Hydration for the Tokyo Olympics: to thirst or not to thirst?

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Endurance and team-sport athletes competing at the 2021 Tokyo Olympics Games can expect hot and humid conditions. Ensuring euhydration prior to an event and minimising dehydration during competition will be important, to ensure an optimal physiological state and competitive advantage.[1] Contention exists, however, regarding a primary recommendation provided to athletes: drink to thirst or plan to drink. The debate is centred on the level of dehydration that can be incurred prior to its effects influencing physiological responses and performance.[2]

Whole-body sweat rate during exercise ranges from 0.5 to 2.0 L hour^{-1} with some athletes (~2%) sweating substantially more (>3.0 L hour^{-1}).[3] Gradual reductions in body mass of 2%–5% can occur if body water losses are not replenished, resulting in marked decrements in plasma (≥10%) and blood (≥6%) volume.[4] Such levels of dehydration lead to a state of hyperosmotic hypovolaemia that is proportional to the decrement in total body water.[5] Hyperosmolality during exercise reduces sweat rate, and thus evaporative heat loss, for any given core temperature.[6] As a result, the magnitude of hyperthermia experienced during endurance exercise under heat stress is exacerbated. Progressive dehydration and hyperthermia also intensify tachycardia and compromise the ability to maintain cardiac output, leading to a reduction in systemic, locomotor muscle and skin blood flow.[7]

Decrements in endurance capacity generally emerge when body mass losses surpass 2%–3% in association with thermal, cardiovascular and perceptual strain.[6 7] To optimise performance, it is recommended to drink during exercise to prevent excessive dehydration (>2% body mass) and electrolyte imbalances.[8 9] A dehydration-induced body mass loss of ~2% in a 70 kg individual is associated with a 2%–3% increase in plasma osmolality (~6 mmol kg^{-1}), which is the approximate osmotic threshold that triggers renal water conservation and acquisition (ie, thirst).[10] As such, it has also been suggested that athletes need only drink to thirst to maximise performance.[11] Given that the sensation of thirst may only be perceived when ~1.5 L of body water has been lost, coupled with thirst being alleviated before complete rehydration is achieved,[12] drinking to thirst may lead to involuntary dehydration. Notwithstanding, several circumstances may warrant drinking to thirst, whereas others might require a more calculated approach.[10] In elite athletes, drinking to thirst may be sufficient to offset fluid losses during low-to-moderate intensity exercise <60 min in cool climates. Conversely, high-intensity exercise eliciting an elevated sweat rate, along with activities lasting >60 min in the heat, should be accompanied with a planned hydration strategy (figure 1).

Of note, a given level of dehydration on completion of an event does not represent the hydration status experienced throughout the event. A 70 kg individual competing at a high intensity for 60 min might sweat at a rate of 2 L hour^{-1}, leading to a 2.9% loss in body mass if fluids are not consumed. In this scenario, a 2% body mass deficit would

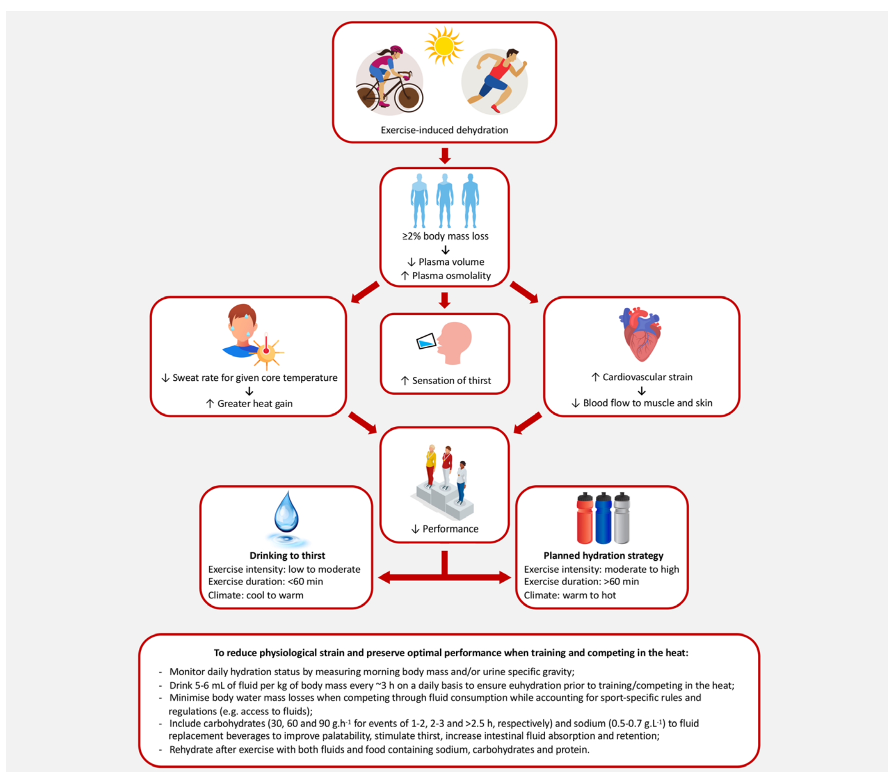

Figure 1 Effects of exercise-induced dehydration and recommendations for optimising endurance performance in the heat. Exercise-induced water loss (>2% body mass) via sweating leads to hyperosmotic hypovolaemia, which triggers the sensation of thirst, but also reduces sweat rate for any given core temperature and increases the cardiovascular response to a given work rate. These adjustments impair endurance performance through exacerbated hyperthermia and reduced blood flow to exercising muscles and the skin. Both exercise-induced dehydration (process of losing body water) and hypohydration (state of body water deficit) induce these responses. The choice of drinking to thirst or adopting a planned hydration strategy should be considered based on exercise intensity, duration and climatic conditions, with the aim to minimise body mass loss within the constraints of the sport (rules and regulations), rather than fully replace the deficit.

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only be surpassed in the final ~20 min of exercise. Given that performance is not suddenly and markedly impaired on reaching a particular level of dehydration, but rather decreases progressively, the impact of such a deficit on performance may be difficult to quantify in a competitive field setting (eg, motivation, pacing, end-spurt). Podium placements are often determined within the final moments of competition, so having an individualised hydration strategy is likely to optimise high-intensity exercise performance in the heat by reducing the detrimental effects of dehydration in the latter stages of an event. Another aspect worth acknowledging is the rate at which fluids can be absorbed. Gastric emptying rates of 15–20 mL min^{-1} can be maintained during exercise when water and/or a dilute carbohydrate solution (<8%) are ingested.[13] At higher exercise intensities (>70% of maximal aerobic capacity) gastric emptying and intestinal water absorption are reduced, which may prevent some hydration regimens from offsetting sweat losses. Consideration should therefore be given to the level of dehydration that will potentially be incurred.

Proper hydration between training sessions and events is as important as fluid consumption during competition, if not more essential. Inadequate hydration following training may lead to a state of hypohydration prior to a subsequent session or competition. Hypohydration leads to hypovolaemia and hyperosmolality, which increase the internal temperature thresholds for thermoregulatory cutaneous vasodilation and sweating during exercise.[14] Initiating exercise hypohydrated will therefore expedite the development of thermal and cardiovascular strain.

Prolonged exercise in hot/humid environments should be undertaken in a euhydrated state with sweat losses replaced to prevent excessive reductions in total body water. Hydration regimens should be athlete-specific and consider both sweat rate and composition (eg, sodium). The choice of drinking to thirst or utilising a hydration plan should be based on exercise intensity and duration, the prevailing ambient conditions, and sport-specific rules and regulations regarding access to fluids. Figure 1 provides recommendations to reduce physiological strain and preserve optimal performance when training and competing in the heat.

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