

Cold Environments

Cold Environments - Health Effects and First Aid

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What are the health effects of exposure to cold?

Exposure to cold working conditions may result in a variety of cold injuries and illnesses - with hypothermia and frostbite being the most serious. Other types of cold stress injuries include chilblain, immersion foot or trench foot, windburn, frostnip, and frostbite.

Generally, toes, fingers, ears, and nose are at greatest risk because these areas do not have major muscles to produce heat. The body preserves heat by keeping the internal organs warm, reducing the flow of blood to the extremities under cold conditions. In addition, hands and feet tend to get cold more quickly than the body (torso) because:

- they lose heat more rapidly since they have a higher surface area-to-volume ratio, and
- they are more likely to be in contact with colder surfaces than other parts of the body.

If the eyes are not protected with goggles in high wind chill conditions, the corneas of the eyes may freeze.

The most severe cold injury is hypothermia, which occurs from excessive loss of body heat and the consequent lowering of the inner core temperature (internal temperature of the body). Hypothermia can be fatal.

For more information on the general effects of working in the cold, please see [Cold Environments - Overview](#).

For information on exposure limits and injury prevention while working in the cold, please see [Cold Environments - Control Measures](#).

How do we lose heat to the environment?

Radiation

Radiation is the loss of heat to the environment due to the temperature gradient. In this case, it is the difference between the temperature of the air and the temperature of the body (your body's core temperature is +37°C or 98.6°F). Another factor important in radiant heat loss is the size of the surface area exposed to cold.

Conduction

Conduction is the loss of heat through physical contact with a cooler object. Heat loss is greatest if the body is in direct contact with cold water. The body can lose more heat when in contact with cold wet objects than in dry conditions or with dry clothing. Generally, conductive heat loss accounts for only about 2% of overall loss. However, with wet clothes, the loss is increased.

Convection

Convection is the loss of heat from the body to the surrounding air as the air moves across the surface of the body. The rate of heat loss from the skin by contact with cold air depends on the air speed and the temperature difference between the skin and the surrounding air. At a given air temperature, heat loss increases with wind speed.

Evaporation

Evaporation is the loss of heat due to the conversion of water from a liquid to a gas. In terms of human physiology, it is:

- Perspiration or sweating – evaporation of water to remove excess heat.
- "Insensible" perspiration – body sweats to maintain a humidity level next to the skin. Particularly in a cold, dry environment, you can lose a great deal of moisture this way and not notice that you have been sweating.

- Respiration – air is heated as it enters the lungs and is exhaled with an extremely high moisture content.

It is important to recognize the strong connection between fluid levels, fluid loss, and heat loss. As body moisture is lost through the various processes, the overall circulating volume is reduced which can lead to dehydration. This decrease in fluid level makes the body more susceptible to hypothermia and other cold injuries and illnesses.

How do we produce and retain heat within the body?

In order to survive and stay active in the cold, the constant heat loss has to be counterbalanced by the production of an equal amount of heat. Heat is both required and produced at the cellular level as a result of complex metabolic processes that convert food – a primary source of energy – into glycogen. Glycogen is a substance (biochemical compound) that is the “fuel” for biochemical processes underlying all life functions, heat production included.

Factors important for heat production include:

- Food intake.
- “Fuel” (glycogen) store.
- Fluid balance.
- Physical activity.
- Shivering – a reflex reaction, which increases the body’s heat production when necessary. This reaction is limited to a few hours because of the depletion of muscle glycogen and the onset of fatigue.

Heat retention and tolerance to cold also depend on the body’s structure, certain reflexes and behavioural mechanisms that retain heat within the body, as well as what you are wearing. They are:

- Size and shape of the body (surface-to-volume ratio).
 - The layer of fat under the skin (Subcutaneous adipose tissue).
 - Decreased the blood flow through the skin and outer parts of the body.
 - Insulation (layering and type of clothing).
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How do we maintain thermal balance?

Cold challenges the body in three major ways (temperature, wind and wetness). Depending on the severity of cold conditions, heat loss can occur. The body maintains its heat balance by increasing the production of heat and activating heat retention mechanisms.

Heat Production	+	Heat Retention	=	Cold Challenge	-	Thermal Balance
• food intake • activity • shivering		• decreased superficial blood flow • clothing				

In the situation where more heat is lost than the combined heat production processes and heat retention mechanisms can generate, the core body temperature drops below 37°C. This decrease causes hypothermia which can impair normal muscular and mental functions.

Heat Production	+	Heat Retention	<	Cold Challenge	=	Hypothermia
• food intake • activity • shivering		• decreased superficial blood flow • clothing				

What are examples of cold-related injuries and illnesses?

Chilblains are mild cold injuries resulting in painful inflammation caused by prolonged and repeated exposure for several hours to air temperatures that are cold but not freezing (from above freezing (0°C or 32°F) to as high as 16°C (or about 60°F)). In the affected skin area, there will be redness, swelling, tingling, blisters, and pain. Seek medical help if an infection occurs. Chilblains will usually resolve on their own, especially in warmer weather. Recurrence may occur.

Immersion foot, or trench foot, results from prolonged exposure to wet and cold conditions. Trench foot may occur at temperatures as high as 15.5°C (60°F), especially if the feet remain wet. Depending on the temperature, the onset of trench foot symptoms may range from several hours to many days. Symptoms include tingling, numbness, itching, pain, swelling of the legs, feet, or hands, and blisters. The skin may be red initially and turn to blue or purple as the injury progresses. In severe cases, gangrene may develop. A similar condition of the hands can occur if a person wears wet gloves for a prolonged period under the cold conditions described above. Symptoms are similar to immersion foot.

Windburn occurs when cold wind removes the top layer of oil from the skin causing excessive dryness, redness, soreness, and itchiness.

Frostnip is the mildest form of a freezing cold injury. It occurs when ears, noses, cheeks, fingers, or toes are exposed to the cold and the top layers of the skin freeze. The skin of the affected area turns paler than the area around it and you may feel pain or stinging, followed by numbness. The skin may also appear shiny and rosy, as well as hardened. The top layer of skin may feel hard but the deeper tissue still feels normal (soft). It is a warning that frostbite is beginning. Frostnip can be prevented by wearing warm clothing and footwear.

Frostbite is a common injury caused by exposure to cold or by contact with cold objects (especially those made of conductive metal or stone) and happens when tissue temperature is below 0°C (32°F). It may also occur in normal temperatures from contact with cooled liquids such as oil, fuel, or antifreeze. The skin may look waxy and feel colder than the area around it. It may also be harder to the touch. Blood vessels may be severely and permanently damaged, and blood circulation may stop in the affected tissue. The first symptom is usually numbness in the affected body part. In mild cases, additional symptoms include inflammation of the skin in patches accompanied by pain. In severe cases, there could be tissue damage without pain, or there could be burning or prickling sensations resulting in blisters. Frostbitten skin is highly susceptible to infection, and gangrene (local death of soft tissues due to loss of blood supply) may develop.

Hypothermia - In moderately cold environments, the body's core temperature does not usually fall more than 1°C to 2°C below the normal 37°C (98.6°F) because of the body's ability to adapt. However, when a person is exposed to very cold temperatures for long periods of time without adequate clothing, the body is unable to compensate for the heat loss and the body's core temperature starts to fall. Hypothermia happens when the core body temperature falls below 35°C (95°F).

As the temperature continues to drop or as the exposure time increases, the feeling of cold and pain starts to diminish because of increasing numbness (loss of sensation). If no pain can be felt, serious injury can occur without the victim noticing it.

Next, muscular weakness and drowsiness are experienced. Additional symptoms of hypothermia include interruption of shivering, diminished consciousness and dilated pupils. As hypothermia progresses, severe symptoms may occur, including death.

What first aid can I do for frostnip?

First aid for frostnip include:

- Gentle rewarming (e.g., holding the affected tissue next to the unaffected skin of the victim or of another person).
- For all cold-induced injuries, never rub the affected parts—ice crystals in the tissue could damage the skin if the skin is rubbed.
- Do not use very hot objects such as hot water bottles to warm the area or person.

What first aid is appropriate for frostbite or immersion foot?

First aid for frostbite, as well as immersion or trench foot, includes:

- Never ignore numbness. If the area feels numb or tingly, take steps to warm the area immediately. (e.g., put hands under armpits, or pull arms into the inside of a jacket for more direct contact with the body)
- If possible, move the victim to a warm area.
- Remove wet clothing, and gently loosen or remove constricting clothing or jewellery that may restrict circulation.
- Warm the person by wrapping them in blankets or by putting them in dry clothing. Cover the head and neck. Warm the person slowly. Avoid direct heat which can burn the skin.
- Loosely cover the affected area with a sterile dressing. Place some gauze between fingers and toes to absorb moisture and prevent them from sticking together.
- If the person is alert, give them warm liquids to drink to rehydrate.
- Check for signs of hypothermia and seek medical attention. If necessary, quickly transport the victim to an emergency care facility.
- Treat the person gently and monitor breathing
- DO NOT attempt to rewarm a frostbitten area on site (but do try to stop the area from becoming any colder). Without the proper medical care, the tissue that has been warmed may refreeze and cause more damage.
- DO NOT thaw the area if it may freeze again.
- DO NOT rub the area or apply snow.
- DO NOT allow the victim to drink alcohol or smoke.

What are the signs of hypothermia?

The levels of cold stress and hypothermia include:

Cold stress (not hypothermic)

- Shivering
- Normal mental status
- Able to care for self

Mild hypothermia

- Shivering
- Increased blood pressure
- Poor judgement and behaviour changes
- Difficulty forming or pronouncing words
- Loss of coordination
- Fatigue

Moderate hypothermia

- Weak and intermittent shivering, or shivering that later stops
- Dilated pupils
- Unconsciousness
- Irregular heartbeat

Severe hypothermia

- Shivering has stopped
- Unresponsiveness; breathing has slowed down or stopped
- Loss of reflexes
- No response to pain
- Dilated pupils
- Blue skin

What first aid is appropriate for hypothermia?

Hypothermia is a medical emergency. At the first sign, find medical help immediately. The survival of the victim depends on the co-worker's ability to recognize the symptoms of hypothermia. The victim is generally not able to notice his or her own condition.

First aid for hypothermia includes the following :

- Seek medical help immediately. Hypothermia is a medical emergency.
- Move the person out of the cold, and/or insulate the person (e.g., by applying a hypothermia wrap or layers of dry blankets or coats).
- Check for ABC - Airway, breathing, and circulation.
- Handle the person gently. Do not massage or rub the skin.

- Allow them to lay down. No standing or walking.
 - Warm by carefully applying warm water bottles, heating pads, or electric blankets to the upper body (such as the armpits, chest, groin and upper back). Wrap items in towels or clothing if available. Body heat from another person can also help in an emergency.
 - DO NOT massage or rub the skin.
 - DO NOT rewarm the person too quickly (e.g., do not use a heating lamp or stove, or soak in a hot bath/shower).
 - Give food or warm drinks (caffeine-free, non-alcoholic) ONLY if the individual has mild hypothermia (e.g., when the person is conscious and responsive).
 - Perform CPR (cardiopulmonary resuscitation) if the victim stops breathing. Continue providing CPR until medical aid is available. The body slows when it is very cold and in some cases, hypothermia victims that have appeared "dead" have been successfully resuscitated.
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What is meant by a hypothermia wrap?

Supplies to make a hypothermia wrap include:

- a tarp or plastic sheet to act as a vapour barrier
- an insulated ground pad
- a hooded sleeping bag (or equivalent) to act as the insulation wrap
- another plastic or foil sheet (2x3 metres) to act as a vapour barrier inside the sleeping bag
- source of heat (e.g., warm water in a bottle or hydration bladder, chemical heating pads)

When the person has dry or damp clothing, leave the clothing on.

When the person has very wet clothing:

- wrap the person immediately if shelter and transport are less than 30 minutes away
- if shelter and transport are more than 30 minutes away, protect the person from the environment, remove wet clothing, and apply wrap

To apply a hypothermia wrap:

1. Place an insulation pad (or pads) between the person and the ground.
2. Apply as much insulation as possible. Add extra clothing and wrap the person in blankets or sleeping bags.

3. Add heat sources to the person's upper body inside the wrapping.
 4. Cover the person's head and neck with a toque, heavy hat, or hood, but leave their face exposed enough for breathing.
 5. If the person is dry, place a vapour barrier (plastic or foil) outside the insulation wrap. If the person is wet, place the vapour barrier inside the insulation wrap. If you have two vapour barriers, place one inside and one outside the insulation wrap.
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Can you become acclimatized to cold?

Acclimatization is the term given to the development of resistance to, or tolerance for, an environmental change. Although people can adapt to hot environments, they do not acclimatize well to cold. However, frequently exposed body parts can develop some degree of tolerance to cold. This adaptability is noticeable among fishers who are able to work with bare hands in extremely cold weather. The blood flow in their hands is maintained in conditions which would cause extreme discomfort and loss of dexterity in unacclimatized persons.

For information on exposure limits and prevention of injury while working in the cold, please see [Cold Environments - Control Measures](#).

Are there any factors that determine an individual's response to the cold?

Predisposing Conditions

Susceptibility to cold injury varies from person to person. In general, people in good physical health are less susceptible to cold injury. While anyone working in a cold environment may be at risk, the following conditions may make the risk of cold injury greater:

- Age (infants less than one year, and older adults are more susceptible).
- Diseases of the blood circulation system.
- Injuries resulting in blood loss or altered blood flow.
- Previous cold injury or illness.
- Certain medical conditions, such as hypothyroidism and [Raynaud's Phenomenon](#).
- [Fatigue](#).
- Consumption of alcohol or nicotine (smoking).
- Use of certain drugs or medications.

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