Some Effects of Cold

On a hot train, Alice felt so low,
Faint and shaky from head to toe
She thought, Next time I oughta
Take along a bottle of Water
– Transport for London
(sign in Tube car)

We are getting into the season of low-temperature gliding, and presuming that the heating system in your sailplane works no better than mine, perhaps this would be a reasonable time to review something about your body's adaptations to cold.

We'll assume that you do wear clothing, and that you intend to wear personal insulation sufficient for the planned flight and ground activities. We will also assume that your predictive accuracy is imperfect (this does seem like a reasonable assumption even without quizzing your partner).

Your body's automatic systems put top-level priority on preserving core temperature and keeping it constant. People do vary slightly on their actual core temperature, which is a hair under 38 C / 100 F.

Sweating

One of the difficulties with keeping warm is that we also must stay cool. We sometimes go in just a few minutes from a too-warm to a too-cold environment – from sweaty to chilly. We have all experienced this, even if it's merely walking from a hot parking lot into an air-conditioned movie theater. This happens in a glider on any hot day with good thermals and a low dew point.

The clothing that's comfortable at cloud base is never what was comfortable while assembling. To address this, we can dress in layers; we may carry a jacket in the cockpit to pull across our shirt.

On the other hand, if we get sweaty on the ground, we generally don't change into something dry. We might then wear wet clothing to altitude (because we sweat from the inside out). That is, we are on the inside, including our skin, and our clothing is on the outside. As you have noticed.

One reason to check the dew point on a thermal day is to plan your cockpit wardrobe. On a wave day, expect severe cold. Ice fishermen know how to dress for this. They stand around all day in 40-below cold. If you have any trouble finding the right equipment, Google up a sporting goods store in International Falls, MN or Winnipeg or Saskatoon. They'll have the special boots, the down coveralls, and the mittens, and the experienced advice you need.

We sweat even in cool weather ...

There are two important points about the transition from being hot and sweaty on the ground, then climbing in a strong thermal to the dew point altitude:

1) Wet clothing cools us off needlessly and rapidly in a cool environment. Water conducts heat very well. There's a great risk of hypothermia for people who transition from a hot to a cold environment.

We sweat *even in cool weather* when we do muscular work, because muscles generate a fair amount of heat – our clothing may become soaked, especially our back (which we can't see at all and actually can't feel very well). Water conducts our heat away all too efficiently, so we may get chilled simply by resting in wet clothing, for example, reclining in the cockpit.

2) Another important point is that ***cold adaptation begins long before we feel cold.*** The body's systems begin to cool our extremities as soon as our skin cools, and becomes more enthusiastic after our core temperature falls even a little – *however, we don't yet feel "cold" at this point.*

The first response to cold is that the small arteries in the hands and feet constrict. Of course, without hot blood coursing through them, less heat it lost. In addition, each artery is flanked by a pair of veins, and as the cold blood returns up the leg or arm, the artery warms it – and the arterial blood cools, further chilling hands and feet.

There's also less blood coming back from the extremities (since less is going there, as you've already noticed). The veins constrict to accommodate to this.

The upshot? The entire vascular system has reduced *capacity.* The blood volume that earlier filled our vasculature is now too great. There's only one safe way to reduce this volume, and it's not sweating or vomiting. Our kidneys quickly get rid of the excess, which is collected by your Cockpit Relief System. (That's a topic for another time, I suppose.)

This process – called "cold diuresis," is the reason, after we've been outdoors in cool weather, that we have a full bladder after an hour or so, *even if we do not feel cold.* We "feel cold" only if the compensatory mechanisms are unsuccessful in preserving our core temperature.

Cold diuresis

A "diuretic" is something that creates extra urine flow. We normally think of diuretics as drugs, but there are other ways. High blood sugar does this to diabetics. Drinking extra water does this quickly: our body gets rid of extra water completely within four hours.

Eating salt we don't need (or drinking salty fluids like soup) creates extra urine flow, but not until we've first drunk the water needed to balance it – and even young, healthy people take three days to excrete excess salt. Older folks may never get rid of it.

However, nothing works more quickly than simply getting cool. In the glider, in the swimming pool, riding your snowmobile, or sitting in a cold theater: it's all the same to your vasculature. This is why you have to pee an hour or two after entering a cold environment (before the movie ends).

What's lost with this? *Blood volume.* Essentially, our blood comprises cells, protein, and brine. We can't quickly get rid of cells or protein, but we can easily get rid of the brine. (We call this "normal saline" in medicine.)

Let's eliminate an important misconception. This is *not* exactly dehydration. To dehydrate is to remove *water*. And it's true that water is lost, *but if you replace only the water, you will fare badly*. (The occasional endurance athlete dies by replacing only the water and not the salt.)

To be precise, this is *volume loss*. This is one reason why, when blood is lost, we replace volume, not water – and replace red cells (transfuse) if needed to maintain oxygen transport. Volume lost from sweating or from cold diuresis is best replaced with salt plus water, either salty beverages, or water plus salty food. You will simply recover faster if you do this, will have less headache and fatigue.

Fatigue

A challenge in keeping peak performance is that many adverse physiological changes in our bodies result in nothing more specific than a sense of fatigue. Cold exposure is an exception, except that we may never actually feel personally chilled – if our homeothermic mechanisms are successful – but we may come back home feeling unusually tired. This is mainly due to the "dehydration" ("volume loss") that's due to cold diuresis.

For example, once a cyclist told me of a one-day criterium (a closed-course bicycle race, generally held on city streets), held in 50-degree (F), rainy weather, before the following day's open-road race.

... at this stage your brain is cold and is not working at its best.

Many of the racers were "wrecked" the next day and didn't race because they were so fatigued. The main problem is that they did not know about cold diuresis and the need to replace salt as well as water. A secondary problem was that some became hypothermic and did not know how to recover quickly (a hot bath at 110 F 43 C with sport drink or tomato juice – always very salty – at one's side).

Dizziness

When we fail to replace volume while we warm, the most obvious adverse effect might be feeling very lightheaded when we stand up. This can be dangerous, of course, if it happens while cleaning the second-floor roof gutters, and disabling if you break a wrist or hip on the stairs. Why does this happen?

As we re-warm, our arteries and veins re-expand. If we actually become too hot, such as when we find ourselves scratching for lift down low, or after we have descended to the desert, we re-warm too much, and must get rid of heat.

Our arteries then expand to deliver blood to hands, feet, ears, and scalp so that heat can radiate to the environment. More importantly, the superficial veins, directly under the skin of arms and legs, dilate remarkably to allow heat to radiate away also.

But... while you were busy near the cool, shady cloud base, you (very recently) excreted the blood volume needed to fill these expanded blood vessels.

That volume is gone, irretrievably put into the Cockpit Relief System. It must be replaced to support a normal blood pressure. Where does replacement come from? From the sport drink in your water bottle.

Why sport drink? Because it contains salt, and some glucose, which hastens the drink's absorption by fueling the intestinal pumps that absorb the drink into the blood flowing past. So "hydrate" with salty water!

It's of no use to "hydrate" while you're still in the cold: you'll simply create more urine. It's extremely important to "hydrate" when you are about to get warm. Put some of the fluid in your stomach a few minutes before you enter the warm air, so you start absorbing it as soon as you need it.

Once you get warm, you'll need to drink *at least* a pint of re-hydration solution, more likely two or more, depending on how much sweating you did before take off. My own experience is that continual hydration during the first hour of re-warming may prevent post-flight fatigue and headache.

Hypothermia

The other main effect of being in the cold is (hold your breath) ***getting chilled***. The lack of stoves in our gliders means that for long flights, we have to use our own metabolic fires, and whatever insulation we are wearing.

One of the interesting technical points is that, if you're exposed to a cool environment long enough, especially a wet one (rain, sweat, dew, rivers, oceans, lakes), even mildly cool temperatures cause hypothermia. Water temps in the 70s F, 20s C are enough. If it's air you're exposed to, heat loss depends on how well your clothing and hat insulate you.

In any case, we chill quickly in really cold environments, unless we specifically prepare for this. We lose heat, after circulation to hands and feet is shut down, mostly from our breastbone area and scalp; 25% or more of heat loss is from the scalp, especially those of us with The Manly Hairdo.

So to preserve core temperature and minimize heat loss, an insulated head covering is the most important step. If your hair is long and thick, a big cap may be fine. For those of us without insulation in the attic, down or wool is very, very helpful. (I speak from experience. More than once, feeling chilled, I've simply donned a wool cap and warmed up in minutes.)

Second, having a jacket or wool sweater tucked within reach is helpful. All you have to do is cover your chest from belly to neck.

Shivering

Eventually, with continued flight in cold conditions, we will get too cold. When core temps to to somewhere around 34 C, 94 F, our brain activates the shivering process to generate heat and restore core temperature.

The critical point about shivering is that at this stage your brain is cold and is not working at its best. It's sluggish, as are your reflexes and your muscles. Bear this in mind.

My counsel to you, beloved friend, is to treat shivering as a danger signal, and respond to it as a top priority. Treat it as a priority, because the shivering will stop, and you'll feel better, regardless of whether your core temperature rises or falls. You really, really want shivering to stop for the right reason, warming up.

In any case, even if the hypothermia doesn't kill you, the brain sluggishness might. I remember vividly how much smarter my patient with severe hypothermia was at normal temperature than when he was cold. He was a "patient" partly because his cooling brain made some wrong decisions out in the woods. I wish I could say that he had keen insight into his mistakes after he warmed up, but that's another story, isn't it?

If you are flying and start shivering, *immediately* do as many of the following as you safely can:

- add insulation to head and chest
- decrease ventilation to the minimum needed to keep the canopy clear
- descend to a warm altitude
- take salt and water continually
- land *safely*

Recommendations

1. Plan for getting sweaty before flight.
   – change wet underclothes before takeoff.
2. Plant fo getting rather too cool during flight.
   – bring movable head and chest insulation.
3. Dress flexibly.
4. Expect cold diuresis, and drink while warming begins.
   – you may not need to "hydrate" while climbing into cool air.
   – include salt in the nutrition program while re-warming.