Proper Hydration for Distance Running-Identifying Individual Fluid Needs

A USA TRACK & FIELD Advisory

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INTRODUCTION

Any time a runner hits the road, track, or trail to perform in a race or training session, the need to properly hydrate becomes an issue that will influence the quality of the effort. The evaporation of sweat from the skin's surface is a powerful cooling mechanism to allow you to release the heat that is being produced by working muscles. The replenishment of fluid being lost as sweat is an important consideration during any effort. It has long been preached to runners (and all athletes) that you should consume "as much fluid as possible" to ward off the demons of dehydration. More recently, runners and medical staff have been told to limit hydration due to the potential dangers associated with overhydrating that can occur when running for an extended period of time.

Thus, we have a double-edged sword situation: drink enough fluids during activity to prevent dehydration - which could be detrimental to health and performance - but do not consume too much fluid - which could cause the potentially dangerous problem of hyponatremia.

So, what does the competitive runner do to address the issues related to hydration in order to minimize the likelihood of dehydration and hyponatremia? The answer lies in the process of determining individual fluid needs and then developing a hydration protocol based on those individual needs. This is a simple process that can maximize performance and minimize any potential hazards that may be associated with inappropriate hydration practices. The ensuing pages will provide an overview of dehydration and hyponatremia and provide USATF guidelines for distance runners and other athletes that can be utilized to determine individual fluid needs.

Dehydration

<u>What is dehydration?</u>

Dehydration is caused by two distinct factors that may occur during exercise.

- **The loss of fluids from sweat, urine, and respiratory losses.** Dehydration is the acute change of fluid stores from that of a steady-state condition of normal body water to that being something less than normal body water. If the decreased body water stores remain for an extended period of time, the individual is said to be in a "state of hypohydration", which is a steady-state condition of decreased body water. Since the human body is approximately 65% water, a significant decrease in body water stores will alter normal physiological function. For instance, cardiovascular function (i.e. heart rate), thermoregulatory capacity (i.e. sweating) and muscle function (i.e. endurance capacity) can be detrimentally altered if the amount of dehydration reaches critical thresholds to alter the physiological function of these processes.
- **Fluid intake does not match up to fluid losses.** When fluid consumption is less than fluid losses, dehydration will ensue. The magnitude in which these two factors are out of balance will determine the degree of dehydration. Fluid can be lost in sweat, urine, feces, and during respiration (breathing). The great majority of the loss is that in sweat. Fluid losses can be replaced by that consumed orally or intravenously and that which is produced during metabolism [a small amount of water is actually formed during the metabolic pathways that allow muscles to contract]. The great majority of fluid intake occurs from the oral consumption of fluids (including fluids in food products). So, generally speaking, during exercise, when sweat losses exceed fluid intake via oral consumption, a condition of dehydration will ensue. Mild dehydration, about 1-2% of total body weight, is quite likely and is not a great concern. But, losses beyond this should be avoided if at all possible.

Dehydration occurs:

- During moderate and intense activity- As the intensity of an activity increases, the sweat rate increases. Additionally, as intensity reaches high levels (e.g. >75% VO_2max), the rate at which fluid can be processed and comfortably handled by the stomach and intestines and emptied into the bloodstream is decreased. Also, increasing intensity will likely decrease the amount of time the individual can focus on rehydration.
- During activity in warm and hot conditions- As the temperature increases the sweat rate increases.
- In those with high sweat rates- Those individuals with high sweat rates (and great differences can exist between individuals) will have the need to replenish more fluids for a certain time.
- When proper hydration is not attained at the start- When individuals begin an exercise session not properly hydrated, they may reach a dangerous dehydration level more rapidly.
- During multiple practices the same day- As the number of exercise sessions in a day increases this will increase the amount of fluid needed during the course of the day.
- When there is improper access to meals- A majority of fluid consumption occurs during meal times, so a disturbance in normal meals may alter the ability to maintain proper hydration.
- When there is improper access to fluids- When fluids are not readily accessible during races or training sessions, the likelihood will increase for dehydration.
- When there is poor vigilance- Athletes who are not educated about the needs to properly hydrate will not actively pursue a proactive hydration protocol to address individual fluid needs.

- In larger individuals- A person's size influences sweat rate, so those who are larger will generally have a higher sweat rate.
- Due to personal preferences- If the temperature of the rehydration fluid is extremely hot or extremely cold or if it is a flavor the individual dislikes or is made of non-ideal compounds then this may alter the degree of voluntary rehydration.
- Due to individual differences in fluid tolerance- Some individuals cannot comfortably handle the amounts of fluid to approximate fluid losses during activity. A possible solution to this may be gradually drinking over time and not having one large amount after a period of time. Also, people may be able to alter the amount when the hydration protocol is practiced during training sessions.
- Due to illness.

How do you recognize dehydration?

It is important to remember that while dehydration is an important factor that contributes to hyperthermia associated with exercise, other factors are also very important. For example, intensity of activity, environmental conditions (humidity, temperature, shade/cloud cover), level of fitness, degree of heat acclimatization, amount of clothing/equipment, illness, etc. all contribute to the rate of rise in body temperature and athletes should consider these when looking to decrease the risk associated with exercise in the warm and hot conditions.

Runners, coaches, and medical staff must be adept at recognizing that a problem with hyperthermia exists and treating that first. If it is mild, then the runner needs to slow down or stop depending on the symptoms observed. If the symptoms are more severe, an immediate effort must to made to reduce core body temperature. Runners should be able to recognize the basic signs and symptoms of the onset of heat illness for which dehydration may be a cause: irritability, and general discomfort, then headache, weakness, dizziness, cramps, chills, vomiting, nausea, head or neck heat sensations (e.g. pulsating sensation in the brain), disorientation and decreased performance. Runners have been instilled with the concept that adequate hydration will negate the adverse effect of high heat and humidity. Runners need to learn that core body temperature can rise to dangerous levels despite a proper level of hydration.

In the absence of guidelines for optimum hydration, thirst can be a guiding factor. Runners have been instilled with the concept that hydration must be ahead of thirst and that the presence of thirst indicates dehydration. However, staying ahead of thirst can lead to overhydration as thirst is no longer available as a natural signal to know individual fluid needs. The sensation of thirst is a general indicator of dehydration. It is a clear signal to drink. If the signal of thirst is not used for rehydration, there is greater danger of dehydration and heat illness.

Symptoms that complicate the diagnosis are the feeling of dizziness or weakness and collapsing. When this happens at a point when the runner has stopped either along the course or at the finish line, rather than while in motion, the likely cause is postural hypotension which is a pooling of blood in the legs and inadequate blood supply to the upper body. This can be avoided by walking or flexing the legs when standing in place. When a runner collapses from postural hypotension, the legs should be raised above the head and held there for 3-4 minutes. That should relieve the symptoms.

How do you treat dehydration?

A conscious, cognizant, dehydrated runner without gastrointestinal distress can aggressively rehydrate orally, while one with mental compromise or gastrointestinal distress should be transported to a medical facility for intravenous rehydration. If an exertional heat illness beyond dehydration is suspected then medical treatment would be necessary. Additionally, dehydration itself, if severe, may require medical assistance. See the citation for the Exertional Heat Illness Position Statement at the end of this paper for specifics regarding the prevention, recognition, and treatment of the common exertional heat illnesses.

Exertional Hyponatremia

What is hyponatremia?

Exertional hyponatremia (EH), or low blood sodium (generally defined by sodium levels less than 130mmol/L), is caused by two distinct but often additive conditions that may arise during prolonged exercise, most often 4 hours or more. They include:

- **The excessive intake of fluid**. In this scenario, athletes ingest significantly more fluid than they lose in sweat and urine over a given period of time. Doing so causes them to become hyper-hydrated and blood sodium falls. This is the most critical contributory factor to the onset of EH.
- **The ingestion of low-sodium fluids.** In this scenario, athletes drink fluids that are low in sodium. In doing so, they dilute their blood sodium and fail to replace what they're naturally losing in sweat during exercise. Sports drinks have low-sodium levels in order to be appetizing to the general public. EH results when plasma sodium levels go below approximately 130 mmol/L. The more pronounced the drop, the greater the risk of medical consequences. Runners can still be at risk with higher sodium intake when overhydrating. Excessive fluids are the crux of the problem, but having fluids with sodium is better than without it, excessive drinking or not.

Runners, coaches, and medical staff must be adept at recognizing this condition because rehydration could cause further problems. Severe cases of EH may involve grand mal seizures, increased intracranial pressure, pulmonary edema, and respiratory arrest. The fact is EH can and has led to death—and not just in running, but in a variety of athletic, military, and recreational settings.

When does EH occur?

EH occurs most frequently:

- **In sports that last for longer than four hours-** This gives athletes more time to drink and to lose large amounts of sodium through prolonged sweating.
- **During lower-intensity endurance activities**-where athletes have the opportunity to ingest large volumes of fluid.
- **When athletes drink large volumes of water without adequate sodium intake-**Blood sodium levels fall quickly whenever excess water is ingested, particularly during or after exercise in which large amounts of sweat and salt are lost. This can even happen during exercise or at rest when athletes drink lots of water in a misguided attempt to ward off cramping.

How do you recognize EH?

Unfortunately, EH may mimic many of the signs and symptoms of exertional heat stroke, such as nausea, vomiting, extreme fatigue, respiratory distress, and central nervous system disturbances (i.e. dizziness, confusion, disorientation, coma, seizures).

EH also has unique characteristics that distinguish it from other like conditions such as low plasma sodium levels (< 130 mmol/L). Other symptoms may include:

- A progressively worsening headache.
- Normal exercise core temperature (generally not > 104^{o}F)
- Swelling of the hands and feet (which may be noted with tight wedding bands, watches, shoes, etc.).

How do you treat EH?

If you suspect this condition it is important to be sure of the following:

- Make sure runner is not dangerously hyperthermic. If an immediate measure of rectal temperature reveals extreme hyperthermia (>104^{o}F), begin ice/cold water immersion therapy.
- If hyponatremia is suspected, have the athlete transported immediately to an emergency room where a physician can monitor care and if necessary administer an IV of a hypertonic sodium replacement, diuretic (if hyperhydrated), and/or anti-convulsive drug (if still having seizures).

Rapid and prudent response, along with that of on-site medical personnel, can assure a healthy outcome.

How do you prevent EH?

The most important aspect of preventing EH lies in your having an appropriate hydration protocol for the event or task being performed. This process was discussed in the dehydration section. A few key points include:

- Education regarding replacing fluids in appropriate amounts, not to exceed sweat rates.
- Assuring easy access to a sports drink containing an adequate amount of sodium.
- Monitoring body weights when feasible to identify those who have gained weight from overdrinking.

Additional steps to consider:

- Encourage athletes to be well-acclimatized to the heat because this is an effective way to decrease sweat sodium losses.
- Maintain normal meal patterns and don't restrict dietary sodium intake, so sodium levels are normal prior to the start of an event.
- Consume a little extra sodium with meals and snacks during continuous days of exercise in hot weather to help maintain blood sodium levels.

  There is a great performance benefit associated with proper hydration during exercise, but overdrinking must be avoided. Athletes who lose and replace fluids at equal rates greatly diminish the risk of EH—especially if they drink fluids that contain adequate sodium.

How do you prevent dehydration without overhydrating?

Optimum hydration is geared around the general premise that fluid intake should match fluid losses and that these processes are extremely individualized. It is an individual process because rehydration practices vary based on a wide-variety of issues (discussed earlier). The crux of this process is trying, to the best of your ability, to match fluid intake with fluid losses. If this can be done relatively closely, then all of the hazards of under or overhydrating are avoided and the likelihood of a safe and productive exercise session is maximized. The following guidelines should assist in establishing a hydration protocol:

USATF Self-testing Program for Optimum Hydration

Establish a hydration strategy that considers the sweat rate, sport dynamics (rest breaks, fluid access), environmental factors, acclimatization state, exercise duration, exercise intensity, and individual preferences. To correctly assess rehydration needs for each individual, it is of great importance to calculate the individual's sweat rate. For this process, we recommend the following program:

Calculate sweat rate (Sweat Rate = body weight pre-run – body weight post-run + fluid intake – urine volume/exercise time in hours) for a representative range of environmental conditions, practices, and competitions (Table 1 provides a sample worksheet). This calculation is the most fundamental consideration when establishing a hydration protocol. Average sweat rates from the scientific literature or other athletes can vary from .5 l/h to over 2.5 l/h (1.1 lb/hr to 5.5 lb/hr) and should not be used.

When establishing an individual sweat rate that will be applicable during a long race, try to run at race intensity (for races of 1 hour or more) in a 1-hour training session. Try to establish a sweat rate in similar climatic conditions expected for a targeted race or for long training runs leading up to the race, whichever are in a higher temperature. Follow this procedure:

- Do a warm-up run to the point where perspiration is generated.
- Urinate if necessary.
- Weigh yourself naked on an accurate scale.
- Run for one hour at intensity similar to the targeted race.
- Drink a measured amount of a beverage of your choice during the run.
- Do not urinate during the run (unless you choose to measure the amount of urine).
- Weigh yourself in the buff again on the same scale after the run.
- Enter data into table 1.

You now know your approximate fluid needs per hour.

Clubs may want to organize hydration-testing clinics at which they provide an accurate scale and a means of privacy for disrobing to get weighed along with supporting information about the subject of hydration and supervision of the USATF testing program.

It should be noted that metabolism of carbohydrates, fats, and protein during exercise accounts for a very small amount of the weight lost during activity. The effect of fuel oxidation on weight loss during high sweat efforts is a small enough amount that weight changes that occur following an activity can largely be attributed to sweat losses. However, it should be calculated in when measuring a low-sweat effort at about 15% of the total weight loss.

Heat acclimatization induces physiologic changes that may alter individual fluid replacement considerations.

First, sweat rate generally increases after 10 to 14 days of heat exposure, requiring a greater fluid intake for a similar bout of exercise. An athlete's sweat rate should be reassessed after acclimatization.

Second, moving from a cool environment to a warm environment increases the overall sweat rate for a bout of exercise. Athletes must closely monitor hydration status for the first week of exercise in a warm environment.

Third, increased sodium intake may be warranted during the first 3 to 5 days of heat exposure, since the increased thermal strain and associated increased sweat rate increase the sodium lost in sweat. Adequate sodium intake optimizes fluid palatability and absorption during the first few days and may decrease exercise-associated muscle cramping. After 5 to 10 days, sweat sodium concentration decreases, but the overall sweat rate is higher so the athlete should still be cognizant of sodium ingestion.

Consider the event/training session and how you can approximate your calculated fluid needs. Things to consider are the location of hydration stations, what fluids you want to use, and when and how you can refill fluid containers if you choose to carry your own fluids with you.

Fluid replacement beverages should be easily accessible in individual fluid containers and flavored to the athlete's preference. Individual containers permit easier monitoring of fluid intake. Clear water bottles marked in 100-ml (3.4 fl oz) increments provide visual reminders to help runners gauge proper amounts. Carrying water bottles or other hydration systems during running encourages greater fluid volume ingestion. Hydration systems, in contrast to water bottles, will keep fluids cooler which optimizes the hydration process.

Individual differences will exist with regards to tolerance of amount of fluids that can be comfortably consumed, gastric emptying and intestinal absorption rates, and availability of fluids during the workout or event. Each individual's rehydration procedures should be tested in practice and modified regularly if necessary to optimize hydration while maximizing performance in competition. Individuals should be encouraged to retest themselves during different seasons depending on their training/racing schedule to know their hydration needs during those seasons.

Hydration

<u>Pre-Event Hydration</u>

Runners should begin all exercise sessions well hydrated. Hydration status can be approximated by runners in several ways (Table 2). Assuming proper hydration, pre-exercise body weight should be relatively consistent across exercise sessions. Remember that body weight is dynamic. Frequent exercise sessions can induce nonfluid-related weight loss influenced by timing of meals and defecation, time of day, and calories expended in exercise. The simplest method is comparison of urine color (from a sample in a container) with a urine color chart (Figure 1). A urine color of 1-3 indicates a good hydration status while 6-8 indicates some degree of dehydration. Note that urine color can be offset by recent, excessive supplemental vitamin intake. Urine volume is another general indicator of hydration status. A runner should frequently have the need to urinate during the course of the day. Remember that body weight changes during exercise give the best indication of hydration needs.

To ensure proper pre-exercise hydration, the athlete should consume approximately 500 to 600 ml (17 to 20 fl oz) of water or a sports drink 2 to 3 hours before exercise and 300 to 360 ml (10 to 12 fl oz) of water or a sports drink 0 to 10 minutes before exercise.

Post-Event Hydration

Post-exercise hydration should aim to correct any fluid loss accumulated during the practice or event. Ideally completed within 2 hours, rehydration should contain water to restore hydration status, carbohydrates to replenish glycogen stores, and electrolytes to speed rehydration. The primary goal is the immediate return of physiologic function (especially if an exercise bout will follow). When rehydration must be rapid, the athlete should compensate for obligatory urine losses incurred during the rehydration process and drink about 25% more than sweat losses to assure optimal hydration 4 to 6 hours after the event.

Fluid temperature influences the amount consumed. While individual differences exist, a cool beverage of 10^o to 15^oC (50^o to 59^oF) is recommended.

The Role and Use of Carbohydrates

In many situations, athletes benefit from including carbohydrates (CHO) and electrolytes (especially sodium) in their rehydration beverages. Include CHO in the rehydration beverage during exercise if the session lasts longer than 45 to 50 minutes or is intense. An ingestion rate of about $1\ g \cdot min^{-1}$ (.04 oz/min) maintains optimal carbohydrate metabolism: for example, 1 liter of a 6% carbohydrate drink per hour of exercise. CHO concentrations >8% increase the rate of CHO delivery to the body, but compromise the rate of fluid emptying from the stomach and absorbed from the intestine. Fruit juices, CHO gels, sodas, and some sports drinks have CHO concentrations >8% and are not recommended DURING an exercise session as the sole beverage. Athletes should consume CHO at least 30 minutes before the normal onset of fatigue and earlier if the environmental conditions are unusually extreme, although this may not apply for very intense short-term exercise which may require earlier intake of CHO. Most CHO forms (i.e., glucose, sucrose, maltodextrins) are suitable, and the absorption rate is maximized when multiple forms are consumed simultaneously. Substances to be limited include fructose (may cause gastrointestinal distress), and those that should be avoided include alcohol or high amounts of caffeine (may increase urine output and reduce fluid retention), and carbonated beverages (may decrease voluntary fluid intake due to stomach fullness).

Electrolyte Considerations

A modest amount of sodium (0.5 to $0.7\ g \cdot l^{-1}$) would be an acceptable addition to all hydration beverages since it stimulates thirst, increases voluntary fluid intake, may decrease the risk of hyponatremia, and causes no harm. Inclusion of sodium chloride in fluid replacement beverages should be considered under the following conditions: There is inadequate access to meals or meals are not eaten; when the physical activity exceeds 4h in duration; and/or during the initial days of hot weather. Under the above conditions, addition of modest amounts of sodium (0.5 to $0.7\ g \cdot l^{-1}$) can offset sodium lost in sweat and may minimize medical events associated with electrolyte imbalances (e.g. muscle cramps, hyponatremia).

Potassium levels lost in sweat can be a concern for people in general and especially for people taking diuretics for high blood pressure. Diuretics cause excessive excretion of potassium, and running could result in hypokalemia. Also, plain water intake or hyperhydration will exacerbate losses of potassium by sending the excess fluid to the kidneys for excretion at the expense of potassium.

For more information on hydration, exertional hyponatremia and exertional heat illnesses please see:

Binkley HM, J Beckett, DJ Casa, D Kleiner, P Plummer. National Athletic Trainers Association position statement: Exertional heat illnesses. *Journal of Athletic Training*. 37(3):329-343, 2002.
(can be found at www.nata.org/members1/jat/37.3/attr_37_03_0329.pdf)

Casa DJ, LE Armstrong, SK Hillman, SJ Montain, RV Reiff, B Rich, WO Roberts, JA Stone. National Athletic Trainers' Association position statement: Fluid replacement for athletes. *Journal of Athletic Training*. 35(2):212-224, 2000.
(can be found at www.nata.org/members1/jat/jt0200/jt020000212p.pdf)

Noakes, T., Martin, D.E. IMMDA-AIMS Advisory statement on guidelines for fluid replacement during marathon running. *New Studies in Athletics* 17 (1): 15-24, 2002.

Table 1: Sample Sweat Rate Calculation

Table 3. Sample Sweat Rate Calculation*

A	B	C	D	E	F	G	H	I	J
		Body Weight							
Name	Date	Before Exercise	After Exercise	ΔBW (C-D)	Drink Volume	Urine Volume†	Sweat Loss (E+F−G)	Exercise Time	Sweat Rate (H/I)
		kg	kg	g	mL	mL	mL	min	mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	h	mL/h
		kg	kg	g	mL	mL	mL	min	mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	h	mL/h
		kg	kg	g	mL	mL	mL	min	mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	h	mL/h
		kg	kg	g	mL	mL	mL	min	mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	h	mL/h
Kelly K.‡	9/15	61.7 kg	60.3 kg	1400 g	420 mL	90 mL	1730 mL	90 min	19 mL/min
		(lb/2.2)	(lb/2.2)	(kg × 1000)	(oz × 30)	(oz × 30)	(oz × 30)	1.5 h	1153 mL/h

*Reprinted with permission from Murray R. Determining sweat rate. *Sports Sci Exch.* 1996;9(Suppl 63).
†Weight of urine should be subtracted *if urine was excreted prior to postexercise body weight.*
‡In the example, Kelly K. should drink about 1 L (32 oz) of fluid during each hour of activity to remain well hydrated.

Table 2: Indices of Hydration Status (general guidelines)

	% Body Weight Change	Urine Color
Well-Hydrated	+1 to -1 %	1 or 2
Minimal Dehydration	-1 to -3 %	3 or 4
Significant Dehydration	-3 to -5 %	5 or 6
Serious Dehydration	> 5 %	> 6

$$\% \text{ Body Weight Change} = \frac{\text{Pre Body Weight} - \text{Post Body Weight}}{\text{Pre Body Weight}} \times 100$$

See Figure 1 for Urine Color Chart and appropriate reference. Please note that a urine sample may not be possible during serious dehydration.

Also, these are physiologically independent entities and the numbers provided are only general guidelines.

Figure 1: Urine Color Chart