CASE STUDIES
ELABORATE LESSON 13

Dehydration Article

A gruesome death: the macabre science of dehydration

Publish Date: August 13, 2021
Publication: Big Think
Author: Jonny Thomson
Link: https://bigthink.com/health/gruesome-death-macabre-science-dehydration/

In 1994, the Italian athlete Mauro Prosperi entered one of the most intense and grueling endurance races in the world: the Marathon des Sables. This six-day ultra-marathon takes place in the Sahara desert, and it pushes people to the limits of their mental and physical abilities. The temperatures of the race can reach up to 50 C° (122 F°), and the average runner drinks 13 liters (3.4 gallons) per day, most of which comes straight out as sweat.

But for Mauro, things were even worse than that. After a sandstorm, the former Olympian was caught alone for ten days in the desert without a support team or supplies to help him through. Over the course of his wandering, Mauro stayed alive by storing his earliest urine in bottles — since this had the highest water content — and drinking it later on. He killed and ate twenty bats and drank their blood in the hope of staying hydrated. Luckily, it worked just long enough. Eventually, he came across a goat herder, and his long recovery began.

But in such a short time, his body was wrecked by dehydration. His eyes were nearly ruined, and his liver was seriously damaged. He could not eat anything other than soup or water for weeks, and it took him two years to fully recover.

Walking bags of water

It has long been known that hydration is essential to a properly functioning body. Our bodies are 50 to 70 percent water, which means an average man will contain up to 40 liters (10.6 gallons). This can differ on any given day, and it largely explains why our body weight also can fluctuate by about 2 kg (5 pounds) per day.

It is recommended that we each drink roughly 3 liters (0.8 gallons) of water a day to replace the stuff we lose through breathing, sweating, and urinating. While this seems like a lot, for most of us, that water comes from drinks like coffee or soda, and up to 20 percent of it can come from the food we eat. Yet, on some days, we just do not drink enough, and it shows.

When we are mildly dehydrated, our bodies start to creak. We get headaches because, without water, the brain will contract ever so slightly, causing it to pull away from the skull. We get constipated because our body draws needed water from the large intestine. We get tired and find it hard to focus because,

without water, our blood literally thickens, meaning the body has to work harder to get nutrients and oxygen to the organs.

It is thought that even a 2 percent drop in hydration levels can noticeably impede performance in a variety of areas. Usually, this can be easily resolved, but what happens if you continue to dehydrate? And why is it thought to be one of the most painful and protracted deaths that we can experience?

A gruesome death by dehydration

Imagine for a moment that someone was to lock the doors where you are right now. Assuming you had no emergency bottles of water, it would take you roughly seven days to die from dehydration. If you were lost in the desert with no water at all, it would take a day and a half.

When the body is forced into extreme situations like heat, cold, or water deprivation, it makes a tactical decision to withdraw resources from the least essential parts first. With dehydration, this initially happens in the kidneys. Our kidneys will reabsorb water that would have been used in urine, so this is why your urine gets darker when you are dehydrated — the urea concentration increases.

When this is still not enough, the body will draw water from your cells and organs to retain the necessary water. Your eyes will contract to expose the conjunctiva, your lips will shrivel away entirely, your teeth and gums will project outward like on a skeleton, your skin blackens and dries out, and your tongue becomes a tiny piece of beef jerky. If you are cut, you are too dry to even bleed.

Only after days of this slow torture will you die. With less and less water, the blood in your body will thicken, and your blood pressure will drop drastically. This means that all of the oxygen and nutrients in your blood will take a lot longer to get to your organs, and so they become deprived. Your brain, heart, kidneys, and liver begin to fail. Ultimately, your brain will start to shrink from osmosis in an attempt to hydrate the body (the brain has a lot of water), which eventually will cause you to die.

Overhydration Article

Strange but True: Drinking Too Much Water Can Kill

Publish Date: June 21, 2007
Publication: Scientific American
Author: Coco Ballantyne
Link: https://www.scientificamerican.com/article/strange-but-true-drinking-too-much-water-can-kill/

Liquid H_2O is the sine qua non of life. Making up about 66 percent of the human body, water runs through the blood, inhabits the cells, and lurks in the spaces between. At every moment, water escapes the body through sweat, urination, defecation, or exhaled breath, among other routes. Replacing these lost stores is essential, but rehydration can be overdone. There is such a thing as a fatal water overdose.

Earlier this year, a 28-year-old California woman died after competing in a radio station's on-air water-drinking contest. After downing some six liters of water in three hours in the "Hold Your Wee for a Wii" (a popular Nintendo game console from the late 2000s) contest, Jennifer Strange vomited, went home with a splitting headache, and died from so-called water intoxication.

There are many other tragic examples of death by water. In 2005, a fraternity hazing at California State University, Chico, left a 21-year-old man dead after he was forced to drink excessive amounts of water between rounds of push-ups in a cold basement. Club-goers taking MDMA ("ecstasy") have died after consuming copious amounts of water trying to rehydrate following long nights of dancing and sweating. Going overboard in attempts to rehydrate is also common among endurance athletes. A 2005 study in the *New England Journal of Medicine* found that close to one-sixth of marathon runners develop some degree of *hyponatremia* or dilution of the blood caused by drinking too much water.

Hyponatremia, a word cobbled together from Latin and Greek roots, translates as "insufficient salt in the blood." Quantitatively speaking, it means having a blood sodium concentration below 135 millimoles per liter, or approximately 0.4 ounces per gallon, with the normal concentration lying somewhere between 135 and 145 millimoles per liter. Severe cases of hyponatremia can lead to water intoxication, an illness whose symptoms include headache, fatigue, nausea, vomiting, frequent urination, and mental disorientation.

In humans, the kidneys control the amount of water, salts, and other solutes leaving the body by sieving blood through their millions of twisted tubules. When a person drinks too much water in a short period of time, the kidneys cannot flush it out fast enough, and the blood becomes waterlogged. Drawn to regions where the concentration of salt and other dissolved substances is higher, excess water leaves the blood and ultimately enters the cells, which swell like balloons to accommodate it.

Most cells have room to stretch because they are embedded in flexible tissues such as fat and muscle, but this is not the case for neurons. Brain cells are tightly packaged inside a rigid bony cage, the skull,

and they have to share this space with blood and cerebrospinal fluid, explains Wolfgang Liedtke, a clinical neuroscientist at Duke University Medical Center. "Inside the skull, there is almost zero room to expand and swell," he says.

Thus, brain edema, or swelling of the neurons of the brain, can be disastrous. "Rapid and severe hyponatremia causes entry of water into brain cells leading to brain swelling, which manifests as seizures, coma, respiratory arrest, brain stem herniation and death," explains M. Amin Arnaout, chief of nephrology at Massachusetts General Hospital and Harvard Medical School.

Where did people get the idea that guzzling enormous quantities of water is healthful? A few years ago, Heinz Valtin, a kidney specialist from Dartmouth Medical School, decided to determine if the common advice to drink eight eight-ounce glasses of water per day could hold up to scientific scrutiny. After scouring the peer-reviewed literature, Valtin concluded that no scientific studies support the "eight x eight" dictum (for healthy adults living in temperate climates and doing mild exercise). In fact, drinking this much or more "could be harmful, both in precipitating potentially dangerous hyponatremia and exposure to pollutants and also in making many people feel guilty for not drinking enough," he wrote in his 2002 review for the *American Journal of Physiology—Regulatory, Integrative and Comparative Physiology*. And since he published his findings, Valtin says, "not a single scientific report published in a peer-reviewed publication has proven the contrary."

Most cases of water poisoning do not result from simply drinking too much water, says Joseph Verbalis, chairman of medicine at Georgetown University Medical Center. It is usually a combination of excessive fluid intake and increased secretion of vasopressin (also called antidiuretic hormone, or ADH), he explains. Produced by the hypothalamus and secreted into the bloodstream by the posterior pituitary gland, vasopressin instructs the kidneys to conserve water. Its secretion increases in periods of physical stress—during a marathon, for example—and may cause the body to conserve water even if a person is drinking excessive quantities.

Every hour, a healthy kidney at rest can excrete 800 to 1,000 milliliters, or 0.21 to 0.26 gallons, of water, and therefore, a person can drink water at a rate of 800 to 1,000 milliliters per hour without experiencing a net gain in water, Verbalis explains. If that same person is running a marathon, however, the stress of the situation will increase vasopressin levels, reducing the kidney's excretion capacity to as low as 100 milliliters per hour. Drinking 800 to 1,000 milliliters of water per hour under these conditions can potentially lead to a net gain in water, even with considerable sweating, he says.

While exercising, "you should balance what you're drinking with what you're sweating," and that includes sports drinks, which can also cause hyponatremia when consumed in excess, Verbalis advises. "If you're sweating 500 milliliters per hour, that is what you should be drinking."

But, measuring sweat output is not easy. How can a marathon runner, or any person, determine how much water to consume? As long as you are healthy and equipped with a thirst barometer unimpaired by old age or mind-altering drugs, follow Verbalis's advice, "Drink to your thirst. It's the best indicator."