Korey Stringer Institute
University of Connecticut
Preventing sudden death in sport

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The Influence of Hydration on *Intense Exercise in the Heat*

Summary of Findings

- **Scientific Definitions:** Hypohydration is the steady-state condition of decreased total body water. Dehydration is the process of losing body water (eg, during exercise).
- Dehydration increases exercising core body temperature, and when exercising in the heat, dehydration will lead to a greater core body temperature than when hydrated.
- Exercise in the heat has the potential to limit exercise performance due to the cardiovascular, thermoregulatory, metabolic, and neuromuscular changes that occur in the body.[1]
- During exercise, 70-90% of metabolic energy is released as heat and the rates of heat production and heat dissipation determines the rise in core body temperature.[1,2]
- As ambient temperature rises, the body relies on evaporative heat loss to dissipate the heat produced during exercise. During exercise in the heat, skin blood flow increases in response to evaporation of sweat. The increased skin blood flow competes with the increase blood flow needed for the working muscles. As a result, as ambient temperature rises there is a decrease in cardiac output, which decreases exercise performance.
- Dehydration, as little as 2% body mass loss, has been shown to further degrade performance in the heat by decreasing plasma volume levels, which put further strain on the cardiovascular system.[3–9] Dehydration also increases resting and exercising core body temperature, thus increasing the risk of heat illness during exercise in extreme temperatures.[10]
- Heat acclimatization is a process in which the body adapts to exercise in the heat through various physiological adaptations (increased sweat rate, decreased level of sodium lost in sweat, decreased rate of rise in core temperature, lower exercising heart rate, etc). Exercising in the heat in a dehydrated state negates any benefits of heat acclimatization.[2,11,12]

	Exercise in the Heat	Exercise in the Heat (Heat Acclimatized)	Exercise in the Heat (Hypohydrated)
Exercising Heart Rate	↑	↓	↑↑
Sweat Rate	↑	↑↑	↓
Rise of Core Temperature	↑	↓	↑↑
Skin Blood Flow	↑	↑	↓
Plasma Volume	↓	↑	↓↓
Cardiac Output	↓	↑	↓↓
Overall Exercise Performance	↓	↑	↓↓

←→: Negligible Change, ↑: Small Change ↑↑: Moderate Change, ↑↑↑: Large Change

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Practical Applications

- Athletes should maintain an appropriate level of hydration prior to the start of exercise in the heat and aim to minimize fluid losses during the event to attenuate any performance decrements.
- Ensuring proper hydration during exercise in the heat is of utmost importance as the added heat stress amplifies the cardiovascular strain and resulting performance decrements found with dehydration.
- During competition, an athlete who is hydrated is able to compete at a higher intensity with a lower heart rate, which improves overall performance.
- In competing in sports, which expose athletes to heat stress, it is important that athletes undergo a period of heat acclimatization in addition to maintaining an appropriate level of hydration. Heat acclimatization is a series of cardiovascular and other physiological adaptations that improves heat tolerance and improves the ability of athletes performing in the heat.
- Although an athlete may undergo a period of heat acclimatization to increase their performance during exercise in the heat, it is necessary to maintain an appropriate level of hydration because hypohydration negates any performance benefits associated with heat acclimatization.
- Maintaining an appropriate level of hydration is imperative during exercise in the heat.

Looking Ahead

- Further research is needed examining the effects of dehydration on exercise performance during real-world events in the heat. Some evidence shows that dehydration (<4% body mass loss) has no effect on exercise performance during real-world events (time trials, etc.), but the literature examining these effects in the heat is limited and has conflicting results.
- Examining the effects of dehydration during exercise in the heat in various age groups will help in identifying if a particular age group is more at risk for performance decrements or risk of exertional heat illness when exercising in the heat in a dehydrated state.

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