Non-Freezing Cold Injury – Immersion Foot

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Non-Freezing cold injury or immersion foot results from prolonged exposure to wet cold conditions—conditions which many outdoors people avoid. But military operations rarely have the luxury of choosing their weather conditions, and like National Outdoor Leadership school (NOLS) expeditions, may live and work for days in weather conducive to the development of immersion injury. Understandably much of what we know about non-freezing cold injury—immersion foot or trench foot—comes from the military. In World War I—when the term trench foot was coined—the British Army alone experienced 29,000 cold injury casualties in the winter of 1915-16, while frostbite and immersion foot casualties for U.S. forces in Europe in WWII totaled 90,000. This article, written for wilderness leaders, shares our experience with non-freezing cold injuries and immersion foot.

What is immersion foot?
Immersion foot is a local, non-freezing injury that occurs in cold, wet conditions, usually in temperatures of 30° to 40°F. The injury occurs when blood vessels constrict in response to heat loss, reducing blood flow to the extremity and depriving cells of oxygen and nutrients. Nerves are especially sensitive. The ensuing injury may range from a few weeks of sore feet to permanent muscle and nerve damage. In some cases, victims experience months of pain and disability and even amputation.

The term trenchfoot is often used interchangeably with immersion foot, and both are non-freezing cold injuries

We've seen immersion injury in cooler climates from sweat-dampened socks. We've experienced immersion foot in plastic boots, neoprene socks and other vapor barrier systems, as well as with supergaitors and gore-tex boots. We've seen it in novices and experts. In summer and winter. It happens on winter ski trips and in the desert. The key is how cool and damp your extremities are, no matter what you wear on your feet.

We used to think that at least 12 hours exposure to cold, wet conditions was necessary to produce the injury. You will still hear this figure quoted, and it's probably true in most cases. Our experience however, tells us that a non-freezing cold injury can happen much quicker. We've seen it develop over a long, wet, cold hiking day and in a multi-hour river crossing. Murray Hamlet DVM, an expert on non-freezing cold injury, says the minimum exposure is as little as three hours, although he thinks it takes 12 hours to have a serious injury. These episodes of short onset immersion foot could be due to individual susceptibility, or be the culminating event of long-term exposure. There are times when our diligence prevents immersion foot, although we will have chronically cool feet. But, as little as an afternoon's lapsed attention can undo our best efforts.

Assessment of Immersion Foot: "Classic" Signs and Symptoms
Immersion foot is usually described in a worst case scenario. The extremity appears cold, swollen and mottled. Cyanosis is usually present. Tactile sensitivity is reduced, as is capillary refill time. The foot may look shiny. The patient may describe the foot as feeling wooden. When the extremity warms, the skin becomes warm, dry and red. The pulse is bounding. The injury is painful. The injured area may itch, tingle and exhibit increased sensitivity to cold, possibly permanently. The recovery period can last weeks. Nerve damage may be permanent. The development of blisters, ulcers and gangrene is possible.

Assessment of Immersion Foot: Common Signs and Symptoms
All these "classic" signs and symptoms are true. However, we most often see subtle forms of non-freezing cold injury that do not necessarily look mottled, gray, or waxy, nor do we always experience poor capillary refill, or altered skin color and temperature. All we may see is cool pale extremities, numbness or tingling, itching and mild swelling. We may see mottled areas, often on the underside of the foot. Only rarely are our cases serious enough for the patient to describe wooden-like feet or a cotton-wool sensation, to experience edema and blistering, or to be unable to walk. Pain is unusual in the field, more common after blood flow has returned to the extremity. Pain may not fully develop for several days.

I've seen several people with a non-freezing cold injury whose feet were warm, dry and pink with good capillary refill time. Numb toes were the chief complaint of one, painful feet of another. We scratch our heads and consider if this is a cold injury, “numb toe” from boot pressure, or simply a case of sore feet in a person new to walking long distances. Murray Hamlet says we should be suspicious about any numbness, tingling or pain in our feet when we are in cool conditions. I agree with him. Nerves are susceptible to injury from reduced blood flow. Many of the long-term affects of immersion foot are due to damaged nerves in our feet: pain, numbness, chronic tingling and itching.

The patient may not notice the condition of their feet until they are warmed after the trip. We've learned to advise people returning from prolonged wet and cold conditions to avoid long, hot showers or baths. The rapid warming can surprise the unwary with swollen and painful feet.

Treatment for Immersion Foot
In serious cases swelling, pain and blister formation will prevent walking. In most cases the extremity will only be sore. Avoid walking on injured feet, and elevate the feet to reduce the swelling. Ibuprofen is recommended because of its anti-inflammatory properties. Aspirin and acetaminophen may also help.

It has been our experience, which is shared by military experts, that non-freezing cold injuries can produce pain resistant to the strongest of medicine. Patients can't walk, wear shoes, or even accept the pressure of a bed sheet on their feet. Their feet look normal, but they have pain that defies medication.

Prevention
Immersion foot can be dismissed as a disease of the past by those who think modern equipment provides protection, but the recent experience of the British and Argentine armies in the Falklands demonstrate that this is not the case. The British had excellent footwear, yet none proved effective in the cold, wet climate.

As an experienced U.S. Marine officer told me, “Immersion foot is a leadership problem, not a medical problem.” It was only the behavior and leadership of the British troops that kept them from having serious immersion foot problems, although the condition affected many of the troops. The Argentines on the other hand, with poor leadership and untrained troops, suffered 274 amputations.

In WWI the British dramatically reduced immersion/trench foot casualties by using techniques (without making significant footwear changes) that we still follow today: good boot fit with heavy wool socks; keep the body warm; remove socks and dry and massage the feet twice a day; do not sleep in wet footwear; dry wet socks against your skin; keep your feet out of water or mud as much as possible; watch carefully and react promptly if you experience numbness or tingling; keep footwear loose to allow for circulation.

Dry your socks
Drying socks is a continual activity on wilderness trips. During the day we stick wet socks into our shirts to dry them against the skin, and likewise at night drape them over our chest and belly in our sleeping bags. We'll hang them in the sun and dry them over a fire. Keep one pair of dry socks in a dry place such as in a sleeping bag or a small plastic bag.

Sleep with warm , dry feet
Sleeping in dry feet is very helpful, but there is a false impression that this offers complete protection. People coping with multi-day wet cold conditions have developed immersion foot by hiking for a single day in wet socks. A single night of sleeping in cool wet socks has undone weeks of vigilant attention. Not only should we go to bed with warm dry feet, they need to stay that way all night long.

Look at your feet
We suggest leaders check in with participants regularly, and consider periodic visual inspection. When the conditions are ideal for cold injury to occur consider twice daily visual checks, changes to dry socks and foot massages to help circulation. Visual checking must be part of the routine. A verbal confirmation is insufficient. Messages sent to the brain are faulty due to nerve damage. Ask people if their feet tend to sweat, tend to be cold, or hard to keep warm. People whose feet sweat excessively may be more apt to develop immersion foot.

Change your socks. Warm your feet
If during the day you experience damp socks or feet that are feeling sweaty, air your feet and change into dry socks. Warming cool feet on a companion's belly, or stopping to change socks in the middle of the day should be routine tasks, not impositions.

In camp
When you get to camp, get out of your wet boots immediately. Change into a pair of dry socks and begin to actively dry your wet or damp socks. Warm your feet promptly. Don't wait until bedtime. Foot powder does not seem to be helpful in preventing immersion injury other than as a discipline in conjunction with changing socks. People with a tendency toward athlete’s feet (fungal foot infections) have found medicated foot powders helpful.

Role model good habits
Role modeling of good foot care by leaders is essential. The image of a cold injury to many outdoor enthusiasts is often frostbite, and they are less informed on the subtleties of non-freezing injuries. Novices often assume some degree of cooling is unavoidable, and inadvertently cross a line from extremity cooling to a cold injury. If participants see leaders aggressively dealing with their feet, they are more likely to do the same.

If your core is cold your feet will be cold.
Poor nutrition, dehydration, wet socks, inadequate clothing, and the constriction of the blood flow by the shoes, socks, gaiters, or tight clothing are all predisposing factors.

Equipment
Plastic boots and insulated gaitors are improvements over leather boots. Rubber galoshes, while unfashionable, have proven inexpensive, simple and helpful in keeping footwear dry.

Have multiple pairs of socks, two pair on your feet and at least two spare pairs.

Instill awareness.
Non-freezing cold injuries are subtle and insidious. We have to stress prevention in the absence of noticeable signs and symptoms—a challenging task.

The Evacuation Decision
The evacuation decision for immersion foot is not black and white, so I'll make a few comments to help us navigate the gray. In some cases evacuation will be a clear. The patient will be unable to walk. They may have cyanosis, numb feet or severe pain. We step into the gray when we have intervened early and signs and symptoms are mild. The patient can walk, pain is tolerable, the toes pink and warm.

We now have to consider factors that are less medical, more in the realm of expedition leadership; the trip route, anticipated weather conditions, ease or difficulty of evacuation later in the trip and the patients outdoor skills. I don't want to give the impression that all cases need to be evacuated. This is likely, but not universally true. If we can keep the feet warm and dry the patient can stay in the field, but, they have to be able to care for themselves with unswerving diligence. There can be no further lapses in attention or technique.

Closing thoughts
Common thread in many NOLS non-freezing cold injury scenarios are people who tolerate cold feet, wait too long before intervening, and who are surprised when they discover they have been injured. I've had serious frostbite. My approach is that if your feet are not definitely warm, you're doing something wrong. People may believe they have to tolerate some level of cold extremities as a unavoidable consequence of camping. While there is some truth to this, a novice lacks the experience to know how much they can tolerate before an injury occurs. Even an expert can be fooled. I'm one of those people who rationalized delaying warming by saying "My feet are cold but they are not *that* cold." I was wrong.

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