4
	Elev 120*	30 (6)	0.83	2	5	24 (8)	0.87	3	7
Posterior Tilt (+)	Retraction	-18 (6)	0.92	2	4	-12 (8)	0.92	2	5
	Protraction	-18 (8)	0.89	2	6	-21 (7)	0.86	3	6
	Elev 120*	-18 (6)	0.93	2	4	-4 (7)	0.94	2	4

*Elev 120: Arm elevation to 120° degrees of flexion in the scapular plane (30° in frontal plane)
All reported values represent degrees, with exception of ICC values.

Reliability of the Hruska Adduction Lift Test

Stant MF, Scibek EP, Grimes JK: Sacred Heart University, Fairfield, CT; University of Delaware, Newark, DE

Context: Groin injuries, including hip adductor strains commonly occur in sports that require cutting and quick acceleration/deceleration movements. The current battery of tests used to predict those at risk for groin injuries continues to produce mixed results in effectiveness. Furthermore, investigations into groin injuries have not considered the possible effect trunk musculature activation and core stability have in injury risk. The Hruska Adduction Lift Test (HALT) is a test that examines hip adductor strength with trunk musculature activation, yet its effectiveness has not been determined. Therefore, the purpose of this study was to determine the intertester and test-retest reliability of the HALT. **Methods:** Cross-section design. Forty healthy NCAA D-I student-athletes (21 females, 19 males, age=20.0±1.2 years, mass=77.4±19.6kg, height=175.1±10.7cm, BMI=24.9±3.9kg/m²) were recruited, provided informed consent, and were enrolled in the study. The HALT is initiated by having the subject in a side-lying position with the superior or uppermost lower extremity abducted and resting on the examiner's shoulder. The hip is in a neutral position in the sagittal and transverse planes. In a 3-step process, the subject is asked to (1) raise the ankle of the lower leg to the knee of the top leg, (2) raise the lower knee off the table and (3) raise the lower hip as high as possible without letting the pelvis rotate forward or backward. The HALT is scored on a scale of 0-5. Following a practice trial, subjects performed two trials of the HALT on both left and right sides. Two different examiners scored each trial simultaneously. Subjects were then asked to report back in 3-5 days to perform testing again. The highest score obtained for each side was used for data analysis. Interrater reliability was assessed using

Pearson Product Moment Correlation coefficients, while intraclass correlation coefficients (ICC) were used to examine test-retest reliability. **Results:** Significant Pearson's r values ($p=.01$) were derived for both examiners in Session 1 (Right $r = 0.75$ and Left $r = 0.74$) and for Session 2 (Right $r = 0.85$ and Left $r = 0.88$). Examiner 1 demonstrated moderate test-retest reliability for the right HALT (ICC=0.67) and the left HALT (ICC=0.53). Examiner 2 also demonstrated moderate test-retest reliability for the right HALT (ICC=0.65) and the left HALT (ICC=0.56). **Conclusions:** The HALT demonstrated excellent intertester reliability and moderate test-retest reliability. Clinicians should consider using this assessment test in the evaluation of acute groin injuries in athletes as a reliable tool. Clinicians should also consider utilizing the HALT with the current battery of tests used to predict those at risk for groin injuries. Future investigations should explore the validity of the HALT as compared to other diagnostic measures and whether or not it can be used as an accurate prediction tool.

The Inter-rater Reliability of a Battery of Open Kinetic Chain Upper Extremity Physical Performance Measures

Coulter CB, Marant DJ, Olds M, Hoch JM, Sciascia AD, Uhl TL: University of Kentucky, Lexington, KY; Flawless Motion, Auckland, New Zealand; Eastern Kentucky University, Richmond, KY

Context: There is limited literature investigating open kinetic chain (OKC) physical performance measures in the upper extremity, particularly in overhead positions.¹ We created four open chain clinical tests to assist clinicians in return to play decision-making following a shoulder injury. We hypothesize these four novel upper extremity physical performance measures, designed to evaluate endurance and stability, will have inter-rater reliability that exceeds an intraclass correlation coefficient (ICC) >0.85 between raters. Methods: This is a quasi-experimental, repeated measure design performed in a clinical laboratory setting. Thirty-three healthy

subjects (18 male, 15 female; age: 24±6years; height: 177±8cm; weight: 78±16kg; upper extremity activity scale: 15±19) with no history of upper extremity injury or surgery within the last year, volunteered from a collegiate community. Subjects completed a series of four OKC upper extremity physical performance measures on two separate days one week apart. All performance measures were performed for one minute with a two-minute rest between each test. The tests were recorded by one examiner with a video camera and independently scored by all three clinicians blinded to each other's scores. The four tests consisted of: 1)Abduction External Rotation Test: subject stands holding a 3kg ball in one hand at the shoulder, extends the ball horizontally with palm up to maximal elbow extension, returns the ball to the shoulder, pushes the ball over head to full extension, then returns to the start position for one repetition. 2)Tennis Ball Drop Catches: subject holds a tennis ball in a position of 90 degrees of shoulder abduction and 90 degrees of elbow flexion, drops the ball and internally rotates their arm to catch

the ball and returns to starting position for one repetition. 3)Physioball Wall Taps: subject places a 55cm physioball above their head with arm fully extended, dribbles it down to 90 degrees and then dribbles back to starting position for one repetition. The previous three tests were performed bilaterally. 4)The Overhead Snatch: subject squats down holding a 5 kg medicine ball with both hands, touches the ground, presses overhead to full shoulder elevation and knee/hip extension and returns to the starting position for one repetition. Tests for each subject were administered in randomized order that remained consistent for both days of testing. Results: A two-way random ICC (2,1) was used to determine the level of reliability of each test between the three raters on day two and found to be excellent ranging from 0.91-0.982 (Table). Conclusions: This test battery is easily performed in the clinical setting and challenges the upper extremity in various planes of motion with good consistency between raters. Small changes less than 5 repetitions indicate meaningful change in performance measures with familiarization.

D.Table for Reliability: Comparison of 3 Raters

	Rater 1 Mean(SD)	Rater 2	Rater 3	ICC	SEM	MDC ₉₀
DropCatchR	52(13)	52(12)	53(13)	.96	2	5
DropCatchL	48(14)	49(13)	49(13)	.97	2	5
BallTapR	7(3)	7(3)	7(3)	.95	1	1
BallTapL	7(3)	6(3)	7(3)	.91	1	2
ABERR	16(4)	16(4)	16(5)	.92	1	2
ABERL	14(5)	14(5)	15(5)	.96	1	2
OH Snatch	23(5)	24(5)	24(5)	.98	1	1

SD= standard deviation; ICC= intraclass correlation coefficient; SEM= standard error of measurement; MDC₉₀= minimal detectable change with a 90% confidence interval

**Within- and Between-Day
Reliability of Corticomotor
Excitability Assessment
Techniques in the Upper
Extremity: A Reliability Study**

Takeo K, Norte GE, Glaviano NR, Ingersoll CD: University of Toledo, Toledo, OH

Context: Transcranial magnetic stimulation (TMS) is commonly used to quantify corticomotor excitability for both healthy and pathologic population. Improving our understanding of normal central neuromuscular function may help a health care provider identify possible origin of the musculoskeletal dysfunction and make informed clinical decisions. While reliability of assessment techniques with TMS has been studied extensively in lower extremity musculature and intrinsic hand muscles, their reliability has not been fully examined in muscles in the proximal upper limb. Therefore, our purpose was to examine within- and between-day reliability of corticomotor excitability assessment techniques for the upper extremity musculature in healthy individuals. **Methods:** This descriptive laboratory study was conducted in a university laboratory. Seven healthy individuals (5 males, 2 females; age = 22.4±1.1 years, height = 176.0±7.0 cm, mass = 78.3±8.2 kg) volunteered. Participants were assessed at 3 separate testing sessions on two days. We assessed within-session reliability by comparing two testing sessions performed 60 minutes apart on Day 1. Whereas, between-session reliability was assessed by the first measurement on Day 1 compared to the measurement on Day 2 approximately 24 hours apart. We recorded active motor threshold (AMT) and motor evoked potential at 120% AMT (MEP120) in flexor carpi radialis (FCR), middle deltoid (MD), and upper trapezius (UT) muscles bilaterally. MEP120 was normalized by mean pre-stimulation background EMG for statistical analysis. Intraclass correlation coefficients (ICCs_{3,1}) with 95% CI were used to assess reliability,

and are reported below. **Results:** In FCR, we observed good-to-excellent within-session (ICC_{3,1}=0.79 [95% CI: 0.18-0.96], and 0.91 [0.55-0.98]) and between-session (0.91 [0.57-0.98], and 0.88 [0.47-0.98]) reliability for AMT in dominant and non-dominant limbs respectively. Moderate-to-good within-session (0.81 [0.23-0.96], and 0.72 [0.03-0.95]) and between-session (0.50 [-0.32-0.89], and 0.74 [0.07-0.95]) reliability for MEP120 were observed. In MD, we observed good-to-excellent within-session (0.89 [0.51-0.98], and 0.83 [0.30-0.97]) and between-session (0.85 [0.36-0.97], and 0.92 [0.60-0.99]) reliability for AMT. Moderate-to-good within-session (0.81 [0.25- 0.97], and 0.78 [0.17-0.96]) and between-session (0.61 [-1.25-0.93], and 0.79 [0.19-0.96]) reliability for MEP120 were observed. In UT, we observed poor-to-moderate within-session (0.66 [-0.10-0.93], and 0.40 [-0.43-0.86]) and between-session (0.61 [-0.17-0.92], and 0.35 [-0.47-0.85]) reliability for AMT. Poor-to-moderate within-session (0.65 [-0.10-0.93], and 0.72 [0.03-0.95]) and between-session (0.32 [-0.50-0.84], and 0.73 [0.05-0.95]) reliability for MEP120 were observed. **Conclusions:** AMT and MEP120 were reliable outcome measures for clinical research on corticomotor excitability of flexor carpi radialis and deltoid muscles in healthy individuals. However, for proper techniques to assess corticomotor excitability of upper trapezius, further studies are warranted to establish reliable methodology. In addition, we suggest that future studies should examine test-retest reliability in longer time intervals, inter-rater reliability as well as other TMS variables to improve our understanding of normal central neuromuscular functions in upper limb muscles comprehensively and more in depth.

Free Communications, Poster Presentations: Social Media and Telemedicine

Mandalay Bay Convention Center, Hall Bayside D; Tuesday, June 25, 10:00AM-5:00PM; Wednesday, June 26, 10:00AM-5:00PM; Thursday, June 27, 10:00AM-1:00PM

Authors present June 24: Peer Review Authors – Last Names A through M: 10:30AM-11:15AM; Peer Review Authors – Last Names N through Z: 11:15AM-12:00PM

Athletic Trainers' and Orthopedic Physicians' Experiences With Telemedicine in Musculoskeletal-Based Patient Encounters

Winkelmann ZK, Eberman LE, Powden CJ, Games KE: Indiana State University, Terre Haute, IN

Context: Telemedicine is the delivery of healthcare across distances using videoconferencing for interactions among providers and patients. Telemedicine has been proposed to improve access to care while decreasing wait time. The integration of telemedicine as a supplement, rather than replacement, in athletic training has not been evaluated for musculoskeletal cases. Therefore, this project aimed to investigate the perceptions and experiences of healthcare providers regarding the integration of telemedicine. **Methods:** We used a cross-sectional explanatory sequential mixed-methods design with an online survey and individual phone interviews. A convenience sample of seventeen athletic trainers from a Midwestern, NCAA Division 1 institution (age=27±7 years; credentialed experience=4±5 years) and five orthopedic team physicians (age=59±10 years, credentialed experience=19±11 years) from a sports medicine clinic

located 92 miles from the institution participated in the study. Participants completed the valid and reliable theory of planned behavior and technology acceptance model tool (TPB-TAM). The TPB-TAM has six constructs scored on a 7-point Likert scale (1=strongly agree, 7=strongly disagree, score of ≤ 3 indicates positive planned behavior). Following the tool, participants were trained in the telemedicine platform. The participants used the telemedicine platform over a six-month intervention period for initial, follow-up, and discharge patient encounters. After the intervention period, individual phone interviews were conducted following a 12-question semi-structured protocol. Quantitative data were analyzed using descriptive statistics and an independent samples t-test. A 3-member coding team and two external auditors used the consensual qualitative research tradition to determine adoption status, domains, and categories. **Results:** 72% of providers (n=16/22) had no previous experience with telemedicine. From the interviews, the providers were characterized as a telemedicine adopter (n=14) or non-adopter (n=8). The adopters reported higher levels of agreement on the TPB-TAM as compared to non-adopters for all constructs (Table 1). While the subjective norm construct was the

sole construct with a negative planned behavior for the adopters, non-adopters reported no positive planned behaviors. Additionally, a significant difference was identified for the subjective norm construct as compared to adoption status (P<0.01). The qualitative analysis revealed five domains: integration challenges, integration opportunities, collaborative practice, anticipatory socialization, and benefits of integration. The participants indicated that integration challenges centered on buy in, whereas opportunities aligned with the patient's condition (e.g. follow-up visits) and technology ease. Participants reflected that they prepared for the telemedicine counters more, and the interaction allowed for cooperative behaviors between providers. Participants indicated the benefits of telemedicine included convenience and scheduling preferences that encouraged their use in future situations. **Conclusions:** The integration of telemedicine in athletic training brought about both challenges and opportunities for collaboration amongst athletic trainers and physicians that were heavily predetermined by the social pressures of colleagues. Stakeholders should consider the TPB-TAM to assess provider adoption when exploring telemedicine integration.

Table 1. TAM-TPB Construct Means (normative value = 3.0; 1-3 = positive behaviors, 3-7 being negative behaviors)

Constructs	Total Sample (n=22)		Adopter (n=14)		Non-Adopter (n=8)	
	Mean	SD	Mean	SD	Mean	SD
Attitude	2.86	0.99	2.57	0.93	3.38	0.93
Subjective Norms	3.67	1.00	3.31	1.03	4.29	0.58
Perceived Behavioral Control	3.00	0.87	2.81	0.98	3.33	0.50
Perceived Usefulness	2.85	1.15	2.64	1.17	3.21	1.11
Perceived Ease of Use	3.18	0.96	2.86	1.02	3.75	0.53
Behavioral Intention	2.97	1.12	2.73	1.26	3.38	1.03

Accuracy and Best Design Practices of Pinterest Bleeding Control Infographics: A Content Analysis

Walz J, Troy J, McKeighan M, Berry DC: Saginaw Valley State University, University Center, MI

Context: Pinterest is a medium for disseminating health-related educational information (e.g., flu prevention) through the use of “infographic pins.” However, it is unclear whether Pinterest pins related to first aid bleeding control are accurate. This study aimed to examine the accuracy of first aid bleeding control infographic pins and whether these pins incorporate best design practices via a content analysis. **Methods:** “Pins” were collected from Pinterest; a web-based social-media platform using a systematic search strategy. Pin identification was adapted from previous research and saved using Google Photos. Pins were collected on September 29th, 2018 using the following phrases: “severe bleeding,” “bleeding control,” “first aid,” “shock AND bleeding,” totaling 559 pins. Inclusion criteria: (1) English-language, (2) pin titles containing search terms or researcher accepted variations. Duplicate pins (n=13) were deleted, resulting in 40 pins. Four certified athletic trainers experienced in bleeding control established the coding rubric’s content and face validity. Three student raters with first aid training (American Heart Association [Dallas, TX]) reviewed and coded pins into Excel (Microsoft, Redmond, CA) for analysis. The rubric included 4-categories: (1) information (data) accuracy, (2) infographic design, (3) image content quality, and (4) rater’s opinion of the infographic. Three subscales (accuracy, design, image quality) were coded present (yes=1) or not present (no=0). Subscale scores were calculated by summing each subscale. A total “pin score” was calculated by summing the three subscales (range 0-21). Nine Likert scale (1=strongly disagree; 5=strongly agree) questions measured the rater’s opinion of the

infographic; score range=9-45. Three pins (3/40, 7%) established interrater reliability. Analyses were conducted using SPSS 22 (IBM Corp, Armonk, NY). Descriptive data were summarized in aggregate. Subscale and total scores served as dependent variables. “Pin scores” between 21-17 were designed “acceptable” infographics, 16-13 were “marginal”, and < 13 were “inadequate”. A Cohen’s kappa coefficient of .65 established an acceptable level of intercoder reliability. Alpha set a-priori at $p < 0.05$. **Results:** Forty pins were selected; 3 validated the coding rubric; 37 were used in the final analysis. One pin was removed; after further investigation, it did not pertain to humans. Thirty-six infographics were rated, scored, and analyzed. Subscale means (SD) and range scores were: (1) information accuracy (2.01 ± 1.41 , range=0-5), (2) infographic design (7.19 ± 1.96 , range=1-11), and (3) image quality (3.06 ± 1.06 , range=0-4). The overall pin score was 12.25 ± 3.68 , range=2-18. The rater’s opinion scored 26.67 ± 7.26 , range=8-36. Of the 36 pins, 1 (2%) were acceptable, 18 (50%) marginal, and 17 (47%) scored inadequate. **Conclusions:** Only 2% of infographic pins were considered “acceptable” for use. Readers looking for bleeding control recommendations should consult other resources. Future research should examine the accuracy of first aid health-related pins. Unless infographics are updated regularly and using evidence-based recommendations, the represented data and content quickly becomes outdated.

Athletic Trainers’ Social Media Use for Professional Advocacy

Hamilton SP, Neil ER, Winkelmann ZK, Eberman LE: Indiana State University, Terre Haute, IN

Context: Social media has become a prominent aspect of society related to sharing, learning, interacting, and marketing. Previous studies have identified the risks of social media and legal implications associated with these risks; however, there is gap in the literature regarding the positive role of social media to the athletic training profession. **Methods:** We conducted a qualitative analysis regarding athletic trainer engagement in social media specific to professional advocacy. Participants were recruited through Twitter® that had an active profile with >200 followers and identified themselves as an athletic trainer in their profile name or bio. The accounts were contacted via direct message to complete a survey containing the informed consent, demographic items, and interview availability. Focus groups consisting of 4-8 participants per session (5 sessions total) were conducted via a web-based videoconferencing platform (Zoom, San Jose, CA) for 40-70 minutes. The sessions followed a semi-structured interview protocol focusing on athletic trainers’ perceptions of how they are using social media, risks associated with social media use, and the role of social media for professional advocacy. The focus group sessions were de-identified, transcribed verbatim, and analyzed using a phenomenology approach with two investigators. The investigators collaborated to develop the themes, independently coded the data, and met to discuss any divergent coded data. An external review was performed to ensure the coded data appropriately represented the principles of the themes that emerged from the focus groups. **Results:** A total of 30 athletic trainers (age= 32 ± 8 years, 10 ± 8 years of clinical experience) that were predominately female (n=18/30, 60%) participated in the focus groups. On average,

participants had 8 active social media accounts that they accessed approximately 13 times per day. The focus group discussions resulted in three overarching themes: (1) mechanisms, (2) motives, and (3) considerations. Participants used a variety of social media platforms with separate personal and professional accounts. Primary motives for using social media included information gathering, information sharing, promoting accomplishments, networking, organizational practices, and peer-to-peer collaboration. The use of advocacy and education was seen through intentional actions such as correcting behaviors of other social media users, teaching non-health-care providers about the profession of athletic training, and the ability to promote professional organizations. Participants also described considerations while using social media including e-professionalism, legal and regulatory implications, and self-regulation including restraining from responding and avoiding impulse posting. Participants also stated they read and viewed some social media posts rather than engaging and replying as a means to limit unprofessional discourse. **Conclusions:** Social media, with conscious engagement, has the potential to be utilized for advocacy purposes within healthcare. Additionally, various social media platforms can allow members to seek out ways to network with other health care providers, discover and disseminate scholarly works.

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