SOARING Rx

BY DR. DANIEL L. JOHNSON

What **Shivering** Means

Past columns are on the web at www.danlj.org/~danlj/Soaring/SoaringRx

It had been meant to be a short local joyride on a blustery winter day at the mountain gliderport. Ron hadn't set up the oxygen system or put on a snowmobile suit. The tow was pretty challenging, with the tug bucking in turbulence and uncommanded rolls of nearly 45 degrees. After release, Ron had struggled up and down in turbulent lift for 45 minutes, gaining altitude slowly. It hadn't helped that the two variometers disagreed – one was obviously wrong, but which? After a while, he decided to believe the pessimistic one, and climbed better.

Suddenly, the turbulence stopped. He was in glassy-smooth lift. The wave was not strong – he was climbing only 200 or 400 feet per minute, depending on which vario was correct, but he was climbing. He changed plans. He would stay up for a while.

As he neared 12,500 ft, FAR 91.211 on oxygen use came to mind. Well, not its number; but, he did recall that he could ascend to 14,000 ft as long as he didn't stay there more than 30 minutes, and he had to use oxygen above that.

While moving fast at 14,000 to avoid climbing, he realized that the FAR didn't say how long he had to be below 12,500 before he could again spend a half-hour at 14,000. He used logic: find the descending part of the wave after about 25 minutes, get the altimeter's long hand below 500 ft and the fat hand near 12, and then promptly go back up again.

After riding this yo-yo a few times, he realized that he felt pretty good, the FAR police were nowhere nearby, and it seemed a good idea to go to at least 15,000 and see how the world looked. (It looked a lot like it had at 14,000, actually, though now through the lens of a guilty conscience.)

After a couple of hours of this madness, the radio crackled. "We're going to shut down at 5, and there are only two of you still out. The wind is gusting to 35 knots, so be careful when you land."

Ron checked his watch. It was nearly 4:30. He hated to go back down. Then he started shivering. Just slightly at first; then his whole body started to shake. Being a physician, the three brain cells still functioning joined hands, and he promptly pulled the spoilers and went straight home. He warmed during descent, and stopped shivering by pattern altitude. Downwind went by very quickly, and he did not regret turning base at the end of the runway, for his final was very steep. Rollout was about ten feet, and he held full spoiler and back stick, and flew the stopped glider, until wing runners had it well in hand.

Why was Ron shivering?
Why was this important to him?

I want to make three points:

- Hypothermia is more likely during hypoxia.
- There are easy clues you can use to detect your own incipient hypothermia.
- Shivering is an emergency. Get warm *now*. Unless your glider has a heater, you'll need to get low.

OK, you can stop reading here unless you want to know how this works.

Hypoxia hastens hypothermia.

You are a *homeotherm*. The enzymes that make you a biochemically dynamic organism, and let you have all sorts of fun, function properly only in a narrow temperature range of about 5 degrees C., 10 degrees F. They're destroyed somewhere above 110 dF and work very badly below 90 dF.

As a history buff, you probably already know that Mr. Fahrenheit didn't have any future scientific discoveries to help him create his temperature scale. So he took as zero the temperature at which salt won't make ice melt (this is why salting the roads doesn't do anything in below-zero Fahrenheit temperatures, so the Finns just use sand). He took as 100 the temperature of a warm-blooded animal. These points allowed the manufacturers of thermometers to calibrate them, and would be comparable. Many years later, Mr. Celsius knew that the melting point of pure water was constant, and its boiling was as well (although altitude-dependent, the relationship with altitude is easy to calculate). This allows the manufacturer to calibrate the thermometer without sticking it up the butt of a live chicken. (*Caution: the historical details here are only approximately correct.*)

As you know, the body burns fuel in small fuel-cells, the *mitochondria*, to produce heat and store energy for action. This involves a very precisely choreographed process at the end of which electrons are accepted by oxygen to produce water. Without fuel, no energy is produced; and without oxygen, no energy is produced. So you see, QED, that when oxygen delivery is deficient, such as at altitudes above about 7000 ft msl, less heat is produced by metabolism.

Thus, we get cold faster, and hypothermia is more likely and more dangerous, at altitude. This is one of the main dangers of climbing Everest without oxygen. It's cold up there, and there just isn't enough air to burn the fuel in each cell's stove.

Ron was going to get too cold regardless. But, he got cold faster at 14,000 msl than he would have at the same temperature at sea level. To put in another way, you can be ice-fishing longer than you can fly wave. The level of tedium is similar; the thrill is different. Preferences differ; though as one of my patients would say, wave soaring might be more fun, but you can't come home and put a freshly caught 8-pound walleye on the grill afterward.

Where were we? We were saying that one of the reasons to don oxygen is to *stay warm*. It makes a difference.

But I only fly during the summer!

The simple truth is that a thinly clothed person will lose heat at any temperature much below body temperature. Certainly, by the time the air temperature is at or below 70 dF, body temperature will drop in an hour or two. This varies greatly with the level of physical activity, but we're really not exercising in the seat of the glider, are we? In my neck of the woods, if the temperature at cloudbase is above 75 dF, it's a hot, humid day, and the soaring isn't very good. On good days, it's cool up high.

So we're almost always at some risk for getting cold while soaring, especially if we soar from the desert, where it's too hot for warm clothes on the ground.

Our bodies cool off slowly. As they cool, predictable changes occur that can give us a clue to add insulation, turn on the heater, or descend to a warm altitude. This cooling-off causes slow, subtle, responses that you can use to judge safety. ☛

Clues you can use.

1: *Cold hands, warm heart.*
2: A *full bladder.*
3: *Feeling* cold is a clue, but is **not** a reliable clue to *being* cold.
4: *Shivering.*

Cold hands, warm heart

It's true that your hands and feet will chill quickly simply by being exposed to the cold. What is more important, they will get cold, even inside down mittens and boots if your core temperature begins to decrease.

If your hands feel cold, you know at least that your body is cooling down. Partly, this is because *warm* hands mean that your body is warmer than necessary, and extra blood is being delivered to your fingers to radiate away extra heat.

If you have your feet in warm boots, or your hands in insulated gloves, and they get cold, your body is cooling down.

If you're wearing shorts, as you cool you will see the skin of your thighs begin to look marbled or mottled. The body shuts down circulation to the skin to preserve core temperature. Blood flow to the skin is delivered through an arteriole that comes straight up from below, and arborizes or fans out through the skin across a distance of about a centimeter, where it enters venules. This creates little fingernail-size pale spots, where the supplying arteriole has cinched down creating pallor, surrounded by a pale blue line at its periphery, where there's a little backflow from the dark deoxygenated blood of the venules. This creates a pale blue honeycombed look, a faint blue reticular pattern.

st
rt
ts
s

If you see this on your own skin, or on someone else's (the classic look of the cheerleader in October at a Minnesota football game), you can be confident that person is developing hypothermia.

This skin change is part of a general constriction of blood vessels to the extremities. There are two systems of veins – superficial veins just under the skin that dilate when we're too warm and constrict severely when we're cool, and deep veins flanking each artery in pairs.

As we cool down, the superficial veins close down. The deep veins are next to the arteries. Heat is given up from outgoing arterial blood to warm incoming venous blood. You who are engineers will recognize this as *countercurrent exchange* (opposite flow permits the exchange of warmth).

A full bladder.

This constriction of blood vessels reduces the capacity of our vasculature. Suddenly we have too great a blood volume for the space now available. Blood flow through the kidneys increases, causing more urine to be formed to get rid of the extra volume.

Long before you feel cold, *before any fall in core body temperature*, you will, after an hour or so in cool surroundings, notice that you have to urinate a lot sooner than usual. This effect is called *cold diuresis*, and its important for two reasons.

The first is that when you land in the heat, your vessels again dilate, but you've pissed away the fluid needed to fill them, to support your blood pressure. This means that you need to be drinking *while you warm up*, such as during descent.

The second is that you get rid of both salt and water, so you need to rehydrate with electrolyte solution or eat some salty food while drinking water, just as if you'd been sweating heavily.

Feeling cold is a clue.

But, it's only a clue. *Feeling* warm or cold is related to our *skin temperature.* If we feel cold, it's because our skin is cold. Generally, this is because our environment is cool, *and* we're making our skin cold by shutting down its blood flow as our core temperature drops (imperceptibly at first).

But, if we feel *warm*, we may be cold, for something may be warming our skin without increasing core temperature. A menopausal hot flush makes a woman feel hot, but the result is actually a drop in core temperature, for heat is lost. Standing by a fire, or in the sun, or climbing into a hot tub makes us feel warm long before our core temperature responds.

A danger of alcohol is that it increases blood flow to the skin, making a person *feel* warm while permitting more heat to radiate away and dropping core temperature. Taking those drinks to warm up has killed people.

Shivering is a danger signal.

When our core temperature drops only 1-2 dC (2-4 dF), we begin to shiver. As we realize when we exercise, our muscles are big fuel cells, making a lot of heat. Shivering is essentially immobile exercise, and generates a lot of heat.

Why do I say shivering is a danger signal?

Because gliders don't have heaters! If we are shivering, our core temperature has already dropped, and we are continuing to lose heat. The brain is already slower, and reactions and judgment will be slower. Shivering is a sign that we really, really need to get warmer.

And because continued cooling will lead to uncontrolled shivering. A core-temperature drop of about 2-4 dC (4-8 dF) will at some point cause shivering that's so severe that normal muscle control is difficult or impossible. We really, really do not want this to happen in the cockpit.

Clothing.

The goal of wearing clothing goes beyond looking great. Even in the plains, on a soarable day, cloudbase is at least 20 dF cooler than the ground, as the dry adiabatic is about 5 dF per thousand feet, and at any site, an excellent day has bases 7000 ft to 15000 ft above ground. It's usually cool, and always shady up there.

You can always know how cold it will be at the top of the climb because the temperature at cloudbase is at the dewpoint, and your AWOS will tell you this. It'll be in dC, but doubling this and adding 30 will get you close enough to dF to know what to wear.

One goal is to keep hands and feet warm enough not to feel pain whilst our body shuts down their circulation to save itself. This is accomplished with long johns and warm sox, and long-sleeved shirt layers with gloves.

The other goal is to keep the core warm by decreasing heat loss, so that the gloves and down boots aren't so necessary. We do this by insulating scalp and breastbone.

We lose heat from our sternum, because under this are the great blood vessels, and from the scalp because it's very rich with blood vessels. We bald guys have 25% of total heat loss from the scalp, and I can tell you that the hat doesn't have to be extremely thick to make a huge difference, especially as most gliders have a windscreen.

Thus, the priorities in keeping warm are:

1: Wear a cap. Wool in cold weather, anything in mildly cool weather.

2: Cover the upper chest. Some pilots take along a jacket and pull it over their chest after climbing out of the heat. Others wear zip-up shirts or pullovers that are closed up high.

3: Wear layers on arms and legs, so that when you get back down, you can quickly shed insulation that's no longer needed.

History bits.

While reviewing literature for this essay, I noticed a couple of interesting facts about the importance of hypothermia to a couple of famous military campaigns.

Hannibal lost nearly half his army of 46,000 crossing the Alps in 218 BC. It was one of those many military ideas that looked good on paper.

Baron Larrey, Napoleon's chief surgeon, reported only 350 of the 12,000 men in the Twelfth Division survived the cold during the Russian campaign.

Recommendation.

When planning the day, look at the dewpoint prediction, and dress for that temperature, in a way that will allow you to alter your clothing on the ground to avoid being too hot.