Hydration for recreational sport and physical activity

Robert W Kenefick and Samuel N Cheuvront

This review presents recommendations for fluid needs and hydration assessment for recreational activity. Fluid needs are based on sweat losses, dependent on intensity and duration of the activity, and will vary among individuals. Prolonged aerobic activity is adversely influenced by dehydration, and heat exposure will magnify this effect. Fluid needs predicted for running 5–42 km at recreational paces show that fluid losses are <2% body mass; thus, aggressive fluid replacement may not be necessary. Competitive paces result in greater fluid losses and greater fluid needs. Fluid needs for recreational activity may be low; however, carbohydrate consumption (sport drinks, gels, bars) can benefit high-intensity (≥1 h) and less-intense, long-duration activity (≥1 h). Spot measures of urine color or urine-specific gravity to assess hydration status have limitations. First morning urine concentration and body mass with gross thirst perception can be simple ways to assess hydration status.

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INTRODUCTION

Recreational physical activity is broadly defined by the US Department of Health and Human Services as “any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level.” This definition encompasses numerous activities from gardening and dancing to hiking, running, or cycling. Individuals who participate in these activities or exercise modalities may participate on an individual basis or may train and compete in a sport as a member of a club or community-based team or league. Whatever the activity, the primary purpose of recreational physical activity is usually participation, with related goals of improved health, physical fitness, fun, and social involvement. Recreational sport/physical activity is typically perceived to be less stressful, both physically and mentally, on the participants relative to competitive sport. However, in practice, the division between the concepts of recreation and competition is often blurred and definitions of either pursuit are somewhat arbitrary because many individuals train and compete in casual sporting activities in a highly competitive manner. Regardless of the degree of commitment to recreational sport or physical activity, the role of hydration remains equally important. However, fluid needs for individuals are highly variable depending upon the amount and intensity of physical activity and environmental conditions, among other factors. Because hydration plays an important role in the ability to perform prolonged athletic and recreational sport/physical activities, individuals must be able to monitor their hydration status accordingly. Thus, the purpose of this review is to provide general recommendations regarding fluid needs for recreational sport/physical activity and to present an overview of hydration assessment and the impact of hydration on performance.

ENVIRONMENTAL HEAT STRESS, DEHYDRATION, AND PERFORMANCE

Fluid needs are likely to be low for many recreational sport/physical activities that are intermittent, of short duration (<1 h), and of lower exercise intensity. However, because many individuals partake in recreational sport/physical activity in a competitive manner, performance is an important consideration and, accordingly, hydration will be a concern. Recreational sport/physical activities
include those that are predominantly aerobic or anaerobic or some mix of the two. Activities that primarily require aerobic metabolism and are prolonged will be more adversely influenced by dehydration than tasks that require anaerobic metabolism or muscular strength and power. Unless the types of activities are repeated bouts, the majority of literature in this area suggests it is unlikely that dehydration degrades muscular strength or anaerobic performance in any meaningful way.

Although the specific mechanism of action is a subject of debate, there is consensus that body water deficits will often degrade aerobic exercise performance. A comprehensive review of a number of studies investigating the impact of dehydration on physical exercise performance reported that in the majority of studies, exercise performance decreased with levels of dehydration of 2% body mass loss, and this reduction in exercise capacity was further accentuated when combined with heat stress. In addition, as the level of dehydration increases, aerobic exercise performance is degraded proportionally and the magnitude of performance decrement is likely related to environmental temperature and exercise task. A recent review by Sawka et al. highlights the impact of high skin temperature in combination with dehydration on the impairment of submaximal aerobic exercise performance. This review presents an overview of work supporting the concept that dehydration impairs submaximal aerobic performance and that the effect is accentuated as skin temperature (i.e., ambient temperature) increases (Figure 1). It is important to note that by maintaining a well-hydrated state during exercise by drinking small amounts of fluid, exercise performance impairment due to dehydration can be abated.

**WATER AND ELECTROLYTE NEEDS FOR RECREATIONAL SPORT/PHYSICAL ACTIVITY**

Physical activity results in increased water requirements that parallel sweat losses for evaporative heat exchange. Heat gain from metabolism is balanced by both dry and evaporative (sweating) heat loss, but very high metabolic rates coupled with warm weather result in a larger physiological requirement for evaporative cooling, leading to greater sweat losses and consequently larger water requirements. Thus, the magnitude of sweat losses incurred during recreational sport/physical activity is dependent primarily on metabolic rate, but also on exercise duration and environment. Usually hydration status fluctuates narrowly within the course of a day, but physical activity can increase water losses substantially. The adequate intake for total water per day is 3.7 L for young men and 2.7 for women. These values include the fluids contained in foods, which contribute approximately 20%. The daily water needs alone for sedentary men are reported to be around 1.2 to 2.5 L and increase to approximately 3.2 L if performing modest physical activity. Compared to sedentary adults, active adults who live in a warm environment are reported to have daily water needs of approximately 6 L, and highly active populations have been reported to have markedly higher values (>6 L). It is important to note that even under standardized conditions, in fairly homogeneous populations, inter-subject sweating variability is significant. In addition to air temperature, other environmental factors such as relative humidity, air motion, solar load, and protective clothing will influence heat strain and thus water needs. Other factors can alter sweat rates and ultimately fluid needs. For example, heat acclimatization results in higher and better sustained sweating rates, whereas aerobic exercise training has a modest effect on enhancing sweating rate responses.

Recreational sport/physical activity comprises a broad range of activities. The individuals who partake in these activities are of varying levels of fitness and body size (among other factors); thus, precise fluid recommendations are difficult to determine. To illustrate fluid needs for a range of exercise durations and for individuals of differing abilities and body masses, the recently developed sweat prediction equation of Gonzalez et al. was used to predict sweat losses for two hypothetical recreational
runners over distances of 5 km to the marathon (42 km). Running was chosen as an example because it is a common component of most sports and is a continuous activity that can be modeled with greater accuracy.\textsuperscript{2} These predictions were made for temperate (22°C) and warm (30°C) conditions common to mass-participation running events\textsuperscript{28} and using typical finishing times of less competitive (Figure 2) and highly competitive recreational runners (Figure 3). These fluid losses were then expressed as the percent loss in body mass over the duration of the competition. As previously mentioned, a threshold of 2% loss of body mass is considered an important threshold, as losses >2% are associated with decrements in aerobic exercise performance.\textsuperscript{29,30} What can be observed is that for most recreational runners, typical finishing times result in fluid losses <2% of body mass for distances up to 21 km and it is not until the marathon distance in hot conditions (30°C) that heavier individuals (80 kg) lose >2% of body mass by the very end of the event. For more competitive recreational runners (Figure 3), fluid losses are more appreciable and both smaller and larger runners exceed 2% loss of body mass in both warm and hot conditions during the marathon but are below 2% loss for the other distances (5–21 km).

These predictions are important because they illustrate that fluid replacement becomes increasingly critical for recreationally competitive athletes as exercise duration increases and weather warms. For individuals who are less concerned with performance and are exercising or performing activities at lower intensities, a fluid replacement plan may not be as important because fluid losses do not appear to approach 2% body mass loss. As previously mentioned, sweat rates can be highly variable\textsuperscript{26} and the predicted group sweating rates\textsuperscript{2} and fluid losses presented (Figures 2 and 3) may be greater or smaller for a particular individual. It is therefore recommended that individuals concerned with performance determine their own sweat rate. This can be accomplished by measuring acute changes in body weight before and immediately after exercise. Exercise is best done in the environmental conditions and at the exercise intensity anticipated for competition. In the absence of drinking, change in body weight can be used as an approximation of the volume of

\begin{figure}
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\includegraphics[width=\textwidth]{figure2.png}
\caption{Percent loss in body mass predicted from sweat rate for recreational runners of average ability weighing 60 kg (clear bars) and 80 kg (speckled bars) during 5 km (25 min), 10 km (60 min), 21 km (130 min), and 42 km (270 min) road races. Dotted line demarks 2% body mass loss. Losses assume no fluid intake.}
\end{figure}

\begin{figure}
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\includegraphics[width=\textwidth]{figure3.png}
\caption{Percent loss in body mass predicted from sweat rate for competitive recreational runners weighing 60 kg (clear bars) and 80 kg (speckled bars) during 5 km (21 min), 10 km (43 min), 21 km (95 min), and 42 km (200 min) road races. Dotted line demarks 2% body mass loss. Losses assume no fluid intake.}
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sweat lost (e.g., 1 kg = 1 L), although there may be some small sources of error in this assumption.31

CARBOHYDRATE AND ELECTROLYTE NEEDS

Absolute fluid needs may be relatively low for shorter-duration activities (<60–90 min), especially in cooler environments. For activities performed for longer durations especially in warm/hot environments, intake of electrolytes and supplemental carbohydrate can be advantageous for retention of fluid and exercise performance. The average American diet contains approximately 3.5 g/day (~150 mEq) of sodium20 in comparison to sweat sodium concentration, which averages approximately 35 mEq/L (range, 10–70 mEq/L).32 Therefore, sodium supplementation is generally not necessary except if performing very heavy activity during the first several days of heat exposure, as normal dietary sodium intake otherwise appears adequate to compensate for sweat sodium losses.30 Although the inclusion of electrolytes in sport drinks is less important as a means of replacing those lost during recreational sport/physical activity, they do play important roles in retention of fluid and fluid acquisition.33

Carbohydrate consumption can be beneficial to sustain exercise intensity during high-intensity exercise events >1 h, as well as less intense exercise events sustained for even longer periods.34 Sport drinks containing a carbohydrate-electrolyte solution between 5% and 10%, consumed at 1 L/h or 1 g/min, have been shown to help maintain blood glucose levels and exercise performance35 and enhance fluid retention by the kidneys. Sport drinks attempt to provide both adequate fluid replacement and carbohydrate supplementation. However, if fluid needs are low (e.g., cooler conditions, slower paces; Figures 2 and 3) but the need to provide carbohydrate exists (activity > 1 h), it may be difficult to deliver carbohydrate at a rate of 1 g/min. In such cases, supplementation with a more concentrated sport drink or nonfluid carbohydrate sources such as gels, energy bars, and other foods can help to sustain exercise performance.

Children and prepubescent youth are likely to take part in recreational sport/physical activity to a greater degree than adults, but have been studied to a lesser extent. Children have been reported to have lower sweating rates than adults and these lower sweating rates are probably the result of smaller body mass and thus a lower metabolic rate. In addition, children’s sweat electrolyte content has been reported to be similar to or slightly lower than that of adults.39 Given their lower sweat rates, in addition to the fact that organized recreational sport practice and competition for youth tends to be shorter duration, intermittent activity with numerous fluid and rest breaks, fluid replacement and carbohydrate/electrolyte supplementation is less of a concern. However, recreational sport for pre- and post-pubertal youth can be of a highly competitive nature and can involve prolonged practice sessions and intense competition multiple times a day. In these cases a sport drink or other nonfluid sources of carbohydrate and electrolyte may be advisable.

HYDRATION IN THE WORKPLACE

Hydration in the workplace is a specific concern because dehydration can affect productivity and safety. It should be noted that a more comprehensive overview of this topic than presented here is available.37 During physical work in the heat, sweat output can often exceed water intake, which can lead to dehydration. Bishop et al.38 observed that, in simulated industrial work conditions, encapsulated protective clothing increased sweat rates up to 2.25 L/h. Given such high fluid losses, maintaining fluid balance can be difficult during the work day, especially during shifts of greater than eight hours. Workers may not only become dehydrated on the job but may remain in this state until the start of the next work day. Few studies exist on the impact of dehydration on manual labor productivity; however, one investigation reported that a >1% body mass loss resulted in a 12% reduction in work output.39 Dehydration has also been shown to adversely influence decision making and cognitive performance,40–42 which may contribute to a decline in productivity and could be associated with increased risk of work-related accidents.41 Informing individuals, especially those who work in a hot environment, about signs and dangers of dehydration and strategies in maintaining hydration while working can reduce dehydration in the workplace. In addition, consumption of meals can also play an important role in helping to stimulate the intake of additional fluids and restoration of fluid balance.33 Furthermore, many foods contain substantial amounts of water. It is also important to note that in both recreational sport/physical activity and workplace settings, accurate hydration assessment is a key to fluid intake guidance.

HYDRATION ASSESSMENT

Presently there is no scientific consensus regarding the best method to assess hydration status, particularly outside the laboratory.20 Recreational sport/physical activity most commonly results in hypotonic fluid losses (sweat), which increases the relative concentrations of blood and urine. Field expedient measures to assess hydration status are available such as body mass, urine-specific gravity and color, and sensation of thirst. However, each has limitations that should be taken into account to allow for accurate results. Changes in body
mass are often used for rapid assessment of acute hydration status in both laboratory and field settings and are often the standard against which other methods of hydration assessment are compared. Acute changes (over hours) require a valid baseline and control of confounding variables. When using changes in body mass, it is assumed that the acute loss of 1 g is equivalent to the loss of 1 mL of water. This method is most effective when the pre-exercise baseline body mass is measured when the individual is well hydrated. First morning nude body mass that deviates by >1% (1–2 lb or 0.5–1 kg) also suggests the presence of dehydration when combined with markers of urine and thirst.

As a screening tool to dichotomize hydration state (well hydrated versus dehydrated), measures of urine concentration can be a reliable assessment technique with reasonably definable thresholds. Measures of urine-specific gravity and urine color are simple to measure in a field setting. Urine color can be compared against a urine color chart or assessed relative to the degree of darkness with darker yellow/brown urine color indicative of a greater degree of dehydration. However, urine-specific gravity and urine color can be easily confounded when proper controls are not employed, such as when they are obtained during periods of rehydration or after exercise when glomerular filtration rate has been reduced. However, use of the first morning void following an overnight fast minimizes confounding influences and maximizes measurement reliability. A urine-specific gravity value that is above 1.020 has been suggested to indicate a state of dehydration. However, given elevated urine-specific gravity values that can occur as a result of diet, heavy daily exercise, high lean body mass, and high protein turnover, values below 1.025 may be more indicative of a normal hydration state.

Sensation of thirst is a qualitative tool that can be used for hydration assessment. While genuine thirst develops only after dehydration is present and is alleviated before complete rehydration is achieved, it is the only reliable subjective sensation that can be reported in response to dehydration. Sensation of thirst works well only at rest, which limits its use during exercise because it is usually not perceived until 2% body mass loss has already occurred. Lastly, use of sensation of thirst to assess hydration status has limited application to children and elderly persons as this sensation may be altered compared to adults.

A simple Venn diagram decision tool does exist that combines markers of hydration, including weight, urine, and thirst (Figure 4). By themselves, no one marker provides enough evidence of dehydration; however, the combination of any two simple self-assessment markers means dehydration is likely, and the presence of all three makes dehydration very likely. In a field setting, in which a scale may not be available for measures of body mass, the combination of first morning urine color and thirst may provide a reasonable indication of the presence of dehydration.

**CONCLUSION**

In conclusion, this review presents general recommendations regarding fluid needs for recreational sport and physical activity. In regard to the importance of hydration, a 2% body mass loss is a recognized threshold beyond which exercise dehydration impairs aerobic exercise performance in temperate conditions and this is accentuated by warm and hot environments. If fluid requirements are low but the need for carbohydrate supplementation exists, more concentrated sport drinks or gels, energy bars, and other foods can help to sustain exercise performance. Dehydration in the workplace can affect productivity, safety, and morale. Strategies to maintain hydration while working can help reduce dehydration. In either a workplace or field setting, the combination of change in body mass, urine color, and thirst can be used to assess hydration and determine the adequacy of fluid intake practices.

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