



Is Hydration Overrated?

New Evidence Suggests That a Little Dehydration May Be a Good Thing for Runners.

BY MATT FITZGERALD

The conventional wisdom about hydration is evolving. For the past 25 years or so, there has been a consensus that runners should drink as much as possible during longer training runs and races. In other words, optimal hydration is maximal hydration. Allowing yourself to become even mildly dehydrated is bad for your performance and your health and must be avoided at all costs. There is no such thing as drinking too much.

This dogma is rapidly being replaced with a more balanced view. New evidence suggests that it's just as important to avoid overhydration during running as it is to avoid becoming severely dehydrated. In fact, you stand to perform best in long runs by drinking to *slow* dehydration rather than to *prevent* it. Let's take a closer look at the new understanding of optimal hydration that is now emerging and its practical implications for you.

WATERLOGGED

The main factor that has inspired experts to revise the rules of hydration is a sharp increase in the incidence of hyponatremia in marathon events in recent years. Hyponatremia, or water intoxication, is a condition characterized by a dangerously low sodium concentration of the blood, which usually results when prolonged sweating is combined with excessive fluid consumption during runs lasting four hours or longer. When large amounts of salt-rich sweat are replaced with large amounts of substantially less-salty sports drinks (or water, which has no salt), the blood becomes diluted. At rest, your body can prevent blood dilution by shunting all of the excess water to the bladder for elimination, but during running, urine production decreases by as much as 60 percent because of increased blood flow to the working muscles, trapping excess water in the body fluids and tissues.

Sodium plays a critical role in maintaining proper fluid balance in body fluids and tissues. When the sodium concentration of body fluids falls too low, the cells begin to swell, which is especially problematic in the case of brain cells, because the rigidity of the skull allows for no release of the resulting pressure buildup.



Symptoms of hyponatremia include stomach bloating, exhaustion, dizziness, confusion, and collapse. Severe cases can lead to seizure, coma, and even death.

A recent study published in the *New England Journal of Medicine* reported that an alarmingly high percentage of the finishers of the 2002 Boston Marathon had developed hyponatremia during the race. Among the 488 runners tested for the study, 13 percent were hyponatremic and three runners were considered dangerously so. The reason? These runners had consumed an average of three liters of fluid while completing the race—enough to actually gain weight despite running (and walking) 26.2 miles.

Another study, this one from the University of Cape Town, South Africa, found an even higher incidence of hyponatremia among participants in the Houston Marathon between 2000 and 2003. Twenty-eight percent of these runners were found to be hyponatremic after finishing the race. As in the Boston Marathon study, those who developed hyponatremia drank much more than those who did not develop hyponatremia. Runners in the Houston Marathon study who maintained normal blood-sodium concentrations drank 18 cups of water during the marathon, on average, while those who became hyponatremic drank 33 cups.

ENOUGH FLUID TO DROWN IN

Thirty-three cups is an astonishing amount of fluid. Why would any runners in their right mind drink so much? The answer is simple. “The reason why athletes drink too much,” writes Tim Noakes, M.D., in *Lore of Running*, “is almost certainly due to hysteria attached to the supposed dangers that dehydration poses to athletes and to the belief that fatigue is caused by dehydration so that replacing more fluid than is lost during exercise will ensure optimum performance.” In yet another study of hyponatremia in a major marathon, all of the runners requiring emergency medical treatment for hyponatremia reported having drunk as much fluid as possible during (and often before) the race.

The blame for inciting dehydration hysteria falls squarely on the sports-drink industry. In the early 1970s, the leading sports-drink makers launched an aggressive campaign to educate doctors, scientists, and other members of the sports-nutrition establishment about the need for maximum hydration. Since then, the sports-nutrition establishment has consistently taught runners and other athletes to fear even mild dehydration and has advised us to drink as much fluid as possible during exercise. As we have seen, this is bad advice for runners, and it is especially bad advice for slower runners, because slower runners are able to drink at higher rates than faster runners. In addition, slower runners sweat less than faster runners (because sweat rate is tied to muscle heat production, which in turn is tied to running speed), so they don't need as much fluid to begin with.

Major marathons have seen a massive influx of noncompetitive runners in recent years, coinciding perfectly with the dramatic increase in hyponatremia.



In all of the studies of hyponatremia in marathons, runners with slower finishing times have been significantly more likely to experience hyponatremia than faster runners.

AN OUNCE OF PREVENTION

As dangerous as it is, water intoxication is easily avoided by means of two simple precautions. First, never drink so much that you gain weight during a run. You can determine your rate of weight loss during running by weighing yourself without clothing immediately before and immediately after a run, adding the volume of fluid consumed during the run to the difference, and dividing by the number of hours you ran. For example, if you lose 3 pounds (48 ounces) during a two-hour run during which you drink 20 ounces of fluid, your rate of weight loss during running (at that pace and air temperature) is $48 \text{ ounces} + 20 \text{ ounces} \div 2 \text{ hours}$, or 34 ounces per hour. Therefore, 34 ounces per hour should be your absolute maximum drinking rate.

In most cases, you can skip the math and just drink according to your thirst. Research has shown that the *ad libitum*, or natural, drinking rate in runners is almost always somewhat lower than the rate of weight loss—about 60 percent of the weight-loss rate in cool conditions and 70 to 75 percent of this rate in hot weather. In other words, when they go by feel, runners drink at a rate that ensures that they dehydrate at a slow rate. For precisely this reason, the sports-nutrition establishment has traditionally cautioned runners to “drink ahead of your thirst.” But biological urges that are as evolutionarily hard wired as the thirst response aren’t stupid. If we lack the drive to drink more than we do while running, there has to be a good reason. As it turns out, despite all you’ve been taught, dehydration is far less likely to cause adverse health events during running than overhydration. In fact, adverse health events in runners, such as heat injury, are almost never strictly related to dehydration. More on this topic follows.

There may be a simple explanation of why our natural drinking rate is slower than our sweat rate during running. Scientists normally assume that all of the body weight lost during a run is accounted for by body-fluid depletion. But this is not really the case. While running long distances, we convert large amounts of stored fat and carbohydrate into energy. Fat and carbohydrate molecules have weight, and when we metabolize them for muscle energy, that weight is lost. In addition, both fat and carbohydrate are stored with water, which is released into the bloodstream when fats and carbs are burned and then contributes to sweat losses. Over the course of a marathon, the burning of fats and carbs and the water lost in these processes could easily account for a few pounds of weight loss—weight loss that does not come from body fluid and therefore has no dehydrating effect. So runners who voluntarily drink at a rate that represents only 60 to 70 percent of



their rate of weight loss may well be drinking at a rate that is closer to matching the actual rate of body-fluid depletion.

THE SODIUM SOLUTION

A second way to reduce blood dilution during running, in addition to drinking according to your thirst, is to consume salt. The most convenient way to do this is to drink sports drinks instead of plain water while running. Water has a much greater diluting effect on the blood than sports drinks, because water contains no sodium, whereas sports drinks do.

The salt in sports drinks also increases their rate of absorption, so they hydrate faster than plain water. Fluids are absorbed through the gut and into the bloodstream faster when their *osmolality* closely matches that of body fluids such as blood. Osmolality is the concentration of dissolved particles in a fluid. The sodium and carbohydrates in sports drinks give them a much higher osmolality than water, and as a result they are absorbed faster. Sports drinks with higher sodium concentrations are absorbed fastest (and also have the smallest diluting effect on the blood). For this reason, use a sports drink that contains at least 15 milligrams of sodium per ounce.

Even the saltiest sports drinks contain only one-quarter to one-half as much salt as sweat (larger amounts would make them unpalatable). Consequently, during very long runs, a sports drink can dilute your blood, too, if you drink enough of it. For this reason, during runs lasting four hours or longer, you should consider supplementing your sports drink with salt tablets made especially for endurance athletes, such as Endurolytes and Lava Salts. Use salt tablets according to label directions during runs lasting four hours or more. Studies involving the use of salt tablets in ultramarathons have shown that they are effective in keeping blood-sodium levels higher, but as yet no study has shown a beneficial effect on performance.

A PAIN IN THE GUT

Hyponatremia is a concern only at low running speeds. At faster running speeds, it is almost impossible to absorb enough fluid to cause water intoxication. For this reason, hyponatremia is most common in ultramarathon runners and, as mentioned, in slower marathon participants. Competitive marathon runners usually encounter a different problem when they try to drink too much: gastrointestinal distress.

Due primarily to the jostling of the gut that occurs during running, we can neither tolerate as much fluid in the stomach nor absorb this fluid as quickly while running as we can at rest. This is the case at any running speed, but the faster we run, the lower the tolerable stomach volume falls and the slower that fluid is absorbed through the gut.



When there is too much fluid in your stomach, its jostling causes an unpleasant sloshy feeling that you've probably experienced—a feeling that becomes full-blown nausea in some cases. Stomach jostling also contributes to a reduced gastric-emptying rate (that is, slower absorption of nutrition through the stomach and intestine) during running. The result, if you try to drink too much, is a nutrition backlog in the stomach, small intestine, and possibly the colon that is not unlike the damming of a river and subsequent flooding of riverfront properties. Such a backlog and the resulting accumulation of fluid in places it should not be (such as the colon) causes a bloated feeling and leads to diarrhea in extreme cases.

DEHYDRATION: NOT AS BAD AS YOU THINK

Runners commonly assume that the reason they're supposed to drink to prevent dehydration while running is that dehydration causes heat illness. In fact, dehydration seldom causes runners to overheat. Instead, this problem is much more likely to be caused by simple overexertion in a hot environment.

The harder the muscles work (that is, the faster you run), the more heat they produce. In hot weather (especially hot, humid weather), this excess body heat does not dissipate well, and as a result it accumulates in the body. Heat illness occurs most often during very intense exercise, when the muscles are producing

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the most heat. In these cases, collapse occurs relatively quickly—long before dehydration has a chance to develop. Alberto Salazar's famous heatstroke collapse in the 7-mile Falmouth Road Race is a classic example.

Body temperature does rise as dehydration progresses during prolonged exercise. This is to be expected, since the more you sweat, the more your blood volume decreases, leaving less blood to carry excess heat away from your muscles to your skin, where it can be released into the environment. However, it goes only so far. Even severely dehydrated runners seldom experience heat illness, and those who do are seldom more dehydrated than those who do not. There is evidence that some athletes are particularly susceptible to heat illness and therefore experience it at dehydration levels that aren't a problem for most.

This is not to suggest that dehydration is benign. Extreme dehydration can be fatal. However, athletic collapse is almost never caused by dehydration, which must exceed 15 percent to pose serious health risks. Very rarely do runners or other athletes reach levels of dehydration approaching even 10 percent.

WHAT DOES DEHYDRATION DO?

However, dehydration levels of only 2 percent, which are very common during prolonged running, are sufficient to reduce endurance performance. As blood volume decreases because of sweating, the heart pumps less blood per contraction and therefore delivers less oxygen to the muscles per contraction. As a result, it takes more energy to continue running at the same pace.

Even so, elite runners actually tend to become more dehydrated over the course of a long race than slower runners. In a 1967 study involving English marathon runners, the winner was the most dehydrated and had the highest temperature of all the runners tested. A later study that measured fluid loss in runners competing in 30K races found a similar pattern: the highest finishers were the most dehydrated.

You would expect top finishers to lose the most sweat, because they are running the fastest and therefore generating the most heat. But you might also expect that these runners would have to replace most of this lost fluid through heavy drinking to avoid fading in the late miles because of the efficiency-spoiling effect of dehydration. These studies provide clear evidence that this is not the case. Elite runners appear to succeed despite modest compensation of their body fluid losses through fluid consumption during the race. The typical elite marathon runner drinks 400 to 600 milliliters of fluid per hour, while sweating at rates often exceeding two liters per hour.

The training, nutrition, and other performance-related methods of elite runners evolve through an ongoing collective trial-and-error process. Methods that work well survive and spread, while those that do not work well die out. If most top



Protein—A Hydration Booster?

New evidence suggests that protein enhances both fluid absorption and fluid retention in athletes. In a recent Spanish study, a carb-protein sports drink was found to empty from the stomach significantly faster than a carb-only sports drink in cyclists pedaling at 70 percent of $\dot{V}O_2$ max. And in a new study from St. Cloud State University, a carb-protein sports drink was retained in athletes 15 percent better than a carb-only sports drink (meaning 15 percent less of it wound up in the bladder).

Most sports drinks do not contain protein, but some of the newer sports drinks on the market do. Among them are Accelerade, Endurathon, and E3.

marathon runners drink at only a quarter to a third of their sweat rate in races, you can be sure that it is because this strategy works better than the alternatives. Certainly there have been cases where elite marathon runners have tried to drink more, but it has not worked out, either because drinking more led to GI distress or because they had to slow down too much in order to be able to drink more without GI distress.

The lesson we need to take from the example of the top runners is obvious. If your goal is to get to the marathon finish line as fast as possible, it's better to drink only as much as you can tolerate while running as fast as you can than it is to slow your pace to a level that allows you to drink more. While performance does deteriorate as dehydration progresses, the alternatives (namely, slowing down so you can drink and absorb more fluid or drinking more at the same pace and risking GI distress) are worse.

AN EVOLUTIONARY PERSPECTIVE

To understand what truly constitutes the optimal hydration strategy during running, it helps to take an evolutionary perspective. Evolutionary biologists have recently begun to recognize a much greater role of running in the evolution of modern humans from earlier hominid species than was previously the case. Selective pressure to become more effective hunters on the vast, hot African savanna transformed us gradually from tree climbers into endurance runners able to wear out prey that was able to run faster over short distances but also fatigued more quickly. In an article published in *Nature*, Dennis Bramble of the University of Utah and Daniel Lieberman of Harvard University pointed to the many changes in physiology that made us better runners as we evolved away from the lower apes, including the development of upright posture, longer legs, stronger feet, and bigger buttocks.



We also developed one of the most effective internal cooling systems in the entire animal kingdom. In *Why We Run*, Bernd Heinrich, a biologist and former champion ultrarunner, explains the advantages of this cooling mechanism:

Our nakedness and exceptionally numerous and well-developed sweat glands are potent features that contribute to running speed under external and internal heat. Because of sweating, we can tolerate very high heat loads derived from internal metabolism and the exterior environment. . . . Without sweating, running speed and range would be dramatically reduced. Most arid-land animals are compromised in endurance because they are highly adapted to conserve water. The fact that we, as savanna-adapted animals, have such a hypertrophied sweating response implies that if we are naturally so profligate with water, it can only be because of some very big advantage. The most likely advantage was that it permitted us to perform prolonged exercise in the heat (p. 174).

We are accustomed to thinking of the fluid losses we incur through sweating as a liability. But when we take an evolutionary perspective, we see our exceptional capacity to tolerate large fluid losses as one of the keys to our endurance-running gift. Our ability to become significantly more dehydrated than other animals without becoming exhausted or sick is a key reason we're naturally among the world's greatest endurance runners.

It's important to bear in mind that early human hunters had no way to drink on the run. They had to run in the heat for long stretches of time without drinking, and when they did drink, they had to stop running first. So, while there was a strong selective pressure toward the ability to continue running despite heavy fluid losses, there was little or no selective pressure toward being able to drink effectively while running. Consequently, we modern endurance runners have a very limited capacity to drink on the run.

Fluid belts and race fluid stations now enable us to do what the circumstances of prehistoric desert chases did not. Unquestionably, it is beneficial to take advantage of these resources to limit dehydration on the run. By keeping your blood volume higher, you allow your heart to deliver more oxygen to your muscles per contraction, and you are also able to maintain a higher sweat rate, which keeps your body temperature lower. Both of these benefits slow the loss of running efficiency that comes with dehydration. But in taking advantage of modern opportunities to drink on the run, you must not ignore two hard evolutionary facts: our bodies are designed to tolerate dehydration quite well, and they are not designed to tolerate any more than a modest amount of drinking while we run. So, as the doctor says: drink in moderation.

