Safety in Numbers: How Much Water?

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"Fish gotta swim, birds gotta fly, you gotta drink a lot or you'll die." That's not quite the way that Oscar Hammerstein II wrote it, but it's true. Especially on long days in the outdoors.

We'll begin by reviewing some anatomical basics about water and human hydration. We'll then turn to the issue of how much water you need to drink, and when.

Why We Need Water

You weigh less than rock, more than bread, and about as much as water. The next time you're in a swimming pool, take a deep breath, hold still and you'll probably float. Then exhale all that air and you'll probably sink. It isn't surprising that our density is close to that of water; the average adult is about sixty percent water.

The water in our body serves a dazzling variety of purposes. At a gross level, water helps to transport food into our bodies. (Don't believe me? Try eating four saltine crackers without a drink.) It helps to transport waste material out two different egresses (three if you include our skin). It is a key component in the digestion of the food. Water also provides similar services at the cellular level: it brings in nutrients, removes waste and facilitates critical chemical reactions. Water serves as a lubricant for our joints, and as a suspension mechanism for sensitive organs such as our eyes, brain and spinal cord. It is a key component as our brains manufacture the neurotransmitters essential for cogent thought. If you are running low on water, every one of these processes can be compromised.

Human blood is over eighty percent water. The blood transports nutrients to distant parts of our body and removes waste from them. The old adage tells us that "if your feet are cold, put on a hat." The water in your blood will then efficiently transport the excess heat from your head down to your core and then out to your toes. When we are too warm, the body cools itself by using water for perspiration. The energy lost as that salty water evaporates is an effective way of transferring our body's heat to the atmosphere.

A familiar analogy views the body as a car: food is fuel and water is the oil. In fact, water is also the radiator fluid, the transmission fluid, the windshield washer fluid (brings tears to your eyes!), a key component in the suspension system, and much more.

Hydration and Dehydration

If we already have so much water – about sixty percent of our weight – then why do we need a little more on any given day? By definition, an adequately hydrated person has the right amount of water in his body, and most of us are that way most of the time. If we get too much water, then we'll soon feel the need to urinate. But if we start running low on the precious fluid, then we are said to be dehydrated ("hypohydrated" may be more correct, but we'll stick with common usage), and all sorts of things start to go wrong.

One of the first signs is often a mild headache. We may refer to it as a "backpacker headache", but it is a close cousin of the common hangover, which is also rooted in dehydration. Around this point, well after we are dehydrated, we might start feeling thirsty. Sometimes dehydration progresses to lethargy, irritability, muscle cramps, constipation, dizziness and fainting.

Dehydration is even more serious in extreme temperatures. As our water level decreases, the water is lost from the blood, which becomes more viscous, and is therefore harder to circulate, which compromises our ability to transfer heat within the body. In hot weather, heat exhaustion and heat stroke are rarely seen without dehydration. In cold weather, both hypothermia and frostbite are frequently secondary to dehydration.

How We Lose Water

We most obviously lose water by urinating. If we are particularly well hydrated, then our output is "consistent, clear and copious" – we go frequently (at least every few hours), the stream is long and strong, and is somewhere between clear and straw colored. As we become dehydrated, the frequency and volume of urination decreases, and the color changes to a bright yellow. That is a bad sign that worse things will happen soon.

In hot weather, our bodies dump heat primarily by perspiration. The heat needed to evaporate the sweat on our skin comes from our core and goes to the atmosphere. In the process, though, we also lose the water that we sweat out. While women glow and other men perspire, this particular man sweats like a horse. On warm days I make a point of wearing very thin synthetic shirts that can't hold much water, and even so I sometimes have to stop and wring out my shirt. If the hot air is very dry, then we also lose a lot of water in the moist air that we exhale. (When the hot air is very humid, we lose less water in respiration, but the sweat cannot evaporate, the cooling is ineffective, and we are in great danger for heat illnesses.)

In cold weather, we lose a great deal of both heat and water as we breathe. The cold air is capable of holding little water, so it is necessarily dry air. We therefore inhale cold, dry air and exhale warm, moist air. On a zero-degree day you can feel the heat when you hold your hands over your mouth as you exhale; remove your hands and you can watch the moist air come out.

How Much Water?

Now we know a little about why we need water, how we lose water, and what happens if we lose too much. So how much water do we need to drink? It is easy to find outdoor authorities that state conclusively that "a hiker needs at least *X* quarts (or liters) of water per day". As I was preparing to write this essay, I found values of *X* including 3, 4, 5, 6, 7 and 8! The most extreme such number that I found was in Wilkerson's classic *Medicine for Mountaineering* (Fifth Edition, Mountaineers Books, 2001). In the 1967 Sinai war, Israeli soldiers were allocated ten liters of water per day, and sustained no heat injuries. Their Egyptian counterparts drank just three liters per day, and many of them died from heat illnesses secondary to dehydration. You *gotta* drink a lot or you die.

A Day in the Mountains

I knew most of this as I set out on a hike on July 31, 2001, in the mountains of my boyhood in Southern California. I was hoping to spend the night on top of San Gorgonio Mountain. I downed two quarts of sports drink before I started on the trail at the South Fork parking area. I walked just under five miles to the last certain water of the day at South Fork Meadows, and loaded up. I drank an additional liter there, and filled up three 2.5-liter reservoirs and a 1-liter bottle. So as I left that stream, altogether I had about 3 quarts inside me (well, some had exited) and 8.5 liters (almost 19 pounds) on my back. The temperature that day was perfect for walking: mid 30s at night to mid 60s in the day. It was neither too hot nor too cold, and I was going up with more than a load for desert warfare. I was set. So I walked. And walked. And peed. And walked.

I reached the top of the mountain about on schedule. At that point I had walked a total of 15 miles and gained about 5500 feet for the day. My urine output had been pretty good, but only because I had consumed a lot of water: two of my 2.5-liter reservoirs were empty. I was on top, thirsty, I hadn't peed for a while, and I had only 3.5 liters of water left. My choice was easy: I wasn't going to spend this night on top. The next water was five miles away, so I drank up and headed on.

I ascended three beautiful peaks on my way to the water, for an additional 500 feet of elevation gain. When I stopped for my final pee break of the day, it had been a couple of hours since the last one. I produced a tiny stream of bright orange urine. I had half a liter of water left on my back when I finally stumbled into camp.

That mountain kicked my ass that day. I learned that the one-size-fits-all magic number of ten liters per day sure didn't fit me there and then.

I saw many beautiful views along my walk, but none was anywhere near as wonderful as the steady stream of water at Plummer Meadows. I drank and set up camp and drank and ate and drank and slept; I had downed about three additional liters of water by the time I went to bed. Several times throughout that night I woke up, used my pee bottle, and drank some more. By the next morning my urine output had returned to consistent, clear and copious. I loaded up six liters of water for the next ten miles to Forsee Creek – I got there with a couple liters to spare. There were reliable streams after that, so I dropped down to a three-liter water load, just in case something happened and I had to stay out longer.

So why did I lose so much water that day? The fifteen liters that I consumed was fifty percent more than the ten liters allocated to Israeli soldiers. I'm a big guy – 6'4" and 200 pounds – so maybe I weigh 30% more than the average Israeli soldier (of 1967) and therefore require 30% more water. The day wasn't hot and it wasn't cold. But I was high. I parked my car at 6880 feet, and San Gorgonio is at 11,499 feet. I was acclimated because I had spent most of the previous week at altitude: a few nights in the Yosemite high country at 9000 feet, and then two nights at Iceberg Lake at 12,500 feet while climbing the East Buttress of Mount Whitney up to 14,494 feet. The air that I was breathing on San Gorgonio wasn't hot and it wasn't cold, but it was thin and dry – air

over 10,000 feet can hold very little moisture, and this air was dry even by those standards. Every breath I took moistened that air, and every exhalation gave away more precious water.

How Much Water do *You* Need?

I can't tell you how much water you'll need, and I don't think anyone else can, either. But it may be more than you think. In fact, it may be a *lot* more than you think. Here are some rules that I have developed for myself since that day long ago when I ran out of water.

I maintain a high level of hydration in the city. My colleagues are used to seeing me with my 48-ounce mug of ice water, and to my brief breaks during multi-hour meetings. The day before a hike I drink a little more than usual, and I drink at least a quart of water before I leave my car.

I aim to drink about a half liter per hour while walking, and maybe half that when I'm lounging. If the exercise is particularly strenuous (serious uphill, for example), I increase my intake to a liter per hour. If the air is particularly hot, cold or thin, I might increase those numbers by fifty percent, or even double them. I make a point of not getting too hot or too cold within my clothing. I track my urine output carefully throughout the day, and drink more as soon as it is not consistent, clear and copious.

I carry enough water to satisfy my needs if all goes according to plan, plus a little more just in case something bad happens. At the end of the day, whether I'm in camp or in a car, I start making up any water deficit that I might have.

Let's plug these numbers into that old trip on San Gorgonio. From the last water at South Fork Meadows to the next water at Plummer Meadows I have to walk 15 miles and gain 4700 vertical feet. The essay "How Fast and How Far" describes how I usually estimate my hiking speed at 3 mph and one thousand vertical feet per hour. By that formula, this trip is about 10 hours of walking. My baseline is a half liter per hour, but these are strenuous miles at altitude, so I'll need at least a liter per hour, and ten hours gives ten liters. I'll also need water for, say, twelve hours in camp. I'll start at a quarter liter per hour, and then double that (for altitude) to a half liter per hour, to get six more liters. The grand total of 16 liters for that part of the trip is just about what I ended up using.

You'll need to observe how your body behaves in a variety of conditions to build a similar set of rules that work for you. And never forget the sage advice:

If you don't have to pee, you're not drinking enough.