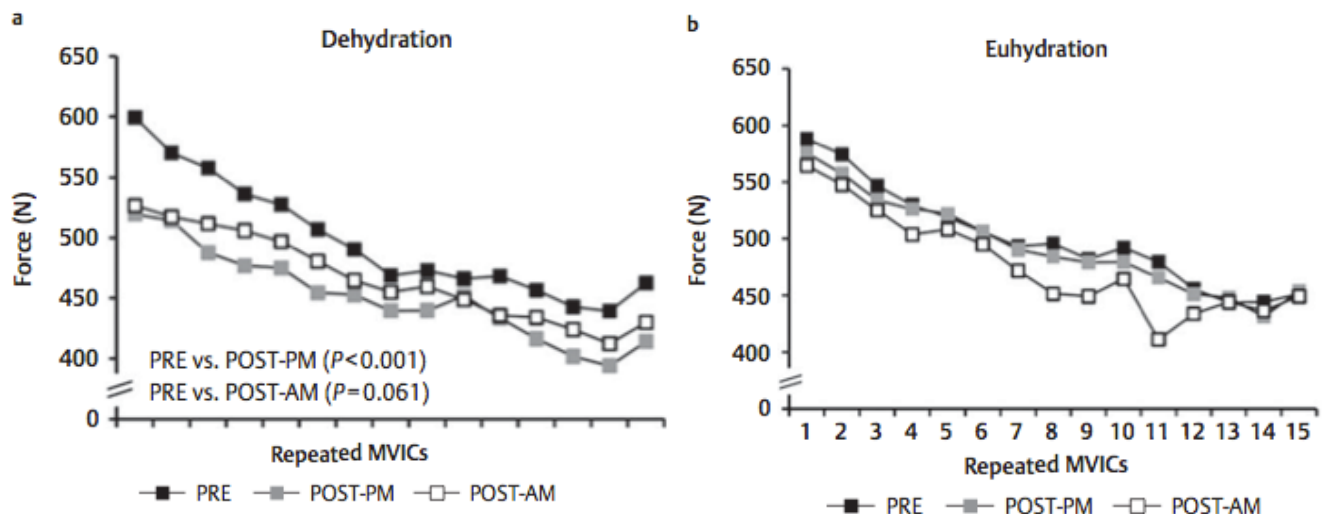


The Influence of Hydration on *Strength*

Summary of Findings

- ***Scientific Definition:*** The term strength is defined as the maximal force that a muscle or muscle group can generate at a specified velocity.¹
- Multiple reviews of the literature found that performance decrements were evident in relation to decreased strength with increased state of dehydration. These results, however, were variable as to magnitude of changes in strength with increasing state of dehydration.²⁻⁴
- It is difficult to interpret the results of the effects of hydration on strength due to both exacerbating (caloric restriction, increased muscle temperature, and fatigue) and masking (endurance training, test type, and menstrual status) factors within the methodological protocols which make it challenging to isolate the effects of dehydration on strength alone.⁵
- Of the six studies⁶⁻¹¹ to accurately assess the effects of dehydration on muscular strength, it is suggested that dehydration at a level of 3-4% body mass loss reduces muscle strength by an estimate of 2%.⁵
- Body mass losses of 3-4% can occur in exercise lasting 60-90 minutes, especially if an athlete begins practice dehydrated or there are additional external factors affecting sweat rate (environmental temperature, protective equipment/clothing, etc.).



These two graphs show the force production during 15 repeated brief maximal voluntary isometric contractions of the knee extensors of the non-dominant leg in both euhydrated and dehydrated subjects. The MVICs were performed prior to an exercise heat stress walk (PRE), immediately following the walk (POST-PM) and the following morning (POST-AM). Results show that there is a significant decrease in strength following the exercise heat stress walk and a near significant decrease in strength the following morning, which isolates the effect of dehydration on strength.¹²

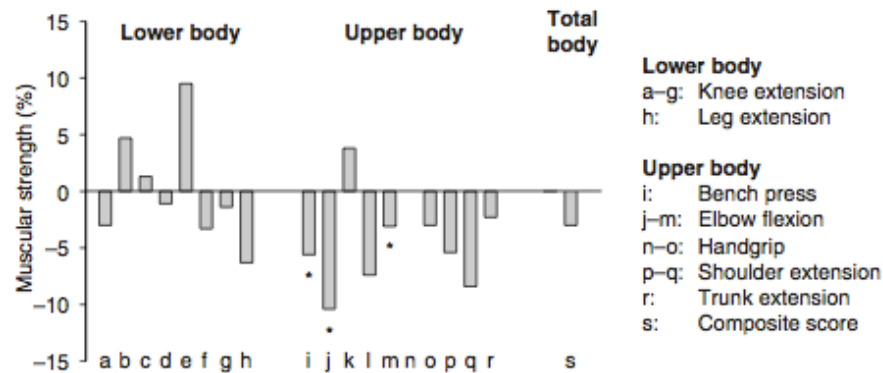


Fig. 1. Non-confounded effects of hypohydration on muscular strength. Data are presented as mean percentage change from baseline. Results from: Bosco et al.^[50] (a, h, j, n, o, r and s) [estimated from figures]; Greiwe et al.^[34] (b and k); Viitasalo et al.^[52] (c); Bosco et al.^[81] (d, e, l, m, p and q); Bigard et al.^[82] (f and q); and Schoffstall et al.^[40] (i). * $p < 0.05$.

Figure 1 take from: Judelson et al. *Sports Med.* 2007;37(10):907–921.

Practical Applications

- Prior to competition, practice, or conditioning sessions, ensure proper hydration to maximize strength during activity.
- Proper hydration during activity will assist in preventing any additive effects of dehydration on strength losses.
- Athletes participating in sports such as football, ice hockey, wrestling, and rugby should maintain adequate hydration to attenuate strength losses during activity.

Looking Ahead

- Further research investigating the effects of dehydration on strength in isolation from exercise or caloric restriction is needed to gain a better understanding of the magnitude on how dehydration affects strength during physical activity.
- Further investigations to determine if greater strength gains in athletes are obtained during strength and conditioning sessions if they are properly hydrated versus if they are dehydrated.

References

1. Knuttgen H, Kraemer W. Terminology and measurement in exercise performance. *J Appl Sport Sci Res.* 1987;1:1–10.
2. Judelson DA, Maresh CM, Anderson JM, et al. Hydration and muscular performance: does fluid balance affect strength, power and high-intensity endurance? *Sports Med.* 2007;37(10):907–921.
3. Sawka M, Pandolf K. Effects of body water loss on physiological function and exercise performance. In: Gisolfi C, Lamb D, eds. *Perspectives in Exercise Science and Sport Medicine*. Vol 3. Caramel: Benchmark Press; 1990:1–38.
4. Maughan RJ. Impact of mild dehydration on wellness and on exercise performance. *Eur J Clin Nutr.* 2003;57 Suppl 2:S19–23.
5. Judelson DA, Maresh CM, Anderson JM, et al. Hydration and muscular performance: does fluid balance affect strength, power and high-intensity endurance? *Sports Med.* 2007;37(10):907–921.
6. Bosco JS, Greenleaf JE, Bernauer EM, Card DH. Effects of acute dehydration and starvation on muscular strength and endurance. *Acta Physiol Pol.* 1974;25(5):411–421.
7. Bosco JS, Terjung RL, Greenleaf JE. Effects of progressive hypohydration on maximal isometric muscular strength. *J Sports Med Phys Fitness.* 1968;8(2):81–86.
8. Viitasalo JT, Kyröläinen H, Bosco C, Alen M. Effects of rapid weight reduction on force production and vertical jumping height. *Int J Sports Med.* 1987;8(4):281–285.
9. Schoffstall JE, Branch JD, Leutholtz BC, Swain DE. Effects of dehydration and rehydration on the one-repetition maximum bench press of weight-trained males. *J Strength Cond Res.* 2001;15(1):102–108.
10. Greiwe JS, Staffey KS, Melrose DR, Narve MD, Knowlton RG. Effects of dehydration on isometric muscular strength and endurance. *Med Sci Sports Exerc.* 1998;30(2):284–288.
11. Bigard AX, Sanchez H, Claveyrolas G, Martin S, Thimonier B, Arnaud MJ. Effects of dehydration and rehydration on EMG changes during fatiguing contractions. *Med Sci Sports Exerc.* 2001;33(10):1694–1700.
12. Périard JD, Tammam AH, Thompson MW. Skeletal muscle strength and endurance are maintained during moderate dehydration. *Int J Sports Med.* 2012;33(8):607–612.