

Hydration and the Marathon Runner

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INTRODUCTION

The importance of hydration in Marathon running has been documented since the late 1960s. (20, 32, 46-48) Studies that were published showed a relationship between the levels of dehydration that develops during exercise and the rise in rectal temperature. The conclusion was that dehydration was the single greatest risk to the health of a marathon runner due to the rise in body temperature leading to heat illness, including heatstroke. Most published recommendations to date continue to emphasize the detrimental consequences of dehydration that can occur in a marathon, while the more recent reports warn us of the morbid consequences of over-hydration in a marathon. Both conditions are extreme and can be minimized or prevented. However; this has led to a controversy regarding the optimal fluid guidelines our athletes should follow. Recently, new recommendations for fluid replacement for marathon runners were published by medical and athletic societies. (1, 3, 8) These new guidelines encourage runners to drink ad libitum between 400 – 800ml/hour as opposed to the previous “as much as possible” advice.

Fluid Guidelines and Why We Need Them

Water serves as the essential solvent for cellular biochemical reactions and facilitates the thermal equilibrium of cells. (12) It comprises of about 63% of our entire body mass and 80% - 84% of our kidney, lung, and skeletal muscle tissues. We must consume water because the amount lost in metabolism exceeds the amount synthesized by our body. Without adequate fluid replacement during prolonged exercise, rectal temperature and heart rate will become more elevated compared with a well-hydrated condition. “The balance between the loss and gain of fluids maintains the body water within relatively narrow limits”. (10) The daily water intake of

3.7 L for adult men and 2.7 L for adult women meets the needs of the vast majority of persons. However, strenuous physical exercise and heat stress can greatly increase our daily water needs, and the individual variability between athletes can be substantial. (11, 20-24)

The two major systems adversely affected by dehydration are the cardiovascular system and the thermoregulatory system thereby potentially reducing oxygen and fatty acid delivery and heat dissipation. In the past, the recommendation has been to replace 100% of fluid lost, or drink “a pint per pound”. Although more recent reports suggest replacing at least 150% - 200% of fluid lost may be needed to ensure complete rehydration. These high doses are calculated to compensate for the urine production and allow the athlete to maintain nearly 100% of their pre-exercise weight. Studies have shown that complete repletion of fluids losses during exercise maintain more normal cardiovascular function and lower rectal temperatures than do lesser levels of fluid replacement during exercise. It is concluded that complete replacement of fluid losses during exercise is desirable.

Hyponatremia Hypothesis

As a result of exercise-induced sweating, athletes and trained individuals can lose up to 3 L of fluid per hour. (14) Fluid replacement is required to maintain hydration and allow us to continue to perform. Inadequate fluid intake will adversely affect temperature regulation, cardiovascular function, and muscle metabolism. As far back as 1932 it was stated that voluntary water consumption replaced only 56% of sweat lost during exercise. (29) Research on ad libitum fluid intake over the last 74 years have repeatedly verified that humans, when given free access to fluids, replace no more than 75% of net losses during physical activity. (26-28, 31-33) Rehydration during exercise maintains sweating and/or skin blood flow, thereby preserving the ability to dissipate heat, and reduces cardiovascular strain. Thirst is not an accurate index of our fluid requirements during exercise. If a marathoner drinks only in response to their thirst they will become sufficiently dehydrated during the event that their performance will be impaired and their health will be placed at risk. Therefore they are required to override their natural inclination and rather to drink “as much as possible”. Fluid intake at rates that exceed sweating rate is predicted to be the primary cause of hyponatremia. (36) Symptoms begin to appear when serum sodium levels fall below 135 mmol/L and water begins to flow into the body cells. (7, 40)

Early symptoms of hyponatraemia include weight gain, puffiness, nausea, while more serious symptoms include vomiting, confusion, irritability and seizures. If hyponatraemia is left untreated it can progress to serious brain and lung swelling, coma and death.

Big City Marathons

With the introduction of the big city marathons, beginning in 1976 with the New York City Marathon, substantial changes have occurred both in the record times that our elite athletes cover the distance of 26.2 miles and the record number of runners who enters a marathon to just go the distance. We have come from what was primarily an athletic event to what is now a physical challenge for many recreational runners or walkers. Although it is great to have so many people participating in the sport we have major concerns as to how well these individuals hydrate themselves before, during and after competing in a marathon.

The hydration status of marathon runners depends on the balance between their sweat losses and fluid replacement. (19-21, 34-39) Staying properly hydrated is important for both safety and performance. Dehydration occurs when fluid losses are not adequately replaced while hyponatremia (a condition related to drinking too much fluid) occurs when individuals are over hydrated. Dehydration decreases blood volume, increases heart rate, and impedes heat loss all of which can cause marathon competitors to slow their pace down or drop out of the race. How much should athletes drink during a marathon? A substantial body of evidence shows that marathon runners should aim to drink ad libitum between 400 – 800ml per hour. (1, 3-6, 8-9) The American College of Sports Medicine (ACSM) and the International Marathon Medical Directors Association (IMMDA) are two such organizations that have made position stands regarding following these guidelines. “The goal of drinking during prolonged exercise is to prevent excessive dehydration (>2% body weight loss from water deficit) and excessive changes in electrolyte balance to avert compromised exercise performance”. (3)

Hydration in the Conditioned vs non-Conditioned Athlete

Conditioned athletes

Conditioned athletes manage adequate hydration in a marathon by ingesting about 200-800 ml per hour; the lower rates mainly due to the difficulty of ingesting fluids when running at

high speeds (<6 minute per mile). Abdominal distress, nausea and vomiting have been reported in highly trained distance runners who have tried to match fluid intakes to sweat rates. (20, 28) Conditioned athletes have a greater capacity to store more glycogen in the muscles, have higher body fluids >60% body mass, greater tolerance to compete at higher temperatures >21⁰ C and spend significantly less time out on the marathon course than the unconditioned athlete. Meal consumption is critical to ensure full hydration on a daily bases. A conditioned athlete's daily caloric intake may consist of 75% - 85% carbohydrates as apposed to 50%-60% intake from the unconditioned athlete. High carbohydrate intake has been shown to increase body fluids and replenish sodium concentration levels after prolonged exercise. This evidence proves that we do not need to drink as much as possible to perform at a world class level. Consistency is the key to success!

Unconditioned athletes

Unconditioned athletes; those who are at the back of the pack of a marathon (>5 hours) are moving at a much slower pace have less chance of accumulating body heat, have low rates of fluid loss and have a much easier time for consuming high doses of fluids. They are often urged to "drink as much as possible" to prevent dehydration. Research shows that these athletes need to be advised "not to drink more than a maximum of 500ml per hour." Higher rates of fluid intake can be fatal if sustained for 5 or more hours. (4, 24) Greater care should be taken in determining fluid replacement rates for athlete competing in a marathon >3 hours. Unconditioned athletes have less ability to generate a high sweat loss based on their intensity level during a marathon about 50% VO₂ max. They also have less ability to store high levels of glycogen in their muscles and a lower tolerance to compete in high temperatures. Focusing on improving fitness level may be the answer to reducing the incidence of dehydration and or overhydration.

Variables Effecting Hydration

The three main factors governing fluid loss during exercise are body mass (bodyweight), running speed (metabolic rate), and ambient temperature. Actual field study data from multiple

endurance studies indicates that the maintenance of bodyweight will actually lead to reductions in serum sodium concentrations from pre-race to post-race. Fluid replacement at or above 100% does not seem to offer any performance benefits. (15)

A. Body Mass

The goal of drinking during exercise is to prevent excessive dehydration >2% body weight loss from water deficit and excessive changes in electrolyte balance. (3) The amount and rate of fluid replacement depends upon the athletes sweating rate, exercise duration and how often the athlete has an opportunity to drink. The longer the exercise duration the greater an athletes risk for dehydration or over-hydration. Only at degrees of dehydration beyond 3% is cardiac output significantly diminished as a result of reduction in circulating blood volume. Female athletes who have a low body mass index and run >4 hour marathon, are at greater risk for over-hydration (hyponatremia).

B. Metabolic Rate

Metabolic rate is one of the major factors that determine the rate of sweat loss and the necessary rate of fluid ingestion during a marathon. The rate of energy expenditure is a function of the athlete's size and running speed. Conditioned athletes can lose between 1-1.5L per hour during a marathon. However for reasons mentioned earlier this does not mean that this is the rate at which fluid must be replaced. Evidence indicates that the rate of fluid intake varies from 400-800ml per hour. (1, 3, 4, 8) The metabolic rate of an unconditioned athlete is much lower <10 METS/hour. Close inspection of a marathon field illustrates the variety of shapes, sizes and speeds that must be taken into consideration when formulating fluid intake guidelines.

C. Environmental Factors

Environmental temperature also plays a key role in dehydration between the conditioned athlete and the non-conditioned athlete. (29-31,33) Studies have shown that when the conditioned

athletes are euhydrated before prolonged exercise they are more likely to perform at a higher rectal temperature than the non-conditioned athlete. Dehydration of 2% body mass during exercise in hot environment ($31^{\circ}\text{C} - 32^{\circ}\text{C}$) has been shown to impair endurance performance. However, when exercise is performed in a temperate environment ($20^{\circ}\text{C} - 21^{\circ}\text{C}$), dehydration by 2% of body mass appears to have a lesser or insignificant effect on endurance performance. (15)

To recommend a specific fluid and electrolyte replacement to a given group of athletes, that have a wide variety of fitness levels (e.g. metabolic requirements, intensity, duration, training status) and exercise tasks (e.g. weather condition, clothing, heat acclimatization) is a daunting task. Our society, as mentioned by the IMMUDA revolves around rules and algorithms to guide us through different situations, athletes should not be confined to these rules in a dynamic setting. It is true there are no shortcuts towards great achievements. Scientists and clinicians must resist handing out unrealistic “blanket advice” to individuals who are seeking simple answers. (1) While not all researchers agree on the ergogenic effect and/or optimal percentage rate of a carbohydrate drink during a marathon, it has been demonstrated that ingesting a fluid containing about 2-4% carbohydrate concentration during sustained exercise can increase endurance time. (13, 15-18, 43-44)

CONCLUSIONS

Keeping the body properly hydrated with the right amount of fluids improves safety and performance in a marathon. By doing so we maintain blood and cell fluid volume for cardiovascular transport and sweating. Dehydration will cause the athlete to slow down or stop when the drop in body water causes a decrease in vascular volume (lower cardio output and decreased muscle cell function). To avoid dehydration and hyponatremia we need to balance fluid intake with sweat losses. In both cases we need to focus on how much water or sports drink we are consuming before, during and after our marathon. I am in agreement with the International Olympic Committee’s (IOC) consensus statement which states; “Sufficient fluid should be consumed during exercise to limit dehydration to less than about 2% of body mass”.

“Sodium should be included when sweat losses are high especially if exercise lasts more than about 2 hours. Athletes should not drink so much that they gain weight during exercise.”

The road to success is to encourage our athletes to explore, understand and be flexible towards their own fluid needs. We cannot generalize one rule for every situation and every athlete. Our guidelines should provide safe advice so that our athletes have a greater understanding on how to replenish their own individual fluid needs.

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