What You Need to Know About Hydration

By: Steve Born

At E-CAPS & Hammer Nutrition, we're known for offering the most complete and technically advanced line of nutritionals an endurance athlete can buy. But we don't sell, and probably never will sell, the most important item in your regimen. As you might have guessed, we're talking about water. It's the most important substance on earth, 60% of your body weight, and the number one concern on any athlete's intake list. For both performance and health, the importance of your water intake exceeds that of your vitamin, calorie, and electrolyte intake.

Even though we're not in the water business we want to make sure you have the right amount on board when you set off on your distance effort, when you finish, and between efforts during recovery. Thus, we've included this section on hydration in this handbook. As you read, you'll learn how sweat loss affects athletic performance, that too much water is worse than too little, and that you can't replace all the water you sweat out. Yes, we will get to that key issue: Just how much should I drink? Of all the many functions water has in human physiology, we'll focus on just a couple that pertain especially to the endurance athlete, cooling the body and transporting nutrients. Let's look at the cooling system first.

HOW YOUR COOLING SYSTEM WORKS

When we exercise, we burn molecular fuel, mostly glycogen, but also some protein, fat, and blood glucose from ingested nutrients. The breakdown of these energy providers releases heat that builds up and raises our core temperature. The body must rid it itself of this heat and maintain a core temperature within a few degrees of the well-known 98.60 F (370C). An active person needs a reliable cooling mechanism. Actually, you have several. You lose some heat through your skin. Blood diverts to the capillaries near the skin's surface, removing heat from the body core. You breathe harder to get more oxygen, expelling heat when you exhale. But by far the most important part of the cooling system, accounting on average for about 75% of all cooling, is your ability to produce and excrete sweat.

Sweat, however, glistening on your forearm or soaking your singlet won't cool you; it must evaporate. Sweat works on a basic physical premise: water evaporation is an endothermic process, requiring energy (heat) to change from liquid to gas. Thus, water molecules in the gas phase have more energy than water molecules in the liquid phase. As water molecules evaporate from your skin, they remove heat energy; the remaining water molecules have less energy, and thus, you feel cooler. Isn't that cool?

Weather conditions greatly affect sweat production and cooling effectiveness. In cool weather, you get substantial cooling from the heat that escapes directly from your skin. As the temperature increases, you gradually rely more on evaporation. On hot days, with little difference between skin surface and ambient temperatures, your skin surface provides only negligible convective cooling, and you need to sweat more to maintain a safe internal core temperature. At 950F or above, you lose no heat at all from your skin; you actually start to absorb heat. Evaporative cooling must do all the work.

Humidity is the other major factor that affects sweat. On humid days, sweat evaporates more slowly because the atmosphere is already saturated with water vapor, retarding the evaporation rate. The sweat accumulates on your skin and soaks your clothes, but you don't get any cooling from it because it's not going into the vapor phase. Soaking, dripping sweat may give you a psychological boost, but it has no physical efficacy to cool; sweat must evaporate to remove heat. On days when it's both hot and humid, well, you don't need to read about what's going to happen when you exercise in those conditions. You do need to know that under the worst of conditions you can produce up to three liters of sweat in an hour of strenuous exercise, but your body can only absorb about one liter from fluid consumption. Yes, this will cause problems before long, and we will discuss that issue below.

WHAT HAPPENS WHEN THE COOLANT RUNS LOW?

Just like a car, your body must dissipate the excess heat generated from burning fuel. Unlike a car, your body's coolant isn't in a sealed internal system; you use it once and then it's gone and needs to be replaced. But we don't come with built-in gauges or indicators that tell us just how much coolant we have left in our system. We can't run a dipstick down our gullet and get a reading that says, "Add a quart." We do have some physiological signs, but they function at the Warning-Danger! level, too late to maintain optimal performance. For instance, by the time you feel thirsty, you could have a 2% body-weight water loss, already into the impairment zone.

The chart below shows what happens to human performance at each percent of weight loss. By weight loss, we mean the percentage of your body weight at the start of exercise that you have lost via sweat. If you go out for a run at 160 pounds and weigh in 20 miles later at 154, you've lost almost 4% of your body weight. That's too much to maintain your pace to the end, let alone expect to kick.

Symptoms by Percent Body Weight Water Loss:

PERCENT WATER LOST --------- SYMPTOMS
0% --- none, optimal performance, normal heat regulation
1% --- thirst stimulated, heat regulation during exercise altered, performance declines
2% --- further decrease in heat regulation, hinders performance, increased thirst
3% --- more of the same(worsening performance)
4% --- exercise performance cut by 20 - 30%
5% --- headache, irritability, "spaced-out" feeling, fatigue
6% --- weakness, severe loss of thermoregulation
7% --- collapse likely unless exercise stops
10% -- comatose
11% -- death likely

[Nutrition for Cyclists, Grandjean & Ruud, Clinics in Sports Med. Vol 13(1);235-246. Jan 1994]

HOW MUCH IS THAT?
As you can see from the chart, sweat loss can easily devolve from an athletic performance issue to an acute medical issue. Clearly, we need to have some quantifiable idea of our intake and output. Let's start with converting the data on the chart to recognizable amounts. Perhaps you remember the saying, "a pint's a pound, the world 'round." Now that's a convenient conversion for endurance athletes. Here's another: one pint = one water bottle. Some bottles hold 20 ounces, but consider a regular water bottle as a pint (fig.1) [Angela: please insert a picture of the E-Caps water bottles, with the captions 16 oz. and 20 oz.]. Two pints make a quart, which is almost a liter. So when you read "liter," think two water bottles. Losing one pound of weight means a one-pint loss. One liter (or one quart) is about two pounds.

CAN YOU DRINK ENOUGH?
Needless to say, maintaining optimal fluid intake prior to and during exercise is crucial for both performance and health. However, as is true with calories and electrolytes, you can't replenish them at the same rate you deplete them; your body simply won't absorb as fast as it loses. Evaporative cooling depletes fluids and electrolytes faster than the body can replenish them. Your body will accept and utilize a certain amount from exogenous (outside) sources, and, similar to calories and electrolytes, maintaining fluid intake within a specific range will postpone fatigue and promote peak performance.

Research suggests that while electrolyte needs for individual athletes may vary up to 1000% (tenfold), fluid loss remains fairly constant. Also, we can measure fluid loss more easily than electrolyte loss; we don't need sophisticated lab equipment, just a scale. Thus, we can come pretty close in calculating fluid loss and replacement.

THE NUMBERS
On average, you lose about one liter (about 34 ounces) of fluid per hour of exercise. Extreme heat and humidity can raise that amount to three liters in one hour. A trained athlete will store enough muscle glycogen to provide energy for approximately 90 minutes of aerobic exercise. As your muscles burn glycogen, water is released as a metabolic by-product and excreted as sweat. Researchers found that during a marathon (26.2 miles), runners released an average of two liters of sweat from muscle glycogen stores. This is in addition to sweat from other body liquids.

You can control or lessen these sweat rates by acclimatization and training for the event. Acclimatized athletes can reduce electrolyte and fluid loss up to 50%, but note that those losses cannot be fully replaced during the event. According to nutrition expert Bill Misner, Ph.D., "The endurance exercise outcome is to postpone fatigue, not replace all the fuel, fluids, and electrolytes lost during the event. It can't be done, though many of us have tried." In other words, our hydration goal is not to replace water pint-for-pint, but to support natural stores by consuming as much as we can adequately process during exercise.

At the most, you can absorb about one liter (about 34 fluid ounces) of water per hour, but only under the most extreme heat and humidity. Most of the time you can only absorb about half that amount, even though it won't fully replace your loss. Repeated intake of one liter (about 34 fluid ounces) per hour will ultimately do you more harm than good.

CAN YOU DRINK TOO MUCH?

Ironically, while you can't drink enough to replace all fluid lost, you can drink too much. Researchers have noted the dangers of excess hydration during events lasting over four hours. Dr. T.D. Noakes collected data for 10 years from some 10,000 runners participating in the Comrades Marathon. This 52.4-mile race, held each June (winter) in South Africa, ranks as one of the world's premier ultra marathons. Noakes showed that endurance athletes who consumed from 16-24 fluid ounces per hour typically repleted as much fluid as is efficiently possible. He also noted the prevalence of hyponatremia (low blood sodium) during ultra-marathons and triathlons in runners who hydrated excessively. This condition can arise from several different physiological scenarios. For endurance athletes, it usually results from sweat-depleted sodium stores diluted by excess hypotonic (low electrolyte content) fluid intake. When blood sodium concentration becomes too dilute, you can develop severe cardiac symptoms leading to collapse.

PROBLEMS WITH TOO MUCH OR TOO LITTLE

Moreover, Noakes noted a pattern of hydration problems among race participants. In ultra events, the leaders usually dehydrate, but the mid to back-of-the-pack athletes tend to over hydrate. Both may end up suffering from the same hyponatremic symptoms, the former from too little fluid intake combined with too much sodium loss due to profuse sweating, the latter from too much fluid intake and relatively less sodium loss. Because most front-runners are extremely competitive, they don't stop long enough during the race to over hydrate. In addition, it's highly likely that elite athletes may be fitter and better acclimatized to deal with hot weather conditions. A tendency to linger at aid stations attempting to relieve the symptoms of fatigue or heat by drinking too much water is a fault found among the majority of the remainder of athletes, those in the middle or back of the pack. Also, these athletes may be novices who have heard the "drink, drink, drink" mantra, but who haven't enough experience to personally calibrate their personal needs. After the 1985 Comrades race, 17 runners were hospitalized, nine with dilutional hyponatremia. In the 1987 Comrades Marathon, 24 runners suffered from dilutional hyponatremia. These athletes had seriously overloaded on fluid intake, with the inevitable result of a totally disrupted physiology.

TRAGIC CONSEQUENCES

Hyponatremia usually results from drinking too much, especially when one drinks fluids such as plain water or a sports drink lacking the proper electrolyte profile. Training and fitness levels, weather conditions, and, undoubtedly, biological predisposition also contribute to developing this form of hyponatremia known as "water intoxication."

Sadly, we must note that this condition has lead, directly or in part, to the deaths of three young and otherwise healthy runners in recent major American marathons. It is hard for us to comprehend the grief of the families they left behind. These athletes went out to run a marathon, to achieve a personal victory. Improper hydration took away their day of glory and also their lives. They collapsed and went into an irreversible condition involving uncontrollable brain edema, coma, and death. We report this to help prevent any future such tragedies. Over hydration represents a very serious problem. Unlike dehydration, which will generally only result in painful cramping, possibly a DNF, or at the worst, IV treatment, over hydration can incite a chain of ultimately fatal physiological consequences.

SO HOW MUCH, HOW OFTEN?

The extreme cases cited above happen very rarely. Lesser degrees of impairment occur frequently from excessive fluid intake. We don't have a chart for over hydration similar to the one for dehydration, giving symptoms for each level of over hydration. Also, you probably don't carry a scale or have regular access to weigh-ins along your training route. So how do you know when it's time to drink? You don't wait until you're down a quart. A good hydration regimen starts before you even get moving.

Noakes believes intake of hypotonic fluids of one liter (33 oz)/hr will likely cause water intoxication and dilutional hyponatremia. He suggests that athletes may do better on 500 ml (16 oz)/hr fluid intake for ultra events performed in hot weather conditions. Other research has suggested that the athlete should drink 14–22 ounces of fluids two hours before exercise and 8 ounces every 20 minutes (24 oz/hr). In other words, start hydrating before you start sweating, drink regularly, and keep your total per hour consumption at about 16-24 ounces, except as noted below. This regimen will adequately hydrate most athletes during running and cycling exercise at any pace.

Based on research, along with the thousands of athletes we have monitored, we believe that to avoid dilutional hyponatremia, water intake should not exceed 28 oz/hr. The exceptions are heavier athletes, athletes exercising at extreme levels (prolonged periods at a high percentage of VO2Max), and athletes competing in severe environmental conditions. When it comes to fluid intake, for most athletes, under most conditions, 16-24 oz/hr will serve you well. That's about one water bottle per hour as a base, with more only as noted above.

REMEMBER YOUR ELECTROLYTES AND CALORIES!

We noted at the beginning that besides cooling, water also plays an important role in nutrient transport. Water consumption bears directly on electrolyte and caloric uptake. You must consider the electrolyte content of your fluid intake, especially if you exceed about 24 oz/hr. If temperature and humidity rise above 700F and/or 70% humidity, we recommend that you take electrolytes before and during every hour of exercise. For a full discussion of electrolyte needs, see the article "Electrolyte Replenishment", which appears in "The Endurance Athlete's Guide To Success".

In addition, avoid fructose or other simple sugar drinks and gels, especially during the heat—unless you want to deal with a gastric emptying problem, which may result in nausea and other stomach maladies. Compared to complex carbohydrates, drinks or gels that contain simple sugars (typically glucose, fructose, and sucrose) require more fluid and electrolytes for effective absorption. Because they require more fluid, you get fewer calories per unit of water. You must restrict simple sugar drinks to a 6-8% solution range, which provides inadequate amounts of calories for energy production. You can make a nice drink in a water bottle that will absorb well and provide adequate fluid, but your caloric intake will fall far short of your body's needs, and your energy level will suffer.

If you make a double or triple-strength batch of a simple sugar drink hoping to obtain adequate amounts of calories, you'll require additional fluids and electrolytes to efficiently process the sugar. You will need to guess how much extra water and electrolytes your body needs to handle the sugar. If you guess low, your GI tract will take water and electrolytes from other areas. This scenario can result in nauseating results as your body literally dehydrates its working muscles while bloating your belly. Why take chances like that when your performance is on the line?

Your wisest choice is to use fuel comprised of complex carbohydrates, such as Hammer Gel and Sustained Energy. Even at an 18-24% concentration, these fuel sources absorb and digest rapidly, do not require excess fluid for transport through the GI system, and provide all the calories your liver can process. For more details on fueling, see the article "Proper Fueling During Endurance Events" in "The Endurance Athlete's Guide To Success" (available free of charge at www.e-caps.com, see info at the end of this article)

INCREASE WATER STORAGE CAPACITY FOR COMPETITION IN EXTREME HEAT

Another wise strategy is pre-event super hydration using a glycerol supplement. You'll want to use this method before a long strenuous event held in very hot or humid conditions. You can increase your water storage capacity by taking a loading dose of a glycerol solution, such as Liquid Endurance, for three days prior to an endurance effort. During this loading phase, you will gain some weight in stored water. It's like having an extra water bottle or two on board. You'll use this extra water first, and extend the time you can exercise in the heat before dehydration.

OTHER WAYS TO COOL YOURSELF IN EXTREME HEAT

Although not directly related to actual water consumption, an external water application can help cool you. A cold, wet towel, sponge, hose, or sprayer on the head and torso can effectively lower body temperature, especially during a one-minute break. If you're running, take a one-minute walk, douse yourself with water, and take a good drink. If you're cycling, find a spot for a good coast or easy spin for a minute. The break from heavy exertion allows dissipation of internal heat. Combined with hydration and external water, this can effectively relieve heat stress, allowing you to finish hot weather endurance events. Highly competitive athletes might scoff at walking, but when it comes to core temperature, nature gives you two choices: cool down or DNF.

PERSONALIZED DATE IS THE KEY TO HYDRATION EFFICIENCY

We offer no "one size fits all" remedies. We do offer prudent and scientifically substantiated advice. We have given you some guidelines to start your assessment and calculation of your personal hydration needs. Each athlete is personally responsible to include hydration, fueling, and electrolyte replacement regimens into his or her training program. You must find out in practice—before competition—what works for you. Most of you will find your final figures will come very close to our suggested starting points. For others, you might find that in certain instances your needs in a particular event will require substantial modification. If you've spent money on a heart-rate monitor, a multi-function watch, or a body-fat measuring device, and if you use those tools

properly, you already have some serious training tools. We suggest that a good scale (preferably one that can measure less than one pound increments, such as a balance scale) may well prove to be your most valuable fitness investment. Weigh yourself before and after each outing, carefully noting the time, exertion level, miles, weather, and fluid, fuel, and electrolyte consumption. Another low-tech hint: make sure you know the capacity of your water bottles and hydration packs. Once you begin to log your fluid consumption and weight fluctuations, you'll have the data to accurately calculate your personal needs in this absolutely vital area.

FINAL CHECKLIST AND SOME QUICK TIPS

1.) If you finish an event weighing the same or more than when you started, you have over hydrated. If you've dropped more 3% or more, dehydration has occurred. Up to 2% weight loss is safe and reasonable.

2.) For very long events, such as a century bike ride, the average rider will also lose a pound or more in energy stores (glycogen, fat, and muscle tissue) in addition to the water, so figure that in your weight difference.

3.) Don't assume that you can drink unlimited amounts of water or fluid during exercise and expect that all of it will be absorbed and the excess will be lost in sweat or through the kidneys. You will instead bloat, dilute your blood, and develop water intoxication.

4.) Train to get fit in the heat. Heat acclimatization and fitness reduce fluid and electrolyte losses by up to 50%. When heat acclimatizing, ignore the clothing advice below.

5.) Wear the lightest, most evaporation-friendly clothing you can afford. Cotton isn't on the list. Many fibers today provide superior wicking and evaporation that allow your sweat to do the work nature intended.

6.) Keep fluid intake between 16-24 oz/hr. If you feel you need more fluids, experiment with it in training, keeping in mind that you will require additional electrolytes. Regular fluid intake over 28 oz/hr increases the possibility of dilutional hyponatremia.

7.) Use cold fluids as much as possible as your body absorbs them more rapidly than warm fluids. Know where to find cold water along your training routes. Use frozen and insulated water bottles and hydration packs.

8.) Urine color can indicate hydration level. Dark yellow urine means low hydration. Pale to light yellow is good. Don't confuse the bright yellow urine you get after vitamin B-2 (riboflavin) supplementation for the dark yellow urine that indicates overly concentrated urine.

9.) For your regular daily hydration needs (that is, besides your exercise-induced needs), about 0.5-0.6 fluid ounces per pound of body weight makes a more accurate standard than the "eight glasses a day" commonly recommended for everyone. Though no research has conclusively arrived at an RDA for fluids, 80-100 ounces of fluids per day will cover most athletes.

10.) During exercise, avoid foods and fuels that contain low chain carbohydrates. These simple sugar fuels require more fluids and electrolytes for digestive purposes. Also avoid carbonated drinks, as the gas inhibits absorption.

11.) Consider using the E-CAPS product Liquid Endurance, a glycerol-based product, in a loading dose format prior to racing in the heat. The use of glycerol will maximize our fluid storage, which can be of great benefit during hot weather racing. Follow the specific instructions that come with the product.

12.) Use caffeine with caution. Used properly and sparingly, caffeine has ergogenic benefits. It does, however, act as a diuretic, which may deplete fluid stores more rapidly.

13.) During the hottest weather conditions, sponging yourself off with cold water, while taking a short periodic break from race pace, will provide heat relief.

14.) Know the symptoms of over hydration and dehydration. Stop immediately if you feel lightheaded or queasy or get the dry chills. No race or training is worth compromising your health.

It’s our hope that after reading this material you will have obtained some insight regarding not just the importance of water itself, but also what constitutes proper water consumption during exercise. Dehydration and/or over hydration is a common problem that plagues far too many athletes, some with severe consequences. Armed with the guidelines contained in this article, along with practice and testing in training, your performance and health need not suffer. Instead, you’ll be ahead of the vast majority of athletes who continue to make the same mistakes over and over again.

Steve Born is a technical advisor for E-CAPS with over a decade of involvement in the health food industry. He has worked with hundreds of athletes - ranging from the recreational athlete to world-class professionals regarding their supplement/fueling program. Steve is a three-time RAAM finisher, the 1994 Furnace Creek 508 Champion, 1999 runner-up, the only cyclist in history to complete a double Furnace Creek 508, and is the holder of two Ultra Marathon Cycling records. In February 2004 Steve was inducted into the Ultra Marathon Cycling Hall of Fame.