SOARING Rx

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Dehydration Without Thirst

When we cool off in climb, we lose body fluid: we lose volume, *not merely water. Volume loss does not cause thirst until it's severe. With volume loss, we feel weakness and fatigue. Taking only* water *does not restore volume or the lost electrolytes (usually salt).*

Summary

- Water/salt balance drives thirst
- Most *dehydration* involves *volume loss*. This is generally water + salt
- Both water and salt must be replaced
- Dark urine
  - Means that you could use more water, because kidneys are conserving water
  - Hard stools mean that you're water deficient
  - Light urine means you have *enough water*, but no answer on *volume*
- "Thirst" reflects only *water* deficit, but usually it's *volume* that's needed
  - You'll feel bad until the volume is replaced
  - Water-only rehydration is dangerous with heavy sweating
- A low-salt diet results in much less urination, a convenience to the pilot.

An ordinary soaring pilot, a male named Leroy, went to the airport on a lovely day. *It would not matter if the pilot were Leticia because the physiology is the same.*

The story is true, but names are changed.

It was a pleasant morning, so he wore light clothes. He spent about an hour-and-a-half assembling his glider and doing light maintenance. With this activity, he sweated a little, just enough to make the band of his cap wet. When he was ready to tow his glider to the runway, he realized he was thirsty, so he drank two tall glasses – about a pint – of water.

A technically-aware pilot, he checked the temperature-dew point spread. On one hand, he was keenly aware that he could estimate the cumulus cloud bases in thousands of feet above ground by subtracting the dewpoint, 35 °F, from the day's predicted maximum temperature and dividing by 5.

He was not so keenly aware that, while he was flying near cloud base in the shade, the temperature in his cockpit would be roughly the temperature of the ground dewpoint. He did realize that it would be cool aloft, so he put on a light jacket. He immediately felt too warm, so felt satisfied. He had no clear recollection of how it felt to wear this jacket when it was 35 °F on the ground.

It was indeed a fine day. Once launched, it was not too difficult to find good thermals. Cloud base was actually about 2,000 ft higher than forecast, and he idly noted that his glider's thermometer showed the temperature to be below freezing. He closed the vents.

When near cloud base, in cloud shadow, he felt quite cool, though he did not feel *cold* and did not shiver. The cockpit was pleasantly warm in the sun between thermals and a little too warm when he got low and had to scratch for lift.

After about an hour and a half, while zipping along near cloud base, he realized that his feet felt a little bit cold, and he also realized that his lower abdomen would feel much more comfortable if he used the Dependable cockpit-emissions garment that he often wore but seldom used.

He had brought water, but didn't feel thirsty and so he didn't use it.

It was a fine day. He was able to fly about 4 hr, was able to complete a modest triangle, and enjoyed a fast final glide back home.

He felt pretty good about the day, and in celebration made a beautifully executed steep turn from downwind straight to final. At the apex of the turn, he felt a little bit strange, but wasn't sure why.

There was a light crosswind, slightly gusty. Though he didn't bounce, he whacked the ground a little more sharply than he preferred, and the wings waggled a little bit more than he would've preferred in front of the gliderport spectators.

He drank some water, then disassembled his glider, put it in the box, and went home. All evening he felt

quite thirsty and had drunk 6 or 8 glasses of water by the time he went to bed.

Have you lost water? Or volume?

- *Thirst* reflects *water* deficiency sensitively
  - A 1% increase of osmolality – electrolyte concentration – results in thirst
  - In practical terms, this is a loss of about 1% of body weight in water. A pint is a pound, so 1% for a 200 lb person is a 2 pint water loss, almost a liter.
- *Thirst* reflects *volume* deficiency less well
  - ~10% decrease of blood volume results in thirst
  - The average blood volume is about 5 liters, so that's about one "unit" of blood (525 ml)
  - Loss of volume causes weakness before thirst
  - Salt lost with sweating delays thirst because it decreases the osmolality drop that would occur purely from the water loss.

In the morning, he passed a turd that was somewhat firmer than usual.

What Happened to Leroy?

First, we must clear up a common misunderstanding.

The ancient Greek word for *water*, ὕδωρ (hydor), is the root of all things hydro- in English and many other languages. But in thinking about our bodies, it's better to consider it to mean "liquid," "juice," or "soup."

In other words, we seldom lack purely water because we often lose both water and the stuff that's in it within our bodies. Our bodies consist of a variety of different soups that are encapsulated by membranes, in which are proteins, salts, and cells, and held together by sinews and bone.

We generally lose proteins and cells along with juice only when we bleed. We may lose protein with juice if we have kidney disease. Otherwise we always lose some salts (electrolytes) along with water.

Thirst is exquisitely sensitive to *water* loss. There *is* a "salt appetite" that is relatively insensitive.

When we lose bodily juice of any kind, and replace only water, we fail to replenish *volume*, so drinking until thirst is quenched fails to replace the volume we've lost.

Quenching thirst shuts off the drive for water when the proportion of water to salt in the blood has become ideal – but if we've lost *volume*, simply quenching thirst wrongly shuts off part of the volume-preserving mechanism prematurely.

Salt-Water Balance: One-Directional

- With water loss or salt intake, fluids are *more concentrated* (higher osmolality), shrinking cells
- Separately, this causes *thirst:* water-seeking and
- Release of: vasopressin – hormone
  - Raises blood pressure
  - Increases water retention by moving aquaporins into the cell membranes of the kidney's collecting ducts
- *There is no un-thirst when water is excessive* (salt is never deficient).

Types of body juices.

Urine: The kidney excretes any salt/electrolyte that's present in excess, and transforms into electrolyte many waste products to make them water-soluble. The kidney does excrete excess water, but must excrete *some* water in order to get rid of the electrolytes it produces. This is called the *obligatory water loss*.

Cooling off causes volume loss through urination.

Cold Diuresis: As the body cools, the veins under our skin in arms and legs constrict to stop radiating heat, and the arteries to our extremities constrict to reduce outward blood flow to protect our core temperature.

This reduces the capacity of our circulatory system and increases the pressure in central veins. This is interpreted by our body as "too much juice" and a signal is sent to our kidneys: "Too much juice onboard; get rid of the extra."

This is why we need to pee an hour or two after getting cool (we don't have to feel uncomfortably cold).

Important – no thirst here: This is balanced water-electrolyte loss, so we lose volume *without thirst*. It even helps to be a little volume-depleted when we cool down because there's less inconvenient urination.

In case it's not obvious, we get in trouble when we *rewarm*, because our vasculature expands and we don't have enough juice to fill it.

The time to drink sport drinks is while we are warming up – during descent in hot weather, in the recovery-sauna in cold weather.

Years ago, I received a nice letter from a paraglider: "You saved my life! I didn't understand why my landings were so sloppy in Death Valley after flying at 17,000 ft. I lost one of my friends in a bad landing there."

After-Chill: I received an email with another aftermath of flying in cool temps that said, "I spent most of the 5 hr flying with Outside Air Temperature (OAT) ~8 °C (45 °F). I pulled the glider about 30 ft (9 m) to the staging area and walked to the bathroom. When I came out, I was shaking with cold. Why? It was obviously much warmer on the ground than in the cockpit."

Medically, this is called "reperfusion hypothermia." The pilot feels cool but not cold lying in the sunny cockpit, wiggling ankles and wrists for five hours. During this time, the muscles receive little blood flow and eventually contain a fair amount of chilled blood. The pilot's core temperature has been protected by the normal mechanisms that restrict circulation and so he merely feels cool, not realizing how much his core temperature has decreased.

Then he hops out of glider and immediately uses his large muscles to move about. This flushes the chilled blood out of the muscles of his legs and lower back, which circulates into his core and drops his core temperature just enough to trigger shivering.

This pilot then warmed up by using his muscles to disassemble his glider. This muscular metabolism generated enough heat to lessen his hypothermia. He did not become weak or faint because he had hydrated well during the flight.

Sweat: There are two kinds of sweat, the smelly kind (apocrine) that develops with puberty and aids social distancing, and the salty kind (eccrine) that exudes from skin everywhere for evaporative cooling when we get too warm.

Sweat is a distillate, as it were, of blood: Sweat glands exude water and electrolytes, and the sweat gland's tubules recover much of the electrolytes (sodium, potassium, and chloride) as the sweat migrates along the tubule to the skin, for evaporative cooling.

How *much* salt we lose depends on three things:

- *The rate of sweat flow.* When we're sweating heavily, there's less time to recover electrolytes.
- *Our dietary salt intake:* The sweat glands go into a salt-conserving state if we follow an un-American low-sodium diet.
- *Heat acclimation.* With several days of continual exposure to heat, sweat glands go into a salt-conserving state. (It takes only 24 hr in an air-conditioned environment to lose heat acclimation.)

The Sum of All Sweating is that we do lose sodium and chloride when we sweat. If we've been sweating heavily, we need to replace both salt and water.

If we only take water, our thirst is quenched, but the lost volume isn't restored – so we feel good, but haven't regained g-tolerance (for example).

Pounding water in response to heavy sweating dilutes the blood and body electrolytes severely, and has killed athletes.

Gastric juice: If you're sick and vomiting, you won't be flying, because who wants to clean the cockpit, eh?

If you *were* sick yesterday, one of the reasons that you still feel crummy today is that you lost more than water.

Key to this point is that stomach juice contains both protons and chloride (hydrochloric acid). If we vomit, we lose acid. Read your favorite medical physiology textbook to find out why the kidneys then excrete potassium and bicarbonate.

The loss of volume and acid increases and prolongs the nausea, so the best way to recover is to sip on fruit juice for a few hours. 4 ounces an hour is enough to keep you safe and usually can be tolerated even with a queasy stomach. Orange juice and grapefruit juice are the two commonly available fruit juices high in potassium.

The point here is to help you recover as fast as possible so that you'll be safe when you drive or fly.

Diarrhea: The colon (large bowel) is an emissions control device. The small intestine, having absorbed the useful nutrients, sends a steady stream of fluid into the colon.

The colon absorbs all the extra water and electrolytes, the bacteria process the indigestibles, and the result is a soft, compact mass, mostly bacteria with food fiber.

When we have diarrhea, the colon is ill and impaired, failing to absorb both water and electrolytes. We lose *volume*, and must replace *volume*.

We experience thirst with diarrhea *only* if the volume loss is severe or when water is lost disproportionate to the electrolytes.

The electrolytes lost are sodium, potassium, chloride, and bicarbonate. The proportions depend on the

cause of diarrhea; the best treatment for this is to sip *oral rehydration drinks*, available at your drugstore, or to add a quarter-teaspoon of salt to a pint or more of fruit juice.

Stool consistency is the most effective way to judge your hydration strategy. If stools are firm, you simply didn't take enough water yesterday.

What Happened to Leroy?

- He was sweating for an hour before he took off and replaced only water, so he was a little short on volume.
- His mild volume deficiency was invisible because his blood vessels constricted as he became cool after takeoff (also diminishing the cold diuresis).
- When he became cool aloft, he urinated frequently as his blood vessels contracted. This represented a balanced volume loss of water and electrolytes, so he was not thirsty. He was not volume deficient while cool, and if he drank extra fluid in flight he would simply have peed it out quickly.
- He was correct to not drink aloft: his vasculature was contracted, and he would simply have urinated more. If we become *thirsty*, we *should* take water, for thirst is a reliable sign that the proportion of water to electrolytes in the blood is awry. (Thirst does *not* reflect volume status reliably.)
- When he warmed up at lower altitudes, his vasculature relaxed, and he did not replace the volume he had lost while urinating during flight. This reduced his g-tolerance, which made him feel weird in a steep turn from downwind to final, itself perhaps a sign that his volume loss had impaired judgment. His awkward landing may have been related to this.
- He only drank water after he exited the glider. This relieved thirst, but did not replace volume. He thought he was tired because he had had a long flight. In fact, he had been lying in a chaise longue wiggling his ankles and wrists, not considered a form of exercise. He was fatigued because he was volume depleted. Some people get headaches with volume depletion. Leroy is headache-immune.
- Significant volume depletion is associated with thirst. In addition, Leroy had some salty snacks and salty food for supper. These reliably cause thirst; no surprise he was thirsty all evening.

The fact that he did not pass a brick the next morning means that the evening's thirst and avid fluid intake brought his volume almost to normal.

Usefulness of Salt	Drawbacks of Salt	Simple Minimum Salt Diet
• If you've lost volume, you'd best replace volume (salt + water) • If you drink water, when you need volume: o Thirst is quenched quickly, but o Volume is not replaced, so that – Antidiuretic hormone continues to be produced, and – Excess water is retained, outbalances body salts, dilutes body water, and hinders brain cell function, etc. • If you eat salt, you gain volume o Water must be imbibed to maintain osmotic balance (concentration) • Use sport drink to replace sweat pound for pound o Replace ½ the loss immediately, ½ over the next half hour.	• 20% of people develop hypertension from extra salt • Salt in the diet replaces the potassium that would protect for the effects of high blood pressure • Excessive need to urinate occurs o All that extra salt is gotten rid of only one way: pee o ~50 milligrams of salt daily are enough o Americans eat ~5,000 milligrams of salt daily o Salt is slowly lost o Increased volume is harmless to healthy persons. • Geezers with bad hearts, kidneys, or livers retain the volume and get edema, shortness of breath, and much more.	• Only eat fresh food; add no salt o Minimize sweet peas, celery, and milk – each has about 200 mg sodium per cup • Don't eat: o Cheese (it's preserved with salt) o Pickled stuff (pickling is soaking in brine) o Processed meats – some shops use sodium nitrite to keep meat red o Canned stuff (brine) o Snack foods and candy (yes, candy) o Restaurants (unless you can negotiate with the chef)

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He is a mediocre soaring pilot with a fine old sailplane, a Ventus Cm, with 27 years, 1,200 flight hr, and 66 engine hr on the clock.