Cold-related Illness

By Cary S. Keller, M.D., FACSM

- Cold temperature, especially in combination with wet conditions or wind, poses the risk for cold injuries such as frostbite and hypothermia.
- Treat frostbite by getting the affected individual to a warm place and re-warm the extremities.
- Suspected hypothermia calls for EMS activation.

SIGNIFICANCE

Cold weather is typically not a barrier to outdoor practices and competitions. However, team and individual sports played in the late fall, winter and early spring place athletes at risk for cold injury. Environmental changes as simple as sunset, a rainstorm or an increase in wind speed can shift the body's thermal balance suddenly. As part or all of the body cools, there can be diminished exercise performance, frostbite, hypothermia, and even death.

BACKGROUND

Athletes lose heat by evaporation, conduction, convection and radiation. Heat is lost from the skin by evaporation of sweat. Conduction is the passive transfer of heat from warmer to cooler objects by direct contact, such as through the loss of heat from the core to the peripheral muscles and skin and the gain of heat from a hand warmer to the fingers. Convection is the warming of the air next to the body and the displacement of that warm air by cool air. Insulating clothing decreases heat loss by convection, while wind accelerates heat loss by convection. Radiation is loss of heat from the warmer body to the cooler environment.

At rest, 20 percent of body heat loss is by evaporation and 50 percent by radiation. With exercise in a warm environment, up to 90 percent of heat loss is by evaporation. Thus, evaporation from wet clothing in a cold environment has great potential to upset thermoregulation during exercise. In the cold, radiation becomes a progressively more important source of heat loss during exercise as ambient temperature falls further below body temperature.

Cold exposure produces peripheral vasoconstriction, decreasing peripheral blood flow, and decreasing convective heat loss from the body's core to its shell (skin, fat, muscle). The peripheral vasoconstriction, therefore, predisposes to cold injury, especially in the fingers and toes. In response to this cooling of the extremities, there is cold-induced vasodilation (CIVD), a transient increase in blood flow and warming which helps to protect against peripheral cold injury. As the core body temperature falls, CIVD is suppressed, and frostbite becomes more likely.

Cold exposure also elicits increased heat production through skeletal muscle activity. This occurs through involuntary shivering (which can increase heat production up to six times basal metabolic rate) and through voluntary increased activity. Athletes exposed to cold repeatedly can exhibit cold acclimatization. The most common acclimatization pattern is habituation, in which both cold-induced vasoconstriction and shivering are blunted, sometimes actually predisposing to hypothermia. Compared to heat acclimatization, cold acclimatization is less pronounced, slower to develop and less effective in maintaining normal body temperature and preventing cold illness.

RECOGNITION

Frostbite, the most common cold injury, occurs when tissue freezes. Frostbite can occur in exposed skin (nose, ears, cheeks), but also can affect the hands and feet, as peripheral vasoconstriction lowers peripheral tissue temperature significantly. Numbness or a "wooden" feeling is usually the first symptom of frostbite in the hands and feet. With frostbite to exposed facial skin, however, there can be a burning feeling. Both cooling and ischemia (decreased blood flow) result in numbing of the skin, so the freezing of the tissue is often relatively painless. Skin color is initially red and then becomes a waxy white. Re-warming is accompanied by sharp, aching pain and persistent loss of light touch sensation.

The risk of frostbite increases as temperature decreases. With appropriate precautions, the risk of frostbite can be less than five percent when ambient temperature is above 5 degrees F. But increased surveillance of athletes is appropriate when wind chill temperature (WCT) falls below minus 18 degrees F, as exposed facial skin then freezes in 30 minutes or less. At these temperatures, consideration should be given to postponing or cancelling athletic events. A close approximation of the WCT should be available from your local weather station.

Hypothermia is defined by a core body temperature below 95 degrees F (35 degrees C). In mild hypothermia, an athlete feels cold, shivers, is apathetic and withdrawn, and demonstrates impaired athletic and mental performance. Coaches and athletes must recognize and respond to these early symptoms to avoid more severe hypothermia. As core temperature continues to fall, there is confusion, sleepiness, slurred speech, and irrational thinking and behavior. In severe hypothermia, the heart rate may become irregular and there is a risk of cardiac arrest. Efforts at resuscitation must persist until re-warming has been achieved.

Exercising athletes produce heat by muscular activity, which helps maintain core temperature, and are at less risk for cold exposure injury. At the end of an event, or when exercise stops due to injury, heat is no longer being generated by exercise, but heat loss continues, and rapid cooling may result. Dehydration may further impair maintenance of core temperature.

Figure 9. Wind Chill Index.

Temperature (°F)

Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91

Frostbite Times: 30 minutes · 10 minutes · 5 minutes

*Reproduced from NWS – 2001

Prevention of Cold Injury

1. EVENT MANAGEMENT

a. **Assess environmental risk factors:** temperature, wind, rain, direct sunlight, altitude. Be alert to changes in these conditions so that athletes can be advised to modify clothing or seek shelter and event managers can consider shortening, moving or cancelling an event. The Wind Chill Index (WCI) integrates temperature and wind to estimate cooling power. The WCI predicts the risk of frostbite to exposed facial skin in a person moving at walking speed, but not the risk of frostbite in the extremities. The wind effect of the athlete moving at higher speed (run, ski, bike, skating) is not considered when calculating WCI.

b. **Assess athletes' risk factors:** exercise demands, fitness, fatigue, health, body fat, age, and nutritional status. (see Table 10).

c. **Prepare appropriately:** adequate training, clothing, water, food, scheduled clothing changes, provision of shelter and re-warming, planned monitoring of weather conditions and of athlete tolerance of the cold, and action plans to care for those who are having difficulty staying warm.

Table 10. Risk factors for Hypothermia and Frostbite.

1. Exercising in water, rain and wind significantly increases risk of hypothermia. Hypothermia can occur rapidly following unexpected immersion in cold water. The heat transfer coefficient of water is 70 times that of air.
2. Lean athletes have more difficulty maintaining core temperature and are at increased risk for cold injury. Athletes with a high body fat percentage and high muscle mass are better insulated and more protected against cold injury.
3. Individuals older than 60 years of age are at increased risk of hypothermia due to reduced vasoconstriction and sometimes decreased fitness.
4. Children and adolescents are at greater risk of hypothermia than adults due to greater surface-to-mass ratio and less subcutaneous fat.
5. Low blood sugar impairs muscular activity and shivering, decreases heat production, and predisposes to hypothermia. Fatigue, energy depletion, sleep deprivation and certain chronic medical conditions result in decreased heat production.
6. Some skin disorders, such as eczema, may increase heat loss.
7. Physical fitness and strength training do not improve thermoregulatory response to cold, but greater fitness allows longer exercise at high intensity and thereby longer muscular heat production and maintenance of core temperature. Poor fitness thereby predisposes to cold injury.

2. CLOTHING

Metabolic rate (exercise intensity) and ambient temperature determine clothing (insulation) requirements during exercise. Hats are useful, as up to 50 percent of heat loss at rest is from the head. Layering of clothing is highly recommended. The inner layer acts to wick perspiration, a middle insulating layer which allows moisture transfer, and an outer layer, worn when necessary, to repel wind and rain, but is capable of transfer of perspiration to the air. Layering allows adjustment in insulation to prevent overheating and sweating, while remaining dry in wet conditions. Glove liners can provide wicking and insulation for the hands. Mittens provide significantly more insulation than gloves. Clothing that constricts fingers or toes predisposes to cold injury in the hands and feet. Wet clothing should be removed quickly and replaced, including socks and gloves.

3. FOOD AND FLUID INTAKE

Exercise in cold environments can increase energy expenditure and fluid loss. Insufficient carbohydrate reserves to maintain core temperature risks cold injury. Dehydration affects neither shivering or vasoconstriction, but significant loss in volume decreases perfusion. In cold, as in all temperatures, carbohydrate availability and dehydration are limiting factors in performance. Athletes can sustain exercise in cold by ingesting six- to eight-percent carbohydrate beverages. Carbohydrate rich foods are appropriate for prolonged exercise in the cold.

Management of Cold Injury

1. FROSTBITE

Seek shelter and insulation. Maintain core temperature and attempt to reverse vasoconstriction by re-warming. Re-warming is best accomplished with body heat of the afflicted individual or someone else’s (e.g., placing the cold hand under the arm pit). Warm water at 104 to 109 degrees Fahrenheit (40 to 43 degrees C) can also be used for re-warming. Do not use warmer water as it produces greater injury, swelling and tissue death. Once re-warming begins, avoid additional freezing. It is better to tolerate some additional time with frozen tissue while awaiting transport to a medical facility than to re-warm and then suffer refreezing during extrication from the cold environment. Rubbing the injured body part adds mechanical damage to thermal damage, and is to be avoided.

2. HYPOTHERMIA

a. **Conscious athlete.** Hypothermic athletes should have wet clothing removed and should be insulated with whatever warming material is available. If possible, evacuate to a warm building/bus/car/shower. Encourage the drinking of large volumes of warm, sweet liquids to improve circulating volume and available energy. Encourage exercise to promote heat production by muscular activity. Such athletes usually respond to peripheral re-warming, but transport to medical care is a precaution against further deterioration.

b. **Unconscious athlete.** Hypothermic athletes should be insulated and transported by the emergency medical system (EMS). Field re-warming and field CPR are usually ineffective and should not delay transport to a medical facility for central re-warming. Warm intravenous fluids and positive pressure, warm, humidified oxygen can be useful but will, alone, be inadequate. The medical facility can provide rapid core re-warming, prevention of arrhythmia, respiratory support, and fluid and electrolyte management.

COLD-INDUCED ASTHMA SYMPTOMS

Exercise-induced asthma (EIA) is a transient narrowing of the airways which is provoked by exercise (see Asthma chapter). Cold-weather athletes have an increased prevalence of EIA. High intensity exercise, high ventilation rate and exercise in indoor rinks predisposes athletes to EIA. EIA with cold exposure is believed to be due to a combination of breathing dry air and reflex response to facial cooling. Impaired air quality in indoor skating rinks is implicated as an additional factor (see Air Quality chapter).

COLD ENVIRONMENT MODIFIES EMERGENCY ACTION PLANS

The assessment and management of the injured athlete in a cold environment follows basic First Aid and CPR/AED protocols. (See Emergency Action Plan chapter). This begins with the assessment of the safety of the scene of injury. In a cold environment, the scene is not safe by virtue of the cold itself. Depending on the severity of the cold, the risk it represents to the injured athlete and to the rescuers, and the availability of warm shelter, the protocol may be modified. The major difference in cold weather is that initial attempts at resuscitation can be delayed in order to get the athlete to a warmer place.

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