

TECHNICAL BULLETIN, MEDICAL

**PREVENTION, TREATMENT, AND
MANAGEMENT OF COLD WEATHER
INJURIES**

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HEADQUARTERS, DEPARTMENT OF THE ARMY

09 February 2026

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SUMMARY of CHANGE

TB MED 508

Prevention, Treatment, and Management of Cold Weather Injuries

This revision, dated 09 February 2026—

- Provides background information for reporting injuries and data collection of epidemiological information to note trends and to identify individual, work, and environmental factors that are not adequately controlled by preventive measures and policies (chap 1).
- Implements procedures for managing cold stress (chap 2).
- Provides guidance to prevent cold injuries during deployment and training (chap 2).
- Provides guidance to understand the physiologic responses and adaptations to cold (chaps 2-3).
- Identifies the risk factors for cold injuries and implement preventive measures (chaps 3-6).
- Provides guidance to understand the principles and use of the wind chill temperature index (chap 4).
- Provides guidance to understand the diagnosis and treatment of hypothermia, nonfreezing and freezing cold injuries and other medical conditions associated with cold weather (chaps 4-7).
- Provides guidance to understand the principles and proper management of cold weather clothing, energy requirements, and hydration (chap 8).

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PREVENTION, TREATMENT, AND MANAGEMENT OF COLD WEATHER INJURIES

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You can help to improve this bulletin. If you find any mistakes or have a recommendation to improve procedures, please let us know. Mail a memorandum or DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to Headquarters, Department of the Army, ATTN: DASG-HS, 7700 Arlington Boulevard, Falls Church, VA 22042-5143.

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Glossary

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CHAPTER 1

INTRODUCTION

1–1. Purpose

This bulletin provides guidance to unit commanders and leaders, military and civilian health care planners and providers, allied medical personnel, preventive medicine officers, and safety and occupational health professionals, to understand the physiologic responses and adaptations to cold and implement evidence-based procedures for managing cold stress.

1–2. References and forms

See appendix A.

1–3. Explanation of abbreviations and terms

See glossary.

1–4. Records management (recordkeeping) requirements

All record numbers, forms, and reports required by this publication must be managed in accordance with the National Archives and Records Administration (NARA) General Records Schedules (GRS) or the applicable Records Retention Schedule-Army (RRS-A). Retention schedules are located on the Records Management Division SharePoint Site at <https://armyeitaas.sharepoint-mil.us/sites/HQDA-CIO-ISES-RMR/SitePages/Records-Management-Division.aspx>. Refer to DA PAM 25-403 for detailed records management procedures.

1–5. Implementation and planning concerns

a. Successful implementation of educational and training programs, based on the principles in this document, can only be achieved through early and constant coordination of unit commanders, medical planners, medical officers, preventive medicine personnel, safety and occupational health professionals, medics, and unit field sanitation teams. A thorough review of all training and operational plans is necessary to ensure adequate planning and resourcing for emergency medical support and cold injury assessment and management where tactically feasible.

b. Planning for cold weather operations includes:

(1) An assessment of training/mission hazards from cold, wetness, and wind exposure.

(a) During the advance planning stages, incorporate information about the mean and extreme climatic conditions at the deployment site, to include the 24-hour pattern of temperature and humidity and the times of sunrise and sunset.

(b) Obtain regular real-time, local weather data and predictions to identify windows of opportunity for critical military operations.

(2) Development and implementation of controls for cold, wetness, and wind exposure.

(a) Ensure Soldiers are provided adequate clothing, shelter, heaters, warming areas, food, and warm beverages for cold weather operations.

(b) Ensure that only Army-approved heaters are used and personnel are trained in the use of the heaters (see para 8–5b).

(c) Consider modifying outdoor activities when wind chill categories indicate extreme risk of frostbite.

(d) Initiate a buddy system under cold conditions, and have personnel check each other for cold injuries.

(3) Provision for safe alternative training for individuals or units identified as being at particular risk for cold casualties.

c. Regional high and low temperatures must be considered when preparing health threat and force health protection information on the operational environment (see Field Manual (FM) 4-02 and Army Techniques Publication (ATP) 4-02.55). Commanders should have awareness of how to protect unit personnel and what climate injuries the medical commander can expect to treat.

d. Medical planning factors include:

(1) Understanding the commander's intent and mission objectives. This enables the ability to advise the commander on the potential adverse effects of cold weather and propose practical options for control of cold, wetness, and wind exposure under difficult circumstances.

(2) Conducting an assessment for each component of cold exposure (environmental factors, condition of the Soldier, workload, and mission requirements) to plan for the primary prevention of cold injuries would include considering the following questions:

(a) What are the anticipated temperatures and wind speeds to which Soldiers will be exposed, and will the Soldier be protected from the effects of cold temperatures, wetness, and wind?

(b) What uniform/equipment will be worn, and is clothing clean and without holes or broken fasteners?

(c) What work intensity and duration are planned?

(d) Will the Soldier be exposed to other materials that increase the risk of a cold injury such as bare metal objects, or petroleum, oils, and lubricants (POL)?

(e) Will the Soldier be able to move around to keep warm, dress down to avoid overheating, or seek shelter to avoid rain/wind/snow?

(f) Will feet be dry and warm, and will Soldiers be given opportunities to change socks/footwear?

(g) Will the Soldier be with a buddy who can assist/watch over him or her to prevent a cold injury?

(3) Determining on-site wind chill temperature using the wind chill temperature index table and provide guidance for adjusting physical readiness training and clothing according to the wind chill category and work intensity.

(4) Assisting the logistician in estimating clothing, shelter, and heater requirements.

(5) Educating the Soldiers about the steps needed to minimize the risk of cold injury, to include risk factors such as age, race, fitness, hydration, nutrition, rest, alcohol and drugs, and actions to avoid cold injury such as understanding environmental and personal risks, establishing observational checks, avoiding contact cooling, using clothing properly, and exercising.

(6) Educating Soldiers in recognizing the signs of impending cold injury and the basics of buddy aid.

e. Force Health Protection activities include:

(1) Estimating the rate of cold injury and arrange required medical support associated with each course of action.

(2) Developing a casualty evacuation plan to include a means of warming and monitoring patients.

(3) Integrating the estimates of mission injury rates, mission-compatible preventive measures, and medical support requirements to determine if alternative plans need to be developed by the command staff.

(4) Becoming aware of what types of illnesses are being seen at sick call and what medications are being used.

(5) Interviewing Soldiers diagnosed as having signs and symptoms of cold injury to describe predisposing conditions and the circumstances surrounding the development.

(6) Reporting cases of cold weather injuries in the Disease Reporting System-internet (DRSi) (in accordance with DoDD 6490.02E and the Armed Forces Reportable Medical Events Guidelines and Case Definitions).

(7) Communicating to field commanders immediately upon recognition of cold injury sentinel events and clusters.

f. Safety and occupational health related activities (see Army Regulation (AR) 385–10) include:

(1) Advising commanders in all safety and occupational health related concerns related to mission execution in a cold weather environment.

(2) Collaborating with the unit medical officer for cold weather injury mishap reporting issues.

(3) Report cold weather injuries to the U.S. Army Combat Readiness Center (USACRC), as appropriate.

g. Concepts provided in this publication will enable Soldiers to:

(1) Become familiar with the causes and risks of cold injury and the personal protective measures they can take to prevent cold injury.

(2) Attend cold injury threat and risk communication briefings and receive appropriate written cold injury prevention materials well in advance of deployment.

(3) Apply personal protective measures and use protective clothing and equipment properly (loose and in layers) when required.

(a) Ensure that their cold weather clothing is clean, dry, and in good repair, without holes or broken fasteners.

(b) Consume adequate food and fluid for optimal performance in the cold.

(c) Ensure their deployment kits contain an initial supply of stock hats, sunglasses, sunscreen, lip balm, and skin-care items.

(4) Use the buddy system to monitor performance and health.

(5) Report to the unit medic/medical officer if they or their buddies develop cold injury symptoms.

CHAPTER 2

BACKGROUND INFORMATION ON MILITARY OPERATIONS AND RISK MANAGEMENT IN COLD ENVIRONMENTS

2–1. Cold stress in military operation

a. Department of Defense (DoD) operations in extreme cold conditions are more relevant today than ever before. The DoD released an Arctic Strategy in 2019 highlighting the importance of the Arctic region. Further, the Army (Regaining Arctic Dominance), Navy (A Blue Arctic), and Air Force (Arctic Strategy) have each released their own arctic strategy documents. In short, there is renewed interest in and increased significance of cold-weather campaigns.

b. Deployed troops often encounter cold stress that requires management for successful mission accomplishment. Excessive cold stress degrades cognitive (thinking, reasoning, or remembering) and physical performance, significantly decreases morale, and may cause cold casualties. Cold stress environments include not only extremely low air temperatures (Arctic regions, for example), but also cold-wet conditions in above freezing ambient temperatures (for example rain or water immersion).

c. The U.S. military has successfully conducted operations in cold weather climates where troops were required to push their physiologic limits by enduring low air temperatures or cold-wet exposure for long hours (for example, World War II European campaigns, Korea, Balkans, and Afghanistan). Regardless of previous success, cold weather conditions impair many aspects of normal military function in the field that worsen Soldier health and performance.

(1) Food and water requirements may be high, yet supply can be difficult in cold stress environments. This mismatch may result in inadequate nutrition and hydration.

(2) Maintaining proper field sanitation and personal hygiene is difficult in cold weather. These conditions contribute to increased disease and non-battle injury. All told, sick and injured individuals are susceptible to medical complications produced by cold weather.

(3) Operational problems often arise in cold weather. Physical performance decrements, equipment malfunctions, and slow movement of vehicles and personnel may delay mission completion. Further, cold weather clothing can be difficult to integrate with chemical, biological, radiological, and nuclear (CBRN) protective clothing/equipment.

(4) Cold stress can reduce the duration of uninterrupted sleep, due to low body temperatures and/or discomfort. Mission requirements that demand intense physical activity with limited food intake and minimal/disturbed sleep make successful cold stress management difficult. Each of the above-mentioned stressors disrupt the normal physiological responses to the cold.

d. Military operations can occur in very cold weather with minimal logistical support, leaving troops under-equipped for the hostile conditions. Individuals in these situations must rely on their training and leadership in cold strain management. This training can determine whether the mission will succeed or fail with either few or many casualties. When military operations involve underprepared troops, unit commanders and trainers must actively plan to prevent cold casualties. Military exercises such as initial entry training, special badge qualification training, or military operations training often occur during cold weather seasons. This training is an opportunity to teach personnel to follow appropriate guidelines for successful completion of missions in cold environments.

e. Training and leadership are critical for successful cold weather military operations. Soldiers should be confident they can use preventive measures to master the environment. Lessons learned from previous cold weather deployments must be emphasized. Leaders must

learn their units' capabilities and manage cold exposure relative to the provided guidance. Guidance is based on the "average" Soldier, but there is significant individual variability. Supporting medical officers must ensure that the principles of this document are incorporated into the commander's plans and are applied to all phases of training and operations: pre, during, and post (see app B for cold weather deployment tips).

2–2. Heat exchange between the body and environment

a. Exposure to a cold environment can cause physiological strain and increase susceptibility to injury; however, as stated decades ago by an Army environmental physiologist, "a man in the cold is not necessarily a cold man". This TB MED illustrates the truth of this statement when appropriate training and preparation are applied.

b. The body produces heat largely through contracting skeletal muscles and metabolic processes. This heat is then transferred from the internal organs and large muscles to the skin for exchange with the environment through four mechanisms: convection, radiation, conduction, and evaporation. Environmental factors including air temperature, relative humidity, wind speed, radiation (solar, sky, and ground), and clothing influence heat exchange between the skin and ambient conditions. Total heat gain or loss is calculated using the following equation (see figure 2–1):

$$\text{Heat Gain/Loss} = \text{Metabolism (+ Work)} - \text{Evaporation} \pm \text{Radiation} \pm \text{Convection} \pm \text{Conduction}$$

Figure 2–1. Equation to calculate total heat gain or loss

Figure 2–2 illustrates heat transfer of a Soldier performing physical work in cold weather. Note that metabolism and physical work contribute only to heat gain while evaporation contributes only to heat loss. Radiation, convection, and conduction can each contribute to heat gain or loss. When trying to avoid cold-related injuries it is important to increase (or maintain) metabolic heat production and limit heat loss through evaporation, radiation, convection, and conduction.

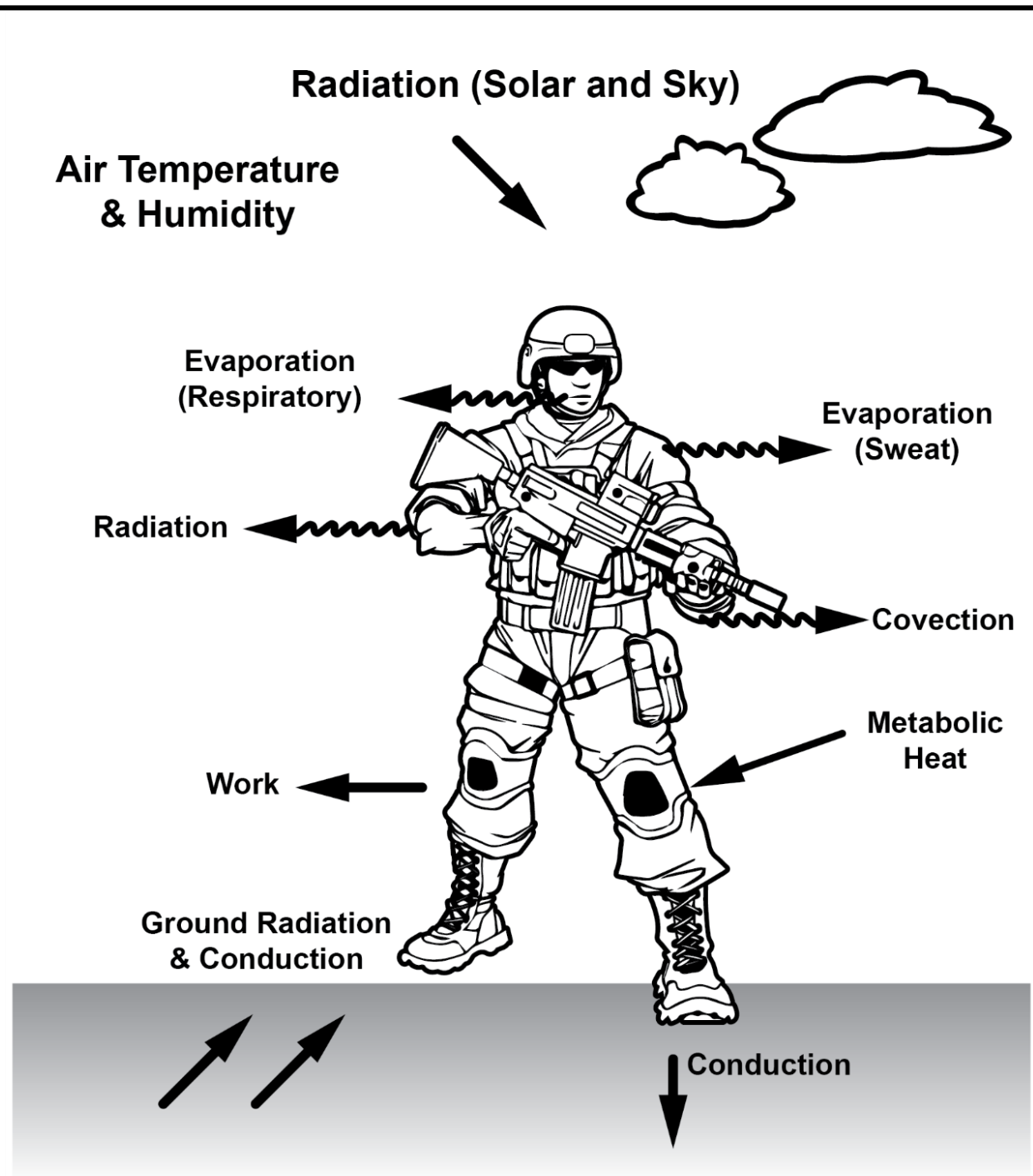


Figure 2–2. Heat transfer of a Soldier performing physical work

(1) *Convection.* The movement of gas or liquid (for example, wind or current) over the body causes convective heat loss when the gas or liquid temperature is below body temperature. Likewise, body motion within still air or water can contribute to convective heat

loss. This movement of gas or liquid decreases the boundary layer over the skin that insulates against heat loss. The rate of heat loss is greater the higher the wind velocity, current, or movement speed. Logically, convective heat loss in air is greater during windy conditions if a protective barrier of clothing is absent.

(2) *Radiation*. Radiative heat loss from the body occurs when surrounding objects have lower surface temperatures than the body. Unlike convection, this heat transfer mechanism is independent of air motion because the body can gain radiant heat from the sun, ground, and surrounding objects even when air temperature is below that of the body. For instance, a Soldier may gain a significant amount of solar radiative heat on a very sunny day when ambient temperatures are low.

(3) *Conduction*. Conductive heat transfer occurs when two objects are in direct contact with each other and have different surface temperatures. Touching metal objects or sleeping on a cold ground are common means of conductive heat loss in cold-weather military operations. Dampness decreases the insulation of clothing and increases the contact area between skin and a surface; therefore, conductive heat loss is greater when skin and/or clothing are wet. Finally, conductive heat loss in water can be large even when the temperature difference between skin and surrounding liquid is small because the heat transfer coefficient of water is 25 times greater than air.

(4) *Evaporation*. Heat loss occurs when liquid converts to water vapor. Sweating and respiration are the two modes of evaporative heat loss. Sweating, whether in cold or warm conditions, is the most significant mode of evaporative heat loss during exercise. The evaporation rate of sweat depends primarily on the water vapor pressure gradient (difference in relative humidity) between the skin and the environment, but also on air movement. Sweat tends to collect on the skin when the air is humid or still. Significant heat strain and sweating can occur in cold conditions when Soldiers perform strenuous exercise in excess clothing. Any non-evaporated sweat will reduce clothing insulation and possibly form ice crystals following exercise. Respiratory water loss is increased in cold air due to its lower relative humidity. It is estimated that a 24-hour workday at -4 °Fahrenheit (F) increases respiratory water losses by 0.34 liters (L) compared to 77 °F.

2–3. Environmental cold stress

a. Cold stress is the combined environmental and personal conditions that remove body heat and decrease body temperature. Cold strain refers to the physiological and psychological consequences of cold stress.

b. Low air temperature, wet skin (for example, from rain, water immersion, and/or high humidity), low ambient radiation, and high air movement contribute to environmental cold stress. Environmental conditions are measured with several instruments. Shaded dry bulb thermometers measure air temperature. Wet bulb temperature (from a thermometer bulb covered with a wet wick) determines the contribution of humidity. A “black globe” thermometer determines the contribution of solar, radiant heat (it is a thermometer resting in the center of a 6-inch hollow copper sphere painted matte black on the outside). Anemometers measure air speed, which by convention is measured at 1.5 meters (m) above the ground. Automated, self-contained systems are now available and acceptable for accurate environmental monitoring in place of the traditional, cumbersome instruments.

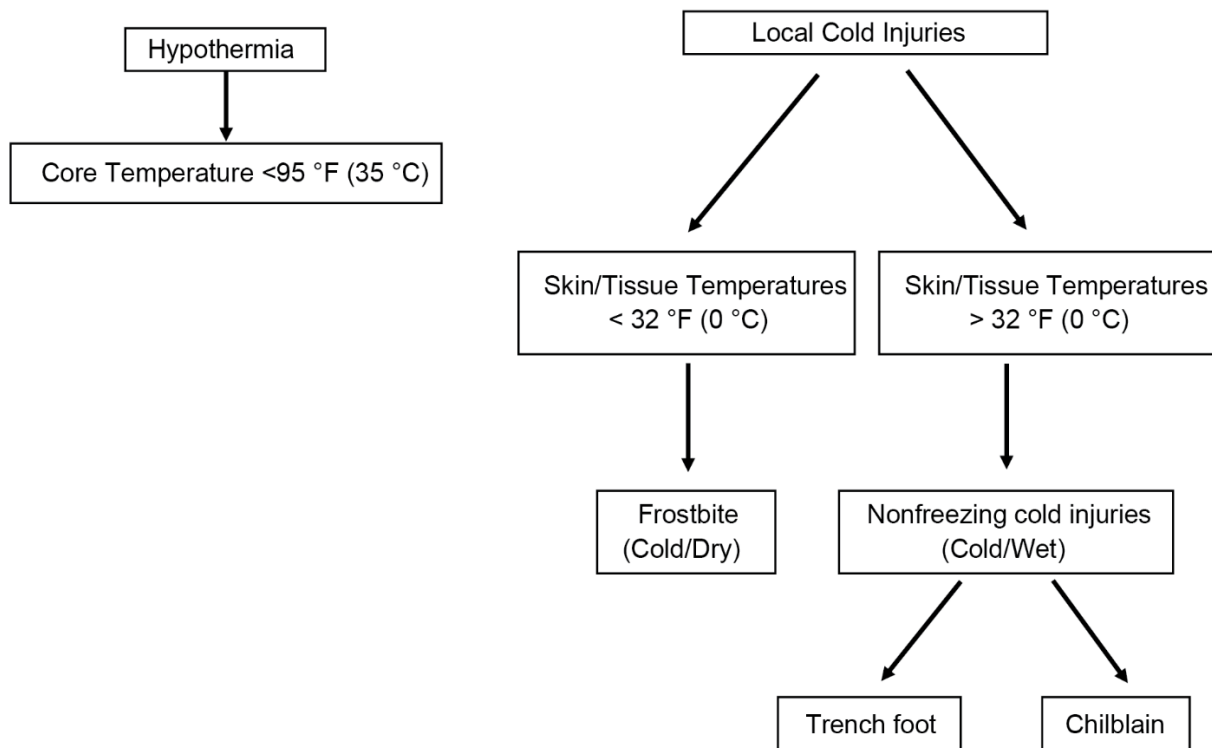
c. The U.S. Army uses the wind chill temperature (WCT) as a measure of environmental cold stress. The WCT integrates air temperature and wind speed to estimate the cooling power of the environment and associated risk of frostbite (see chap 4). WCT is the equivalent still-air (that is, without wind) temperature at which heat loss from bare skin would be the same as

under windy conditions. Individuals riding in open vehicles or exposed to propeller/rotor-generated wind can experience dangerous WCT, even when natural winds are low, underscoring the importance of covering bare skin in these conditions. The risk of frostbite is determined with ambient dry bulb temperature ($< 32^{\circ}\text{F}$) and contact surface temperature (exposed skin). There is no risk of frostbite in dry skin when the ambient air temperature is above 32°F , even when WCT is below 32°F ; however, as temperature falls below freezing the presence of wind can decrease the time it takes for frostbite to develop. Additionally, wet skin will not freeze if the air temperature is above 32°F ; however, wet skin will freeze faster than dry skin when the temperature is below 32°F .

d. Altitude is an additional consideration when assessing weather conditions for operations in mountainous regions or personnel flying in aircraft, particularly if weather measurements are taken from stations at lower elevations. Temperatures and wind chill at high altitudes can differ considerably from lower elevations thereby increasing the risk of cold injury. It is assumed that air temperature decreases 3.6°F ($2^{\circ}\text{Celsius (C)}$) with every 1,000 feet increase in altitude above the site at which temperature was measured. Wind speeds are usually greater at higher altitudes and there is considerably less wind break above the tree line.

2–4. Cold injury types

Cold injuries are classified into three categories: hypothermia, cold/dry (freezing), and cold/wet (nonfreezing). Hypothermia is defined as core body cooling below 95°F . Cold/dry and cold/wet injuries are localized to extremities and exposed skin. Cold/dry injury causes freezing of cells and tissues and is known as frostbite. Cold/wet injury is classified as non-freezing cold injury (NFCI) and includes chilblain and trench foot. It is not unusual for both hypothermia and local cold injuries to occur simultaneously. Figure 2–3 depicts the types of cold injuries and associated body temperatures.

**Figure 2–3. Types of cold injuries****2–5. Cold weather-related problems**

Cold weather-related problems include carbon monoxide (CO) poisoning, cold urticaria, cold-induced bronchoconstriction/asthma/respiratory illness, snow blindness (solar keratitis) and sunburn, and altitude sickness (see chap 7 for further discussion).

2–6. Cold stress risk management

Successful management of cold stress depends on proper education and experience of leaders and troops exposed to cold. Leaders must have the knowledge and understanding of problems associated with working in cold environments in order to minimize each risk factor. Risk management is the process of identifying potential hazards before conducting cold weather operations/training and implementing a strategy to minimize the impact of the hazards (DD Form 2977, Deliberate Risk Assessment Worksheet). Figure 2–4 outlines the cold strain risk management process for preventing cold injuries. An important aspect of this is recognizing changes in weather conditions so that troops are alert to potential modifications that may be necessary to reduce exposure and susceptibility to cold injuries. Therefore, the risk management process must be continually reevaluated as input changes. Finally, being alert to signs of Soldier distress in the cold is critical so that management procedures and interventions can be adjusted accordingly.

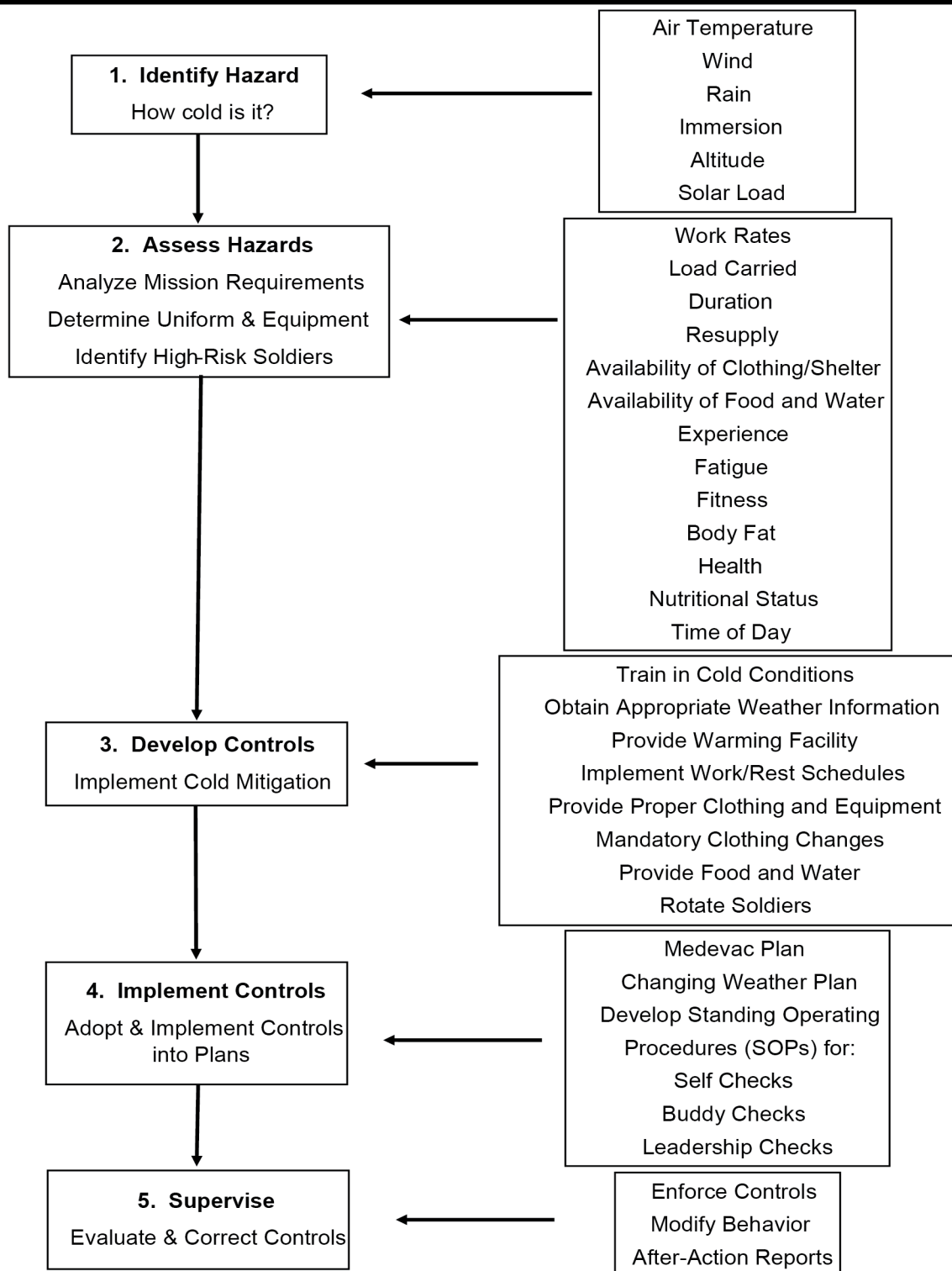


Figure 2–4. Cold strain risk management process

CHAPTER 3

PHYSIOLOGY OF COLD EXPOSURE: ACUTE RESPONSES AND CHRONIC ADAPTATIONS

3–1. Acute physiological and behavioral responses to cold exposure

a. Body core temperature.

(1) Body core temperature is regulated within a narrow range around 98.6 °F (37 °C) through two parallel processes: physiological and behavioral thermoregulation. As a reminder, total heat gain or loss is calculated (see figure 2–1).

(2) Physiological temperature regulation combines heat conservation through peripheral vasoconstriction and heat production through shivering. The physiological responses to cold air exposure are the same as in cold water immersion.

(3) Behavioral thermoregulation includes increases in physical activity to augment heat production and minimizing or avoiding cold exposure using shelter and clothing. In military scenarios, behavioral thermoregulatory actions can often be hindered by mission requirements and situations (for example, inability to move or find shelter and/or inability to change into dry clothing) or lack of resupply. Given potential limitations to behavioral thermoregulation, Soldiers will need to rely on physiological mechanisms at times to maintain their body temperature.

b. Heat conservation.

(1) The primary heat conservation mechanism with cold exposure is peripheral vasoconstriction. The resultant decrease in peripheral blood flow reduces convective heat transfer between the body's core (internal organs) and superficial tissues (skin, subcutaneous fat, and limb skeletal muscle). Skin temperature declines following this vasoconstriction because heat is lost from the exposed body surface faster than it is replaced (see figure 3–1 for the increase in insulative properties of the body by peripheral vasoconstriction).

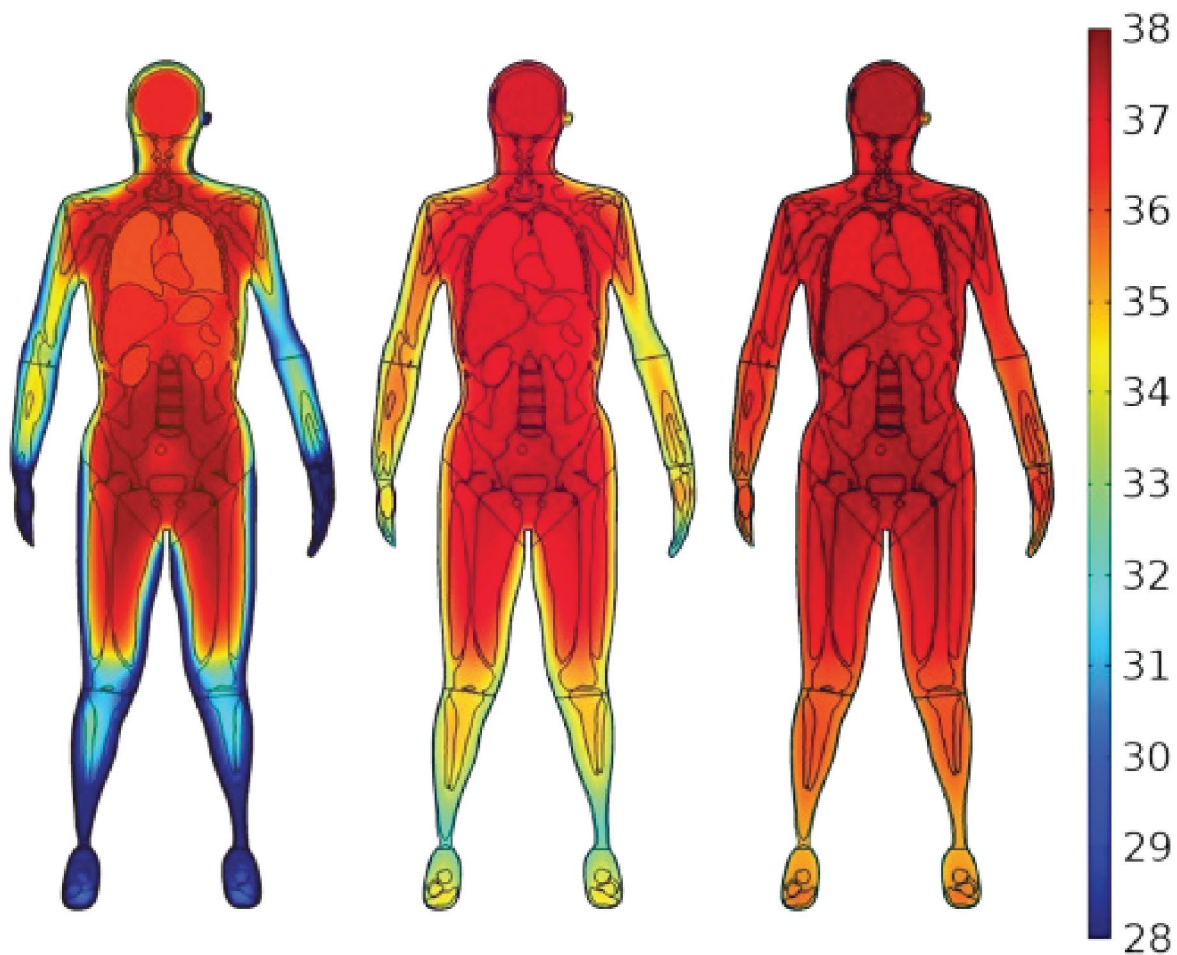


Figure 3–1. Effect of cold (left), thermoneutral (center), and hot (right) environmental temperatures on core and peripheral temperatures

(2) The vasoconstrictor response extends beyond the fingers and occurs throughout the entire body's peripheral shell during whole body cold exposure. Skin vasoconstriction begins when skin temperature falls below about 95 °F (35 °C) and becomes maximal when skin temperature is about 88 °F (31 °C) or less. Blood vessels in underlying tissues vasoconstrict, shunt blood to the body core, and effectively increase the insulating layer as cold strain increases. This causes the underlying muscles to become cold and stiff. This vasoconstrictive response to cold exposure retards heat loss and defends body core temperature at the expense of decreased peripheral tissue temperature. Figure 3–1 (effects of cold, left) illustrates declines in peripheral temperatures during cold exposure with body core temperature contraction.

(3) The vasoconstriction-induced blood flow reduction and fall in skin temperature set the condition for peripheral cold injuries, particularly in the digits and appendages (for example, the ears and nose). Cold-induced vasoconstriction has pronounced effects on the hands, fingers, and feet making them particularly susceptible to cold injury, pain, and a loss of dexterity. Cold-induced vasodilation (CIVD) is a vasomotor response that modulates the effects of

vasoconstriction in the fingers, toes, nose, and ears. Figure 3–2 illustrates fluctuations in finger temperature with the CIVD response.

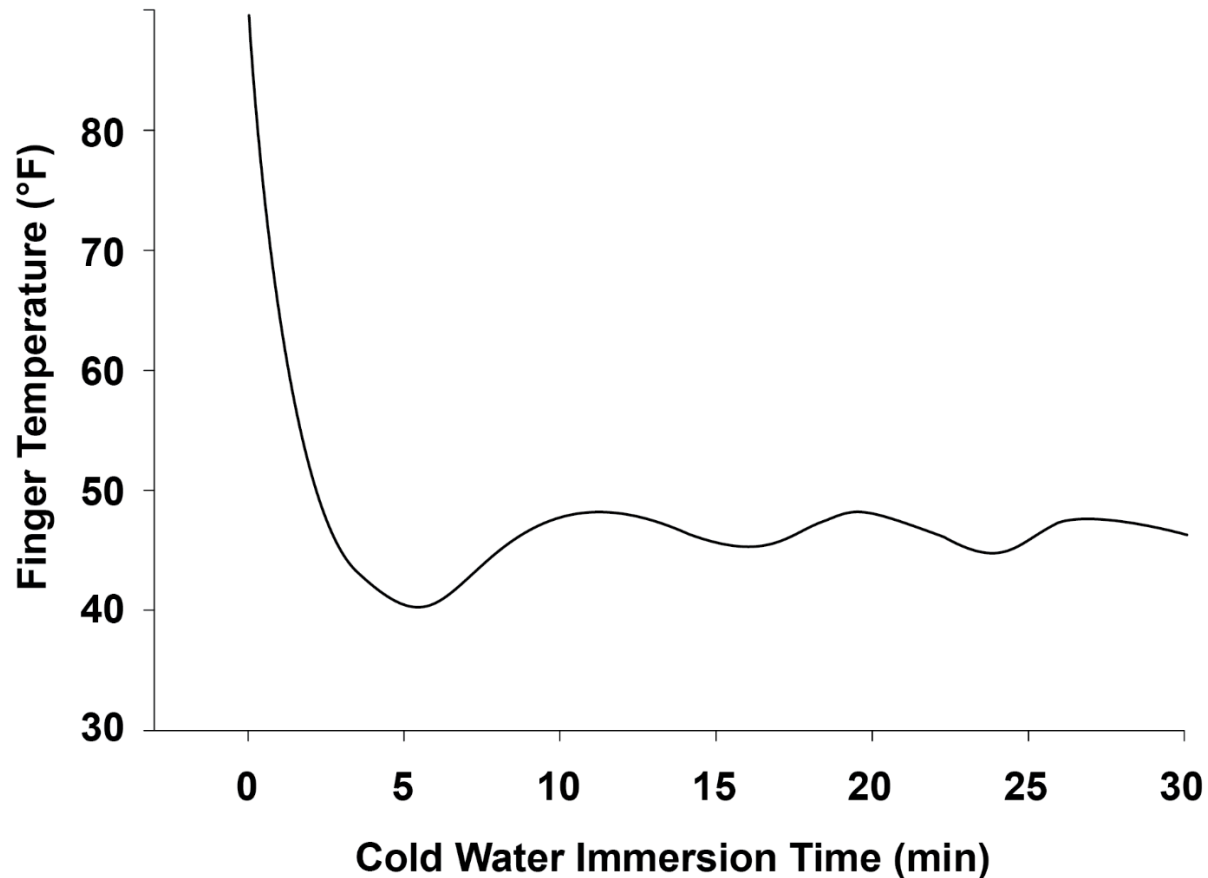


Figure 3–2. Cold-induced vasodilation response

(a) CIVD is a transient increase in blood flow in fingers, toes, cheeks, nose, and ears following the initial vasoconstriction and decline in skin temperature during cold exposure. The transitory nature of CIVD results in periodic oscillations of skin temperature. The increased blood flow raises tissue temperatures to protect peripheral tissues and sustain dexterity in fingers. That said, there are limits to CIVD. As body core temperature decreases, the CIVD response is blunted. This means hypothermic Soldiers are at increased risk for peripheral cold injury.

(b) CIVD is enhanced if a person's hands are exposed to the cold while body core and skin temperatures are maintained. Sustained CIVD was first noted in fishermen who routinely cleaned fish with their hands in cold water while wearing proper clothing to keep their bodies warm. Fishermen maintained warmer finger temperatures than the general population. The normal CIVD response can be blunted by preexisting vascular impairments such as Raynaud's syndrome, diabetes, or use of vibrating machinery for a long period of time.

c. Heat production.

(1) Cold exposure elicits increased metabolic heat production in humans that helps offset heat loss. Skeletal muscle contraction is responsible for cold-induced heat production in humans, as approximately 80% of the total energy expended during contraction is liberated as heat. Humans initiate thermogenesis voluntarily through increasing physical activity (behavioral thermoregulation) or involuntarily through shivering (physiological thermoregulation).

(2) Shivering is involuntary, rhythmic, repeated muscle contractions and is by far the greatest contributor of heat in resting, cold humans. It begins when skin temperature decreases and heat loss increases. Shivering typically begins in the torso muscles and spreads to the limbs. The intensity and extent of shivering varies according to severity of cold stress. Whole body oxygen consumption increases as shivering intensity and the number of muscles recruited increases. The increase in oxygen consumption can be two to three times greater than resting metabolism when a sedentary individual is exposed to cold air and can be four to five times resting metabolism during sedentary immersion in cold water. Figure 3–3 provides a comparison of metabolic rate and heat production during rest, shivering, running at 6 miles per hour (mph), and maximal exercise. Note that heat production while running at 6 mph is more than two times greater than shivering; however, a person can sustain shivering longer than heavy exercise.

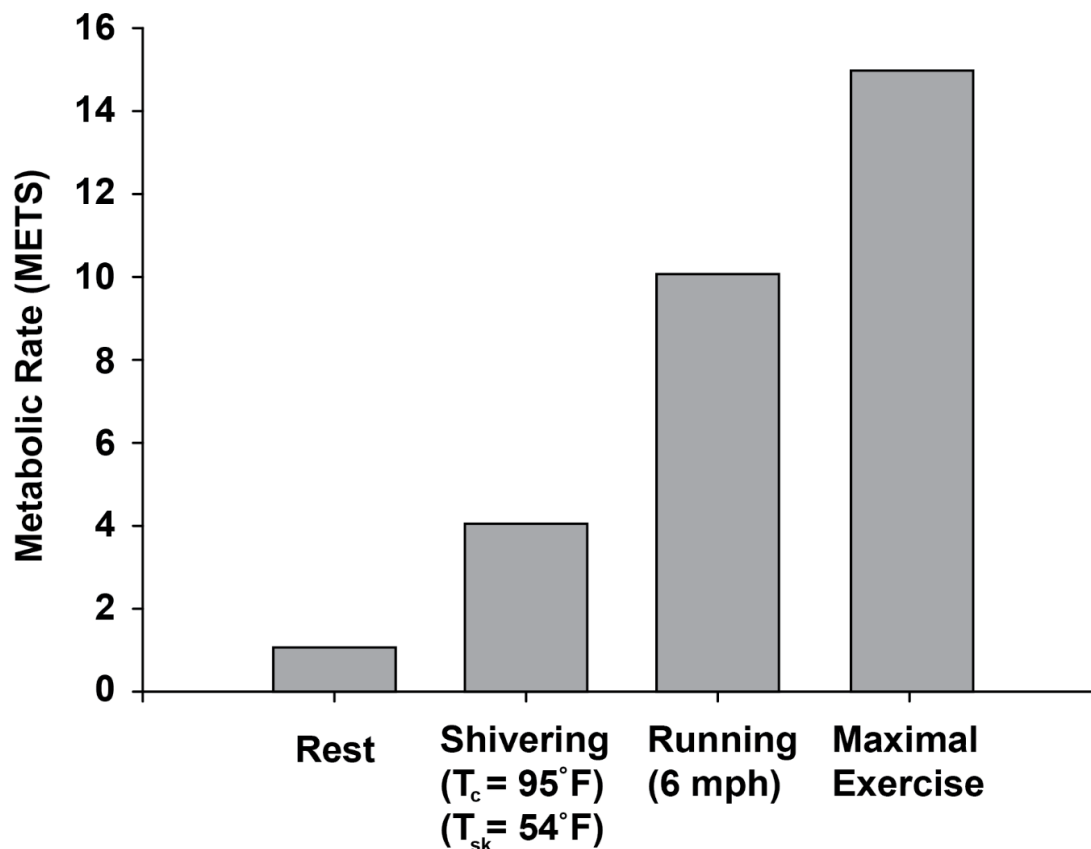


Figure 3–3. Comparison of metabolic rates during thermoneutral rest, shivering in cold water, and exercise

(3) Certain animals can increase metabolic heat production in response to cold exposure through non-contracting tissue. Activation of brown adipose tissue (a special type of body fat that is activated in response to cold) achieves this non-shivering thermogenesis. Adult humans have relatively minimal brown adipose tissue relative to total body mass; therefore, it has previously been assumed this tissue has little thermogenic importance. Newer evidence suggests a potential contribution of brown adipose tissue and non-shivering thermogenesis on whole body metabolism in young, healthy adults when shivering intensities are low. More evidence is needed to fully understand the contribution of brown adipose tissue to whole body thermogenesis in human adults.

d. Thermal behavior.

(1) Humans have a limited capacity for sedentary heat production, which means that personnel exposed to the cold often must take behavioral action. Modifying behavior is a highly effective strategy to limit body cooling. In addition to increasing heat production through physical activity as described above, behavioral strategies to generate and conserve heat in the cold include adding clothing, adjusting posture, huddling, seeking shelter, or applying external heat, if available.

(2) Wearing sufficient clothing protects body temperature. Donning gloves helps to maintain extremity temperatures and prevent cold injury.

(a) Unfortunately, the use of cold weather clothing has limitations. Bulky clothing and gloves restrict movement and reduce manual dexterity and performance. If clothing absorbs sweat, the wet clothing poses a risk for increased heat loss and cold injury during periods of low physical activity. Further, protective headgear can interfere with hearing, speech, and vision, and the weight of certain protective items like boots adds to the workload.

(b) For optimal use, clothing must be frequently adjusted to maintain adequate protection while avoiding overheating and sweating. Optimizing performance requires a balance between functional clothing, behavior, and exposure. The frostbite chapter explains this in more detail.

(3) Other energetically “inexpensive” behavioral strategies to maintain body temperature are postural or positional changes. Curling up and huddling decrease the surface area available for heat loss to the environment. When missions allow, using natural cover to limit exposure to wind and enhance exposure to solar radiation can substantially affect heat transfer.

e. Diuresis and fluid balance.

(1) Cold-induced diuresis (CID) is an increase of urine production and is a widely recognized effect of cold exposure. Upon exposure to cold, there is a redistribution of body fluids from the extremities and skin (that is, peripheral vasoconstriction) to the central circulation, which likely causes CID. This diuretic response is self-limiting, in that the response diminishes as body water volume decreases and dehydration occurs. CID can be minimized or prevented by moderate intensity exercise during cold exposure. Unfortunately, if CID has occurred prior to high levels of physical activity and an elevation of body core temperature, Soldiers may need to rehydrate and reestablish their body water volume to ensure optimal performance.

(2) Cold exposure accompanied by strenuous activity and inadequate fluid intake can cause dehydration. Cold weather presents challenges to fluid intake. First, the thirst sensation is blunted in cold persons. Secondly, cold environments often present practical constraints on voluntary drinking, such as low water availability, freezing of liquids, limited time to drink, and a decreased desire to urinate outdoors in cold climates. With strenuous activity, metabolic heat production can exceed heat loss and result in hyperthermia and sweating. Clothing insulation required for warmth in cold environments is greater at rest and during light activity than the

insulation required during strenuous activity. If an individual vigorously exercises while wearing clothing that is appropriate for a sedentary individual in the cold, sweating and fluid intake requirements increase substantially. Dehydration will ensue if increased fluid intake requirements remain unmet, just as it occurs during exercise in the heat. Dehydration decreases physical work performance, particularly if cold strain is minimized by clothing; however, dehydration does not alter heat conservation or CVD responses.

3–2. Physiological responses to cold water immersion

a. Immediate response (first 3-5 minutes).

(1) In response to cold water immersion, there is an immediate reaction known as the “cold shock response”, which consists of a large gasp for air followed by an acute increase in ventilation, heart rate, and blood pressure. The initial gasp reflex and hyperventilation increase the chances of water inhalation and pose a serious risk for drowning.

(2) Cold water immersion can also induce arrhythmias, which are thought to result from simultaneous activation of the sympathetic nervous system (cold shock response) and the parasympathetic nervous system (“diving reflex” with facial immersion). This autonomic conflict can cause arrhythmias and increase the risk for drowning in healthy individuals, though fatal arrhythmias typically occur only in individuals with predisposing risk factors, for example a cardiac long Q-T interval.

b. Short-term response (≤ 30 minutes).

(1) The main physiological effect of cold water immersion is muscle cooling, especially in the limbs. Low muscle temperature interferes with many chemical cellular processes and physical components of the connective muscle tissue. Nerve conduction slows at muscle temperatures below 68 °F and nerve block can occur when muscle temperatures fall below 59 °F. The effects of neuromuscular cooling can rapidly lead to physical incapacitation and drowning.

(2) Cold water immersion also causes physiological changes that challenge body temperature homeostasis. Cold water leads to greater conductive heat loss compared to cold air of the same temperature. In addition, movement and/or water currents increase convective heat loss and cause body temperatures to cool faster than still bodies of water. Cooling rates are dependent on water temperature and the depth of water immersion and accelerate as the amount of the body surface area exposed increases. Hypothermia (body core temperature < 95 °F) typically begins to develop after 30 minutes or more of immersion.

c. Rewarming response.

(1) During cold water immersion, a temperature gradient develops between the body core and the skin. Blood flow to the skin and muscles decreases during immersion, and these peripheral tissues cool to a greater extent than the core. When the body is rewarmed, blood begins to circulate through the peripheral tissues. The colder blood returning from the muscles and skin may cause an afterdrop, or a continued fall in core temperature, which may be as large as 1-3 °F (0.5-1.5 °C).

(2) Afterdrop can cause a fall in mean arterial blood pressure, or in severe cases, syncope or ventricular fibrillation. Afterdrop is typically larger when rewarming techniques that induce peripheral vasodilation are used because they increase blood flow to the coldest tissues (that is, the skin).

3–3. Physiological responses to exercise in the cold

a. Thermal balance.

(1) Exercising in cold air usually maintains or increases body core temperature because heat production often exceeds heat loss. Generally, the higher the exercise intensity, the higher the steady-state body core temperature and skin temperature in a well-clothed Soldier. The precise effect of exercise intensity on body core temperature during exercise in cold air will depend on the severity of cold stress, total amount of clothing insulation worn, and anthropometric factors (body size and composition, for example, body fat).

(2) Exercising in water or during a rainfall has different effects on thermal balance compared to air. Heat loss is ~25 times higher in water than in air. This means heat losses can exceed heat production generated by either exercise or shivering. For example, executing a mission through a river or swamp can greatly accelerate heat loss and increase a Soldier's susceptibility to hypothermia. Furthermore, if exercise is performed with both the arms and legs while in cold water, greater heat losses will occur than if exercise was performed only with the legs. Arms lose heat more rapidly because they have a greater surface area-to-mass ratio and less subcutaneous fat than legs. Light exercise in water temperatures less than 59 °F has been shown to accelerate body cooling in thin people, compared to resting cold water exposure. In these cases, blood circulating to working muscles may enhance heat loss to cold water, outweighing the heat produced by exercise.

b. Oxygen consumption.

(1) Oxygen consumption during submaximal exercise in the cold may be higher than in temperate conditions, depending on the intensity. At low exercise intensities, metabolic heat production is often insufficient to maintain body temperature without shivering. Thus, oxygen consumption is typically greater than in temperate conditions to account for the added oxygen requirement for shivering.

(2) At higher exercise intensities, metabolic heat production is usually high enough that the need for shivering is minimal and oxygen consumption is the same as in temperate environments. Figure 3–4 illustrates the effect of cold on oxygen consumption during exercise of different intensities. The exercise intensity at which oxygen consumption is equal in cold and temperate conditions (in other words, the intensity at which metabolic heat production is sufficient to eliminate the need for shivering) depends on the severity of cold and other individual factors.

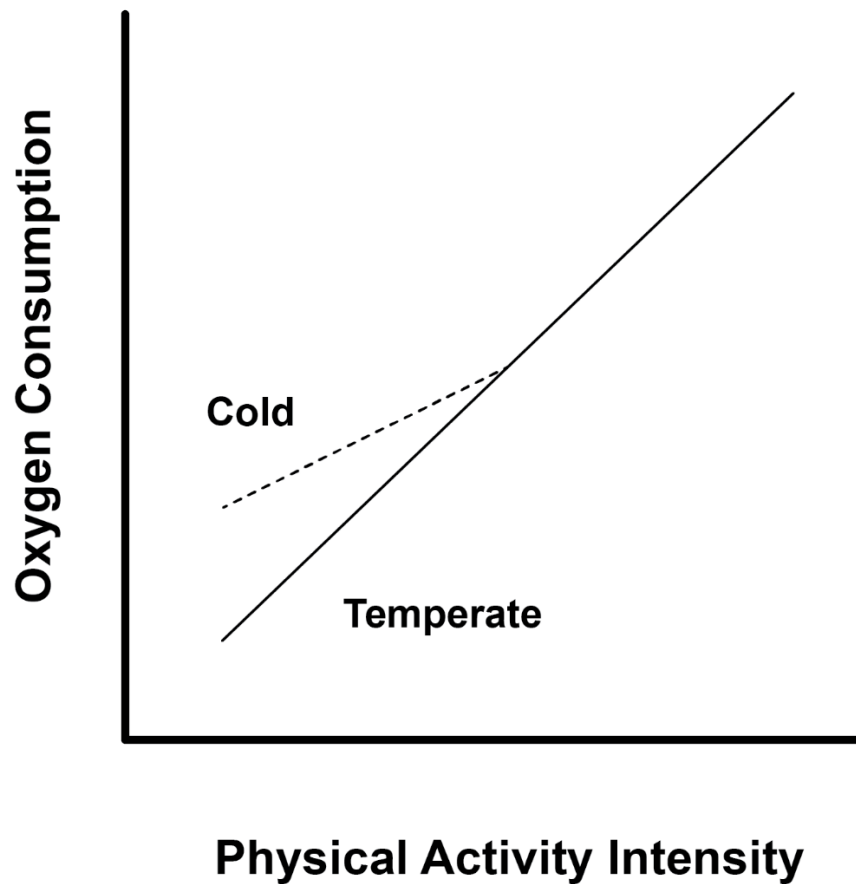


Figure 3–4. Cold effects on oxygen consumption across a range of steady-state exercise intensities

c. Fuel metabolism.

(1) Fuel utilization changes in proportion to the metabolic heat production during cold exposure. During resting cold exposure, plasma glucose oxidation increases 1.5-fold, muscle glycogen usage doubles, and lipid oxidation increases almost 3-fold, due to shivering. Protein use does not change. Plasma glucose, muscle glycogen, fats, and proteins account for 10, 30, 50, and 10%, respectively, of total heat production during resting cold exposure. However, if muscle glycogen levels are reduced substantially, such as following extended physical activity, shivering intensity at rest can be maintained by increasing fat oxidation. Thus, macronutrient reserves (carbohydrates, proteins, fats) do not appear to limit shivering.

(2) During high-intensity exercise in the cold, both carbohydrate and fat use increase substantially. As in temperate environments, stored carbohydrates in the form of muscle glycogen are needed to sustain high-intensity exercise. Furthermore, muscle glycogen utilization has been observed to be more pronounced during low-intensity exercise in the cold (for example, below 25% maximal endurance exercise capability) compared to temperate conditions. Therefore, if Soldiers march slowly for a long period of time in the cold to reach an objective, and then must do high-intensity work, their ability to perform may be compromised. These findings reinforce the importance of eating adequate amounts of carbohydrate to sustain

muscle glycogen at optimal levels. This might be achieved by providing Soldiers with carbohydrate supplements during long-duration tactical movements (see para 8–11). Caloric intake must also account for the increased energy that restrictive, layered cold weather clothing and heavy equipment add to given tasks.

d. Respiratory.

(1) Upper airway temperatures, which normally remain unchanged during exercise under temperate conditions, can decrease substantially when extremely cold, dry air is breathed during strenuous exercise; however, temperatures of the lower respiratory tract and deep body temperatures are unaffected. Pulmonary function during exercise is usually unaffected by breathing cold air in healthy Soldiers, but allergy-prone Soldiers frequently experience bronchospasm. The triggering mechanism for this in susceptible Soldiers remains unresolved but may be related to thermally induced leakage in the lung's microcirculation with subsequent edema or to a sympathetic response secondary to facial cooling.

(2) Soldiers who experience bronchospasm when breathing cold air during heavy exercise, and/or exposure to pollutants, exhibit a reduced forced expiratory volume that can limit maximal ventilation and maximal performance. Lastly, even healthy Soldiers can experience increased respiratory passage secretions and decreased clearance of mucus when breathing very cold air during exercise, and any associated airway congestion may impair pulmonary mechanics and ventilation during exercise, also affecting performance.

3–4. Individual factors modifying physiological responses to cold

a. Body size and subcutaneous fat.

(1) Most of the variability among individuals in their thermoregulatory responses and capability to maintain normal body temperatures during cold exposure results from differences in body size and composition. Individuals with a high amount of body surface area relative to their body mass (long and lean, or ectomorphs) lose more body heat in the cold than individuals with a small surface area relative to body weight (short and stocky, or mesomorphs). The reason for this is that the principal means of heat loss in cold-exposed humans is convective heat transfer at the skin surface. This effect is somewhat lessened in short and stocky people since a large body mass favors maintenance of a constant temperature by virtue of a greater heat content compared to a small body mass.

(2) All body tissues provide thermal resistance to heat conduction (that is, insulation) from within the body, but thermal resistivity of fat is greater than other tissues. Subcutaneous fat provides significant insulation against heat loss in the cold, and thermal conductance decreases with increasing subcutaneous fat thickness. Consequently, people with more fat experience smaller body temperature changes and shiver less during cold exposure than lean persons. As previously discussed, constriction of muscle tissue (underlying cold skin) will reduce blood flow and provide resistance to heat loss. Therefore, heavily muscled persons may be able to defend body temperature better than very lean Soldiers due to better insulation and greater heat production from shivering, though this advantage may be smaller during exercise in cold water when muscle blood flow is increased.

b. Sex.

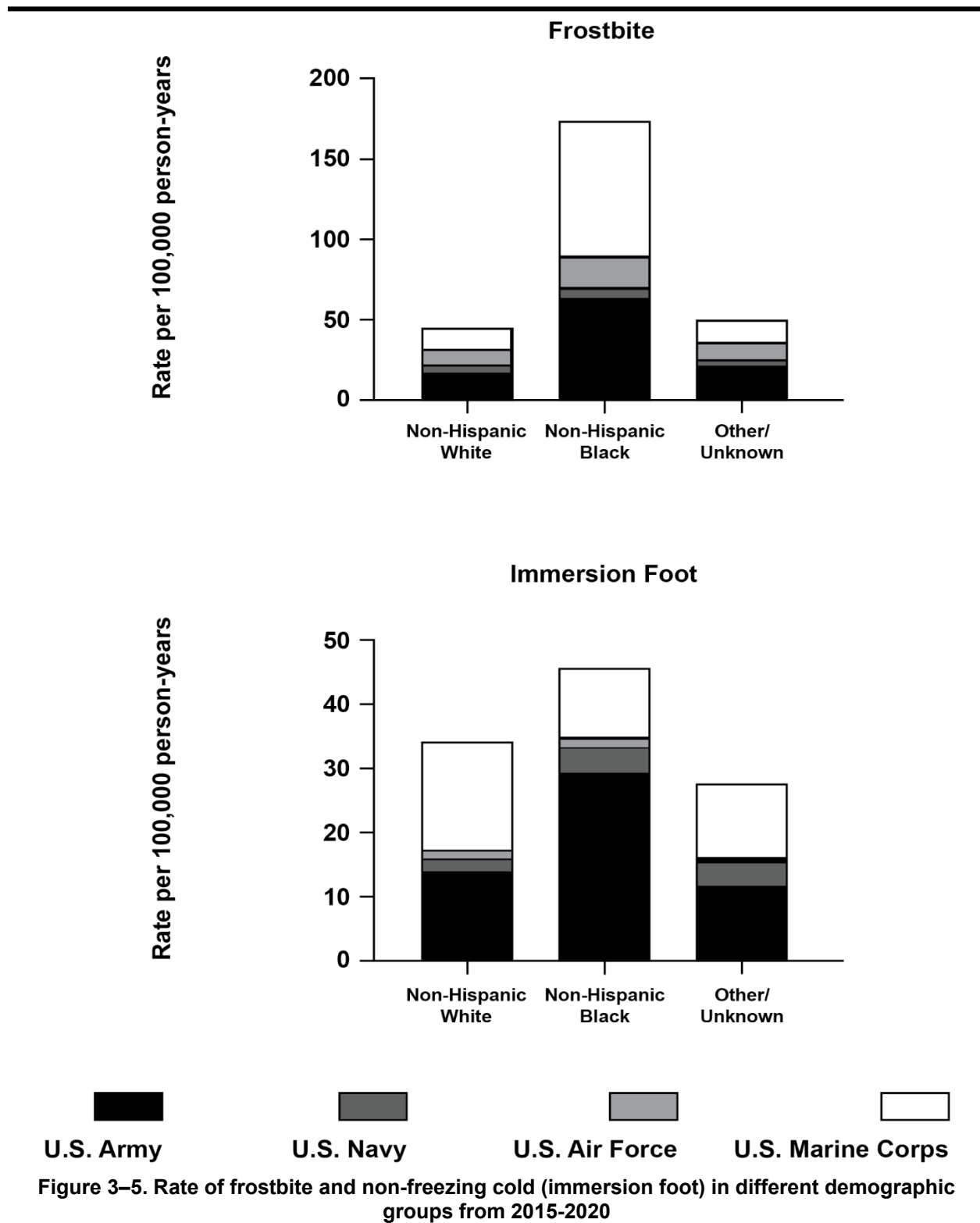
(1) Sex differences in thermoregulatory responses during cold exposure are almost entirely attributable to differences in body composition (women's generally greater body fat content and thicker subcutaneous fat layer) and body anthropometrics (women's smaller body mass to surface area ratio). For example, in men and women having equivalent total body mass and surface areas, women's greater fat content enhances insulation and reduces the fall in body core temperature. However, in women and men of equivalent subcutaneous fat

thickness, the women typically have a smaller total body mass (thus lower total body heat content) relative to surface area than men. Therefore, total heat loss would be greater in women due to the larger surface area for convective heat flux, and body temperature would tend to fall more rapidly for any given cold stress.

(2) The peripheral cold injury rate for female Soldiers is two times higher than the rate for males. Women typically have lower finger temperatures. Furthermore, women have higher rates of peripheral vascular disorders (for example, Raynaud's syndrome) that could make them more susceptible to peripheral cold injury.

(3) Pregnant women should see their physicians to discuss exercising and other activities in the cold. It is very important that pregnant women do not become hypothermic, since this can potentially harm the fetus. In most cases, pregnant women can perform physical readiness training in cold environments if they follow the guidance in FM 7-22 and in this document.

c. *Race.* Black male and female Soldiers are two to four times more likely to suffer cold weather injuries than their Caucasian counterparts. This increased risk is consistent across all career management fields, which suggests that occupational exposure does not account for the differences between Blacks and Caucasians. Blacks have been demonstrated to have a larger reduction in hand skin blood flow (greater vasoconstriction) during immersion and a slower rewarming response relative to Caucasians, which may contribute to their heightened peripheral cold injury risk. Differences between races may be due to cold-weather experience but more likely are due to anthropometric considerations such as longer, thinner digits and greater surface area-to-mass ratio. Figure 3-5 shows the rate of frostbite and non-freezing cold injury in Non-Hispanic Whites, Non-Hispanic Blacks, and other races from 2015-2020.



d. Fitness and training. Overall, physical training and level of fitness appear to have only minor influences on thermoregulatory responses to cold. Most cross-sectional comparisons of aerobically fit and less fit persons find no relationship between maximal aerobic exercise capability and temperature regulation in cold. In those studies, purportedly demonstrating a relationship, differences in thermoregulation appear more likely attributable to anthropometric differences between the aerobically fit and less fit subjects, rather than to an effect of maximal aerobic exercise capabilities per se. The primary thermoregulatory advantage provided by the increased endurance resulting from physical training is that the fitter individual can sustain voluntary activity at a higher intensity and longer duration than less fit persons and thus maintain higher sustained rates of metabolic heat production, which will keep them warmer.

e. Fatigue. Physical fatigue (due to strenuous activity, repeated or prolonged cold exposure, or a combination of both) has been shown to impair shivering and peripheral vasoconstriction responses during cold exposure. Therefore, physical fatigue increases the Soldier's risk for hypothermia. Fatigued Soldiers cannot sustain sufficient activity levels to maintain body temperature during severe cold exposure. As fatigue occurs, the exercise intensity and rate of heat production decline so that heat debt will increase, and body temperature will decrease as long as heat loss continues.

f. Age. Soldiers who are older than 45 years may be less cold-tolerant than younger persons, due to either a decline in physical fitness (will fatigue sooner due to working at a higher percentage of maximal endurance exercise capability), reduced muscle mass (lower capacity for heat production), or reduced vasoconstriction and heat conservation in comparison to their younger counterparts. That said, rates of cold weather injuries among active service members are highest in personnel younger than 30 years old and decrease with increasing age. The higher incidence of cold injury in young individuals may be due to a greater number of individuals under 30 being exposed to cold environments than individuals over 30; however, it is also likely that, despite the physiological effects of aging, the experience gained with age allows individuals to better manage cold exposure.

g. Dehydration. Dehydration can increase susceptibility to cold injury by decreasing the ability to sustain physical activity (particularly if accompanied by heat stress from exercising in excess clothing) and therefore to sustain thermal balance. In addition, dehydration might impair cognitive function and cause Soldiers to use poor judgment. Dehydration has been shown to have minimal impact on peripheral skin temperatures and does not impair shivering.

h. Sustained operations. The combination of exertional fatigue, sleep restriction, and underfeeding are common stressors during sustained operations and together impair a Soldier's ability to increase metabolic heat production and sustain exercise performance. Soldiers engaged in sustained operations also may make more judgment errors when tired and increase their exposure and risk of injury. A given cold stress is more likely to induce cold injury after a long period of sustained operations compared to earlier in the operation. This emphasizes the need for planned rest, sleep, feeding, and recovery before conducting stressful operations in the cold.

i. Underfeeding. Underfeeding can result in the development of hypoglycemia. Acute hypoglycemia (< 60 milligrams (mg) glucose /deciliter (dL) blood) impairs shivering through a central nervous system mediated effect. Also, declining peripheral carbohydrate stores probably contributes to an inability to sustain physical activity and the associated heat production during cold exposure. No food for 48 hours, even in the absence of hypoglycemia, results in an impaired ability to shiver and increases the risk of hypothermia.

j. Alcohol. Although alcohol may impart a sense of warmth, it causes peripheral vasodilation and will increase heat loss and the risk of hypothermia. Alcohol can also cause hypoglycemia which will decrease shivering responses and the ability to sustain physical work.

In addition, alcohol blunts the senses and impairs judgment, so the Soldier may not feel the signs and symptoms of developing cold injury. Soldiers who are exposed to cold weather should avoid alcohol.

k. Nicotine. Smoking or chewing tobacco can increase susceptibility to frostbite by increasing vasoconstriction in the periphery (for example, the hands). Heavy smokers (two to three packs per day) have a 30% higher incidence of peripheral cold injury, perhaps because nicotine reduces the CIVD response. Smoking and chewing should be discouraged during cold weather operations.

l. See table 3–1 for a summary of modifying factors that impact cold tolerance and injury risk.

Table 3–1
Modifying factors that impact cold tolerance and injury risk

Modifying Factor	Physiological Effects in the Cold
Low Muscle Mass	Lower heat generation
High Body Surface Area	Faster rate of heat loss
High Body Fat Percentage	Slower rate of heat loss
Female Sex	Greater risk for cold injury; lower finger temperatures
Non-Hispanic Blacks	Greater risk for cold injury
Higher Fitness Level	Ability to sustain physical activity for heat generation
Fatigue	Impaired shivering and heat conservation responses; inability to sustain physical activity
Older Age	Impaired heat production and conservation responses
Dehydration	Inability to sustain physical activity for heat generation; impaired cognitive function
Sustained Operations	Inability to sustain heat production; impaired cognitive function
Caloric Deficiency	Inability to sustain physical activity and shivering thermogenesis
Alcohol	Increased heat loss through peripheral vasodilation; inability to sustain metabolic heat production due to hypoglycemia; impaired judgement
Nicotine	Increased risk of peripheral cold injury due to enhanced vasoconstriction in extremities

3–5. Cold strain and performance

a. Exercise. Cold stress that does not cause a decrease in body core body temperature of more than 0.9 °F or allow muscle temperatures to go below 97 °F does not alter most exercise performance. However, for every 1.8 °F fall in body core or muscle temperature that occurs, maximal endurance exercise capability is lowered by ~5% and exercise endurance time is lowered by 20%. In addition, maximal strength and power output is lowered by 5%, as cooling of the muscle reduces blood flow and slows nerve signal transmission.

b. Manual dexterity.

(1) Manual performance is important for many military tasks, including knot tying, marksmanship, weapons and equipment maintenance, setting up tents, and lighting stoves.

(2) Pain sensations begin to occur when skin temperatures decrease to 68 °F, and manual dexterity declines after finger-skin temperatures decrease to 60 °F due to cooling of tissues and decreases in joint mobility (see figure 3–6). Finally, tactile sensitivity is reduced as skin temperatures drop below 43 °F. These changes occur due to decreased local finger and hand tissue temperatures. A Soldier can have a normal body core temperature but still have a significant decline in performance of gross and fine motor skills because the hands and fingers are cold.

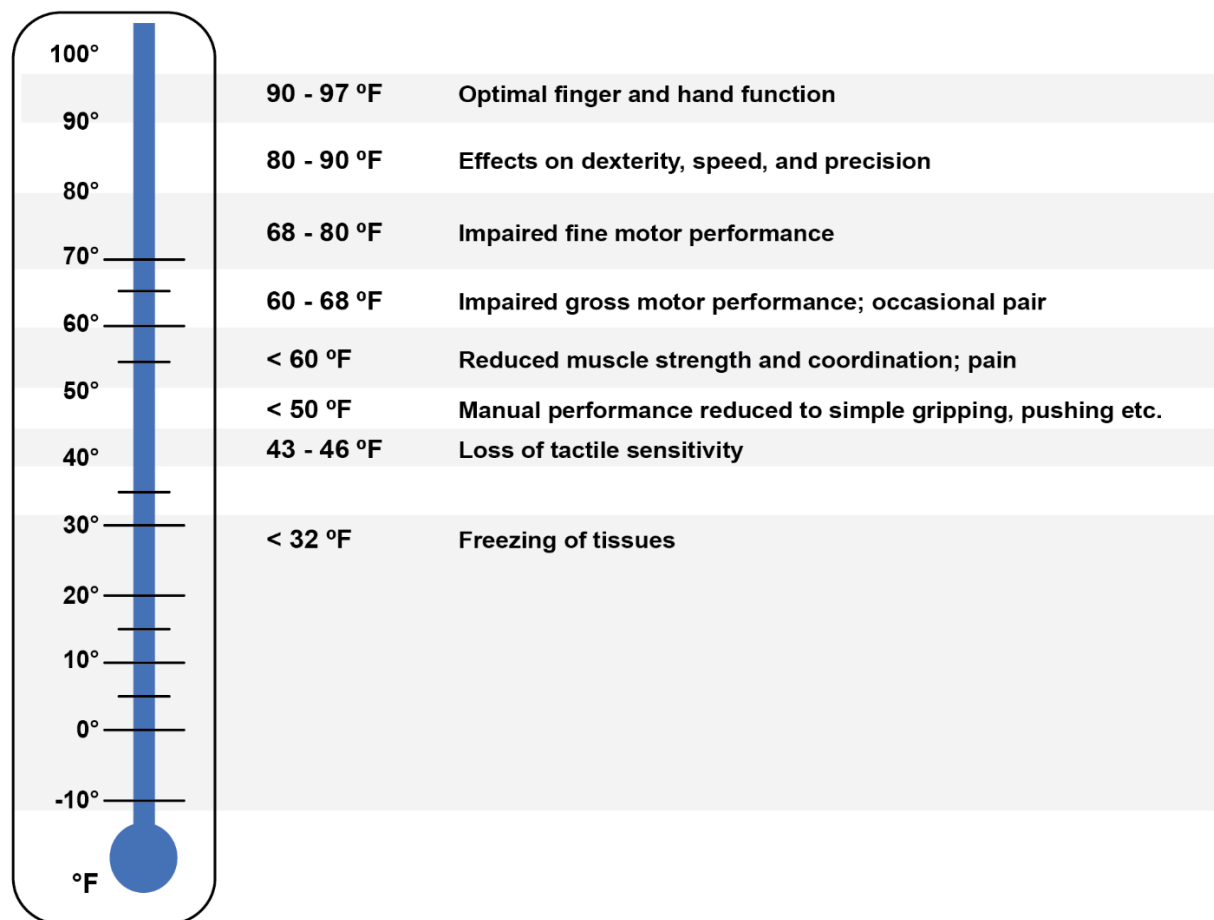


Figure 3–6. Decrements in manual performance at different finger temperatures in the cold

(3) The relationship between finger temperature and performance changes is not linear; rather, there is a clear breakpoint in performance at skin temperatures below 60 °F as hand performance drops off by 10-20%, and a second sharp decline occurs at a skin temperature less than 43 °F when tactile sensitivity is lost. It should be noted that fingertip temperatures can be much lower than that of the hand.

(4) Duration of cold exposure also has a role because underlying tissues will cool more with longer exposures leading to greater declines in performance as muscles and nerves will

both cool. However, immersion of the hands and forearms in 50 °F water for as short as 5 minutes can lower manual dexterity by 20-50%.

c. Cognition. Cold weather operations require a continuous need to adjust protective clothing and equipment, which requires a higher level of attention and cognition. Cold strain can degrade mental performance on complex thinking tasks by 17-20%. Working memory declines up to 20% with significant peripheral cooling, even with no change in body core temperature, and continues to decline when body core temperature falls between 94-95 °F (34-35 °C). Vigilance and tracking decrements also occur when body core temperature falls. Performance decrements can be mitigated through education, preparation, experience, and cold strain management.

3–6. Adaptations to chronic cold stress

a. Compared to the effects of heat acclimatization, physiological adjustments to chronic cold exposure are less pronounced, slower to develop, and less practical in relieving cold strain, defending normal body temperature, and preventing cold injury. Soldiers exposed to cold weather can acclimatize, but the specifics of the physiologic adjustments are modest and depend on the nature and severity of the exposures. Figure 3–7 illustrates patterns of cold acclimatization in persons repeatedly or chronically exposed to cold, manifesting in three different patterns of thermoregulatory adjustments:

- (1) Habituation (blunted cutaneous vasoconstriction and shivering).
- (2) Metabolic acclimatization (enhanced heat production).
- (3) Insulative acclimatization (enhanced cutaneous vasoconstriction and heat conservation).

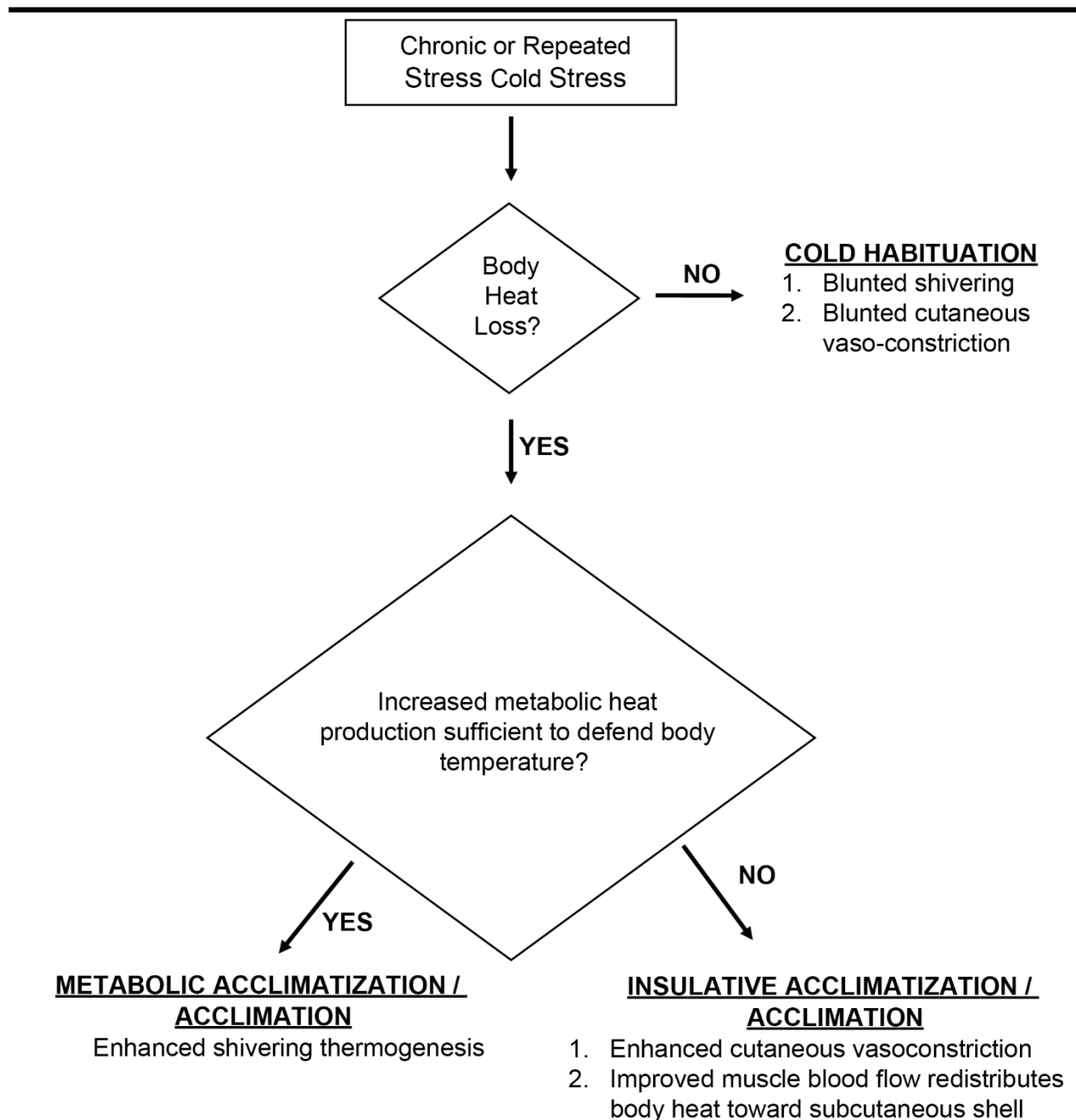


Figure 3–7. Patterns of cold acclimatization

b. Habituation.

(1) Cold habituation is the most commonly observed acclimatization pattern exhibited, in which physiological responses to cold become less pronounced than in the unacclimatized state.

(2) Soldiers will develop this adaptation when exposed to superficial cooling of the body surface, even for short periods and in limited body regions, such as the hands and face. Blunting of both shivering and vasoconstriction are the hallmarks of habituation. Higher

peripheral skin temperatures are accompanied by enhanced CVD responses, decreased pain sensations, and increased manual dexterity.

(3) Cold-habituated persons with blunted shivering and vasoconstrictor responses to cold sometimes, but not always, also exhibit a more pronounced decline in body core temperature during cold exposure than non-habituated persons. This pattern of cold habituation is sometimes referred to as hypothermic habituation. Hypothermic habituation can be advantageous by preserving energy resources without causing a dangerous reduction in body temperature.

(4) Findings from different cold acclimatization studies, when viewed collectively, suggest that short, intense cold exposures (for example, less than 1 hour) a few times per week, with little change in body core temperature but pronounced falls in skin temperature, will produce habituation; however, longer exposures (for example, more than 8 hours) to more moderate cold conditions on consecutive days over a fairly long period (for example, more than 2 weeks) are required to induce the hypothermic form of habituation.

(5) Reduced shivering and warmer skin temperatures caused by habituation could potentially provide a military advantage by improving marksmanship and the ability to perform motor skills, increasing thermal comfort, increasing CVD responses, and reducing susceptibility to cold injury. Habituation may also reduce distraction and improve judgement in the cold. Habituation will naturally occur as Soldiers train outdoors and decrease skin temperatures in cold weather.

(6) The immediate “cold shock” response also habituates following repeated cold water immersions. Habituation of the cold shock response can be achieved with as few as 5-7 repeated neck-deep immersions lasting only 2-7 minutes in 50-60 °F water. Habituation of the cold shock response can importantly reduce the risk of water inhalation and drowning in military personnel during accidental cold-water immersion.

c. Metabolic acclimatization.

(1) A more pronounced thermogenic response to cold characterizes the metabolic acclimatization pattern. An exaggerated shivering response has been reported to develop because of chronic cold exposure; however, evidence for this pattern has not been clearly demonstrated.

(2) More recently, there has been evidence that non-shivering thermogenesis may be enhanced following repeated or chronic cold exposure and that this increase in non-shivering heat production may help compensate for the blunted shivering response that occurs during cold habituation.

d. Insulative acclimatization.

(1) The third major pattern of cold acclimatization, referred to as insulative cold acclimatization, is characterized by enhanced heat conservation mechanisms.

(2) Insulative cold acclimatization occurs when the body core temperature repeatedly falls (for example, during cold-water immersion) over several weeks. With insulative acclimatization, cold exposure elicits a more rapid and more pronounced decline in skin temperature and lower thermal conductance at the skin than in the unacclimatized state. This more pronounced vasoconstrictor response to cold is possibly due to an enhanced sympathetic nervous response to cold. Insulative acclimatization has also been shown to lower resting body core temperatures.

(3) In addition, insulative cold acclimatization may also involve development of enhanced circulatory counter-current heat exchange mechanisms to limit convective heat loss. This type of acclimatization is difficult to induce outside of the laboratory and, in terms of the physiological adjustments in body core and skin temperature, there is little practical value for

Soldiers to repeatedly lower their body core temperatures substantially to induce insulative acclimatization, as this will not protect them from cold injury or improve their performance.

CHAPTER 4

FROSTBITE

4-1. Military incidence/epidemiology

A cold season runs from 1 July of one year to 30 June of the following year. From the 2013-2014 cold season through the 2020-2021 cold season, 1,382 freezing peripheral injuries occurred among U.S. Army Soldiers with an average annual rate of 3.6 freezing peripheral injuries per 10,000 Soldiers (range 2.3-5.2 per 10,000 Soldiers) (see figure 4-1). These injuries account for almost 50% of the total number of cold weather injuries observed over the 8-year surveillance period.

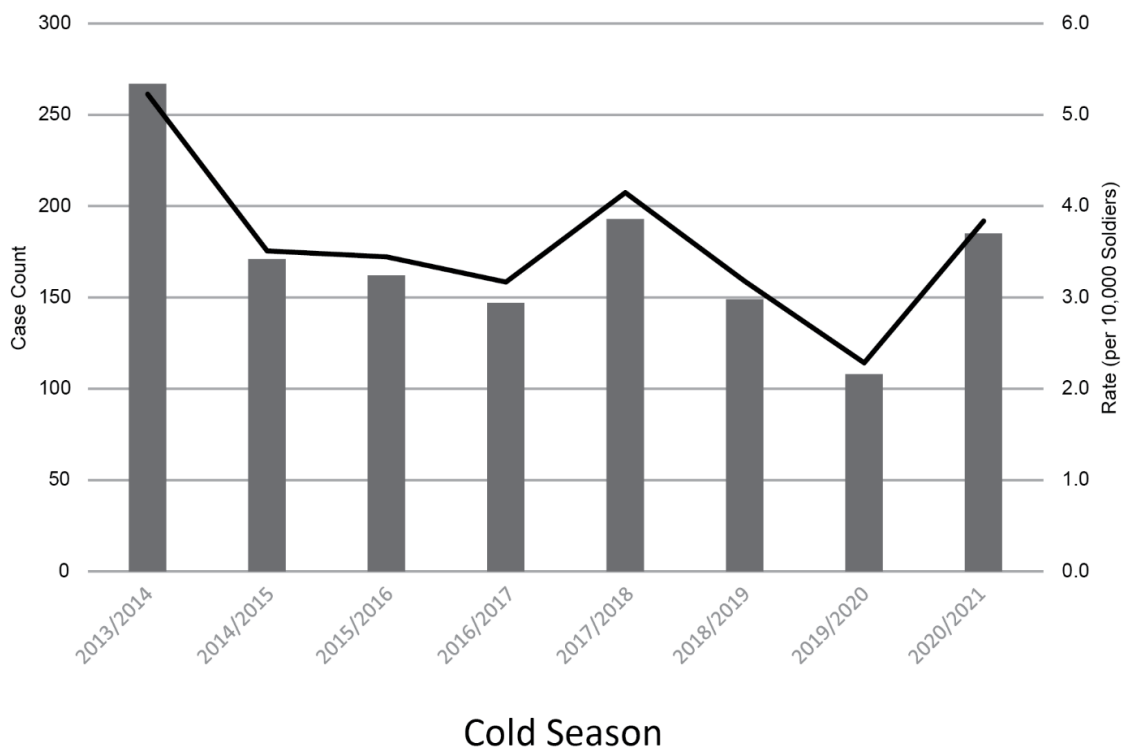


Figure 4-1. Peripheral freezing injuries in U.S. Army Soldiers from 2014-2021

4-2. Definition/signs and symptoms/pathophysiology

a. A freezing peripheral injury (that is, frostbite) is caused by the freezing of tissue fluids in the skin and/or subcutaneous tissues (superficial, deep, and unknown injury classification) and is due to exposure to temperatures below freezing. Frostbite is a direct freezing injury occurring when the skin surface freezes. This occurs at skin temperatures of ~31 °F in saltwater and 26.6 °F in air. Instantaneous frostbite can occur when the skin contacts super-cooled liquids, such as fuel, oils, antifreeze, and alcohol, all of which remain liquid at temperatures as low as -40 °F. Exposure times for injury vary from seconds to hours depending on the type and intensity of

cold exposure, degree of physical activity, protective clothing worn, and various individual factors.

b. The first symptom of frostbite is numbness. In the periphery, the initial sense of cooling begins at skin temperatures of ~82 °F and pain appears at ~68 °F, but, as skin temperature falls below 50 °F, these sensations are replaced by numbness. A pale spot on the skin indicates superficial cold injury, which is characterized by partial skin freezing, discomfort, and mild edema. Soldiers also often feel a “wooden” sensation in the injured area. After rewarming, pain is significant. The initial sensations are an uncomfortable sense of cold, which may include tingling, burning, aching, sharp pain, and decreased sensation. The skin color may initially appear red; it then becomes waxy white.

c. Frostbite pathology can be placed into two categories, direct cell injury and indirect injury/progressive dermal ischemia. Direct cell injury includes extracellular ice formation, which occurs during slow tissue cooling rates and leads to cell dehydration, cell shrinkage, abnormal electrolyte concentrations, changes in protein structures, and cellular pH changes. Intracellular ice formation occurs during rapid cooling rates and is lethal to the cell. There is no correlation between the length of time tissue is frozen and tissue damage.

d. Indirect injuries are caused by freeze-thaw insults. After tissue is thawed, blood clots form leading to microvascular thrombosis and hypoxia. Thawing also increases tissue edema and provokes an inflammatory response and reperfusion injury (from return of blood supply to tissue that has been deprived of oxygen). The primary tissue impacted by frostbite is the vascular endothelium and leads to vascular insufficiency. Thawing and reperfusion lead to formation of free radicals, neutrophil activation, and inflammation. Ischemia following frostbite may be due to the inflammatory mediators PGE₂, TXA₂, and TXB₂, leading to edema and vascular clotting. If freezing occurs again after thawing, intracellular ice formation is likely, resulting in destruction of cells, which is why it is critically important to delay rewarming if there is a strong possibility of refreezing.

4–3. Classification

a. Frostbite has traditionally been classified into four degrees or grades. These are listed below (see table 4–1) along with the physical findings associated with each degree. Before frostbite occurs, frostnip is frequently observed. Frostnip is a superficial nonfreezing cold injury associated with intense vasoconstriction on exposed skin, primarily the fingers, cheeks, ears, or nose. Ice crystals, appearing as frost, form on the skin surface. Frostnip is distinct from and may precede frostbite. With frostnip, ice crystals do not form within the tissue and tissue loss does not occur. Numbness and pallor resolve quickly after warming the skin with appropriate clothing, direct contact, or finding shelter. No long-term damage occurs. Frostnip occurrence signals that conditions are present for frostbite and appropriate action should be undertaken immediately to prevent injury.

Table 4–1
Degrees of frostbite and associated signs and symptoms

Modern Classification	Traditional Classification	Signs and Symptoms	Picture
Superficial (Freezing limited to skin)	1 st degree (Superficial skin freezing)	Absence of initial lesion Erythema Edema (2-3 hours; may continue for 1 month) Minimal or absent initial lesions Blisters occasionally seen, but not often Occasional desquamation of skin (5-10 days later), but no deep tissue loss Patient notes early transient tingling or burning, but generally intact sensation	
	2 nd degree (Full thickness skin freezing [epidermis and dermis])	Erythema Edema is likely, but disappears within a few days Initial lesion on distal phalanges Blisters with clear fluid (favorable prognosis) or hemorrhagic (unfavorable) Hyperhidrosis (second or third week) Desquamation of skin Patient notes throbbing and aching pain lasting 3-10 days after injury	

Table 4–1
Degrees of frostbite and associated signs and symptoms—Continued

Modern Classification	Traditional Classification	Signs and Symptoms	Picture
Deep (Freezing involving skin and tissues below the skin)	3 rd degree (Full thickness skin and subcutaneous tissue freezing)	Generalized edema Initial lesion on intermediary and proximal phalanges Purple or hemorrhagic blisters Some skin necrosis with hard, dry tissue (eschar) Sloughing of skin with ulcerations Patient notes no initial sensations, but later burning, aching, throbbing, or shooting pains	
	4 th degree (Full tissue freezing including muscle, tendon, and bone)	Little edema Initial lesion on carpal or tarsal Hemorrhagic blisters (if blisters present) Initially area is cyanotic, mottled, or deep red; later area is dry and black Extensive tissue necrosis and irreversible tissue damage Patient notes initial insensitivity in area and severe pain on rewarming	

b. For field classification, a simpler two-tier system (superficial or deep) is more appropriate after spontaneous or formal rewarming occurs but before imaging. Superficial frostbite is defined as no or minimal anticipated tissue loss, corresponding to 1st and 2nd degree injury, whereas deep frostbite anticipates tissue loss will occur, corresponding to 3rd and 4th degree injury. It is important to note that different degrees of frostbite may occur within a single extremity. Figures 4–2 and 4–3 show pictures of different frostbite levels.



Figure 4–2. 1st degree frostbite in the fingertips incurred during training in Alaska

c. Panels A-D below present pictures of different frostbite injuries. Panel A shows 2nd degree frostbite in the ear with a characteristic bleb. Rapid rewarming in this person prevented any tissue loss. Panel B shows 3rd or 4th degree frostbite that thawed spontaneously. A metatarsal amputation was performed after this injury. Panel C is a case of freeze-thaw-refreeze injury. The casualty was exposed to < 0 °F for 3 days and suffered a 4th degree frostbite. Panel D shows 4th degree frostbite in the fingers 3 weeks after the injury and spontaneous thawing in a cold cabin. Note the demarcation of tissue.

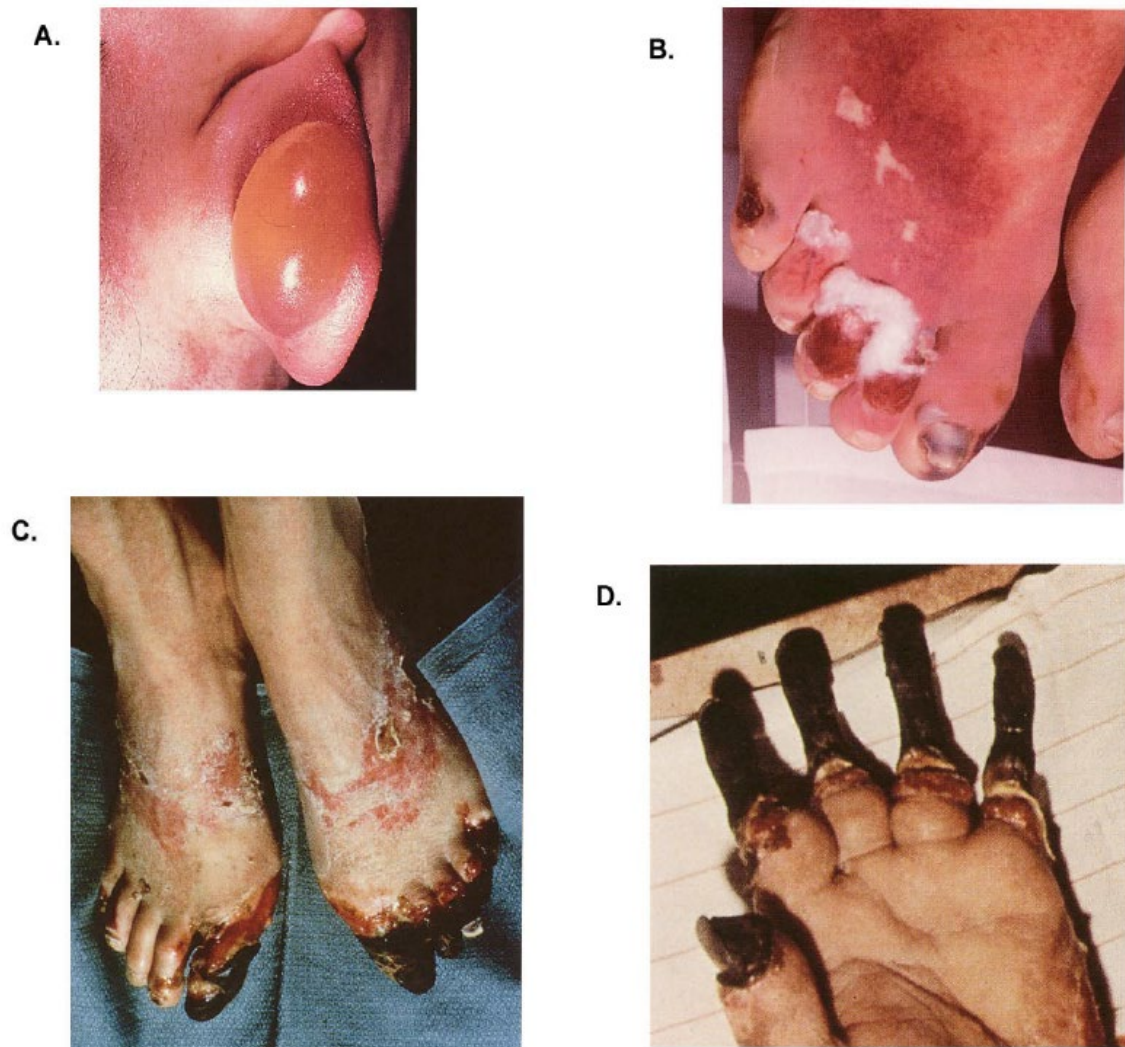


Figure 4–3. Pictures of 2nd through 4th degree frostbite (panels A-D)

d. Another classification system used to describe frostbite injuries is the Cauchy scale. The Cauchy scale uses the probability of amputation in the hands and feet based on the location of the injury (see table 4–2).

Table 4–2
Cauchy system for classifying frostbite amputation risk

Grade	Extent of Involvement	Probability of Amputation (%)
1	Distal Phalanx	0-1
2	Intermediate Phalanx	23-39
3	Proximal Phalanx	60-83
4	Metacarpal or Metatarsal	98-100
5	Carpal or Tarsal	100

4–4. Risk factors

a. Risk factors for frostbite are grouped based on four different causes: environmental, mechanical, physiological, and psychological. Table 4–3 presents these groupings and primary examples of each.

b. Environmental and mechanical causes of frostbite can be prevented by recognizing the potential for these factors to increase susceptibility and by employing appropriate countermeasures. The individual Soldier cannot change most of the physiological and psychological factors, but educating Soldiers about these risk factors will enable them to recognize situations or genetic factors that increase their risk of a cold injury.

Table 4–3
Risk factors for frostbite based on cause

Cause	Risk Factor
Environmental	Temperature Wetness Exposure duration Wind chill Altitude POLs (petroleum, oil, lubricants) Contact with metals
Mechanical	Constrictive clothing Inadequate clothing and shelter Tight boots Cramped positioning

Table 4–3
Risk factors for frostbite based on cause—Continued

Cause	Risk Factor
Physiological	Hypothermia Race Sex Wet skin Prior peripheral cold injury Trauma Erythrodermas Hyperhidrosis Hypoxia Smoking Energy depletion Poor physical conditioning Hypotension Atherosclerosis Raynaud's Syndrome Vasospastic disorders Diabetes Shock Vasoconstrictor drugs
Psychological	Severe mental stress Altered cognitive status

4–5. Prevention strategies

a. Frostbite accounts for the largest number of cold injuries each year. Inadequate planning/training and lack of experience contribute to frostbite injuries. However, frostbite can be avoided by simple, yet effective countermeasures.

b. A systematic risk assessment needs to be completed before conducting cold weather operations to identify potential hazards and frostbite risk. See figure 2–4 for risk management strategies. At high cold-injury risk levels, the benefit of training may be outweighed by the logistical impact of casualty evacuation and ability to complete the mission. If training takes place, more controls may be required to reduce the cold-injury risk.

c. Classroom training on cold injuries and avoidance is not sufficient to prepare troops for operating in cold weather. Therefore, opportunities to learn through experience in a controlled situation are invaluable. Gradually increasing exposure and training time in the cold for Soldiers will give them the confidence and ability to recognize potential areas of risk early enough to

employ countermeasures and will enable them to work successfully in the environmental conditions with little impact on the mission.

d. Frostbite can be prevented by maintaining skin blood flow. This can be achieved by a) increasing core body temperature, b) minimizing blood flow constriction, and c) minimizing effects of medications, supplements, and other substances that decrease blood flow.

e. Exercise can significantly increase core temperature and body heat content, even in extreme cold environments, protecting against frostbite. When Soldiers begin to feel numbness (occurs at a skin temperature around 45 °F), they should increase their physical activity levels to raise their core temperature and increase blood flow to the extremities. As skin temperature falls below 45 °F, further cooling to freezing levels will not be perceived by the Soldier. However, intense exercise can cause fatigue that limits a Soldier's ability to produce enough heat to warm peripheral tissues. Exercise can also induce sweating, causing a degradation in clothing insulation. Wet skin increases the risk of frostbite.

f. Wind also impacts the ability of exercise to raise skin temperatures. Physical activity is an effective countermeasure for increasing skin temperature when wind is not present; however, when exposed to wind, physical activity does not significantly alter the temperature of exposed or covered skin. At 14 °F with no wind, moderate activity can increase finger temperature from 63 °F-80 °F. However, the addition of an 11 mph wind reduces finger temperatures below 59 °F and hinders finger temperatures from rising above 59 °F with moderate physical activity. However, increasing the exercise intensity from light to moderate increases nose temperatures from 40 °F-48 °F, even in an 11 mph wind.

g. Minimizing blood flow constriction aids in frostbite prevention. Straps on gloves and other equipment should not be too tight. Backpack straps may decrease blood flow to the arms and hands, so dropping the load every few hours may be necessary to allow increased circulation.

h. Medications with sedative effects, and/or impair judgment, increase susceptibility to frostbite. These include anxiety-reducing medications, antidepressants, phenylephrine, and antihistamines. Leaders should be aware of individuals who are taking these medications and closely observe them.

i. Minimizing tissue exposure to cold also prevents frostbite. This can be achieved by a) protecting skin against wind and wetness, b) avoiding wet skin and clothing, c) adding clothing insulation, d) not touching cold materials without proper clothing and equipment, and e) reducing duration of cold exposure.

j. Clothing.

(1) The principles of layering clothing and staying dry for core temperature maintenance (see chap 6 on hypothermia) are also used for gloves/mittens, socks, and hats. Gloves and hats can be used to regulate heat loss and local skin temperatures for each individual by adding or removing particular items based on individual subjective thermal sensations. Gloves and mittens should be donned before the hands become cold. Then as the work intensity increases and the hands become warm, gloves can be removed so that sweat does not accumulate in the fabric. Using mittens, compared to gloves, will provide greater protection from cold injuries. However, this protection must be weighed against the significant decline in manual dexterity that occurs with mitten use. Glove liners can be used to keep moisture away from skin, allow for dexterity with protection, and add a layer of insulation. Effective countermeasures for minimizing the impact of wind include adding windproof clothing and seeking shelter (lee side of building, bivouacking in tree line).

(2) Soldiers should not blow warm breath into mittens or gloves because it can cause the hands to become even colder due to the vapor from the breath adding moisture to the glove that may freeze and contribute to further cooling.

k. Face camouflage paint should not be used when the air temperature goes below 32 °F, because the paint conceals any changes in skin color which signal the early development of frostbite. Spreading petroleum jelly or other emollients onto the skin (except the lips) does not lower the frostbite risk and in fact increases risk by giving a false sense of security because the skin is perceived to be warmer than it is. These products should not be used in below freezing weather (< 32 °F).

l. Contact frostbite.

(1) Fingers and other open skin areas can cool rapidly when coming into contact with cold materials, especially metal and liquids. Extreme caution must be taken if it is necessary to touch cold objects with bare hands at temperatures below freezing as contact frostbite can occur. Contact gloves should always be used to create a barrier between the hand and material and can reduce performance decrements associated with hand cooling even at temperatures above freezing. Extra pairs of contact gloves also allow them to be changed if they become wet, such as from handling snow covered ropes or other materials. Metal tools and other frequently touched metal parts can be covered with tape to limit heat loss.

(2) Likewise, fuels have a very low freezing point (-40 °F), and contact with these super-cooled liquids can cause instantaneous frostbite. Protective clothing must be used when handling fuels and POL products to avoid splashing on exposed skin and soaking into clothing. Rifle butts and charging handles also cause contact frostbite to the face and nose when Soldiers are sighting and firing weapons. Table 4–4 shows that touching the trigger area of a rifle (steel) with a bare finger at a weapon temperature of 14 °F will cause the finger skin temperature to reach 32 °F in just 15 seconds.

Table 4–4

Time (seconds) to reach a finger-skin temperature of 32 °F (0 °C) while touching various materials at different temperatures

Material Temperature	Aluminum	Steel	Stone
32 °F (0 °C)	43	> 100	> 100
23 °F (-5 °C)	15	50	> 100
14 °F (-10 °C)	5	15	62
5 °F (-15 °C)	2	5	20
-4 °F (-20 °C)	1	2	7
-13 °F (-25 °C)	<	<	4

m. Frostbite surveillance.

(1) Cold injury surveillance (tracking and observation) of Soldiers is one of the most effective means to prevent frostbite. Troops should be taught to check on their buddies every few hours by looking for blanched skin on the fingers, ears, cheeks, nose, and toes. Leaders must also ensure that Soldiers are comfortable about reporting any potential cold-injury issue and that there will be no negative consequences from reporting. Many cold injuries occur because a Soldier is afraid to appear “weak” by mentioning to the chain of command that something is wrong (for example, “my fingers are numb”). In such instances, appropriate

preventive measures that could resolve the problem are not taken, and then a cold injury develops. If one person has a problem, it is likely that others are also having issues with the cold. Table 4–5 presents a summary list of frostbite prevention strategies.

(2) Appendix C provides more guidance on clothing, equipment, training, food and water, and shelter and heat for five temperature zones, ranging from 55 °F to less than -40 °F.

Table 4–5
List of frostbite prevention strategies

Wear cold weather clothing loose and in layers

Do not wear cold-weather clothing too tight

Stay dry

Use wind protective clothing

Use contact gloves

Wear mittens, if appropriate, instead of gloves. Tie mittens to string and hang around neck, so they cannot be lost. When necessary (for example, snowfalls), tuck mittens inside the outer clothing layer, so they do not fill with snow.

Do not wear tight-fitting boots

Maintain good nutrition

Know the wind chill temperature

Buddy checks

Wear the appropriate personal protective equipment (PPE) when handling POLs

4–6. Wind chill temperature

a. The relative risk of frostbite can be determined by monitoring the air temperature and wind speed. Air temperature is the most important determinant for frostbite risk. As the air temperature falls below 32 °F, the risk of frostbite increases. However, wind speed also has a role. Wind increases convective heat loss by disturbing the boundary layer of air that rests against the skin and causes the skin to cool at a faster rate than if no wind was present. Wind, however, will not cool skin, or any tissue, below the ambient air temperature. Therefore, frostbite cannot occur if the air temperature is above 32 °F.

b. The relative risk of frostbite is evaluated by using the WCT index value. Figure 4–4 shows the WCT index integrates wind speed and air temperature to provide an estimate of the cooling power of the environment. It standardizes the cooling power of the environment to an equivalent air temperature for calm conditions.

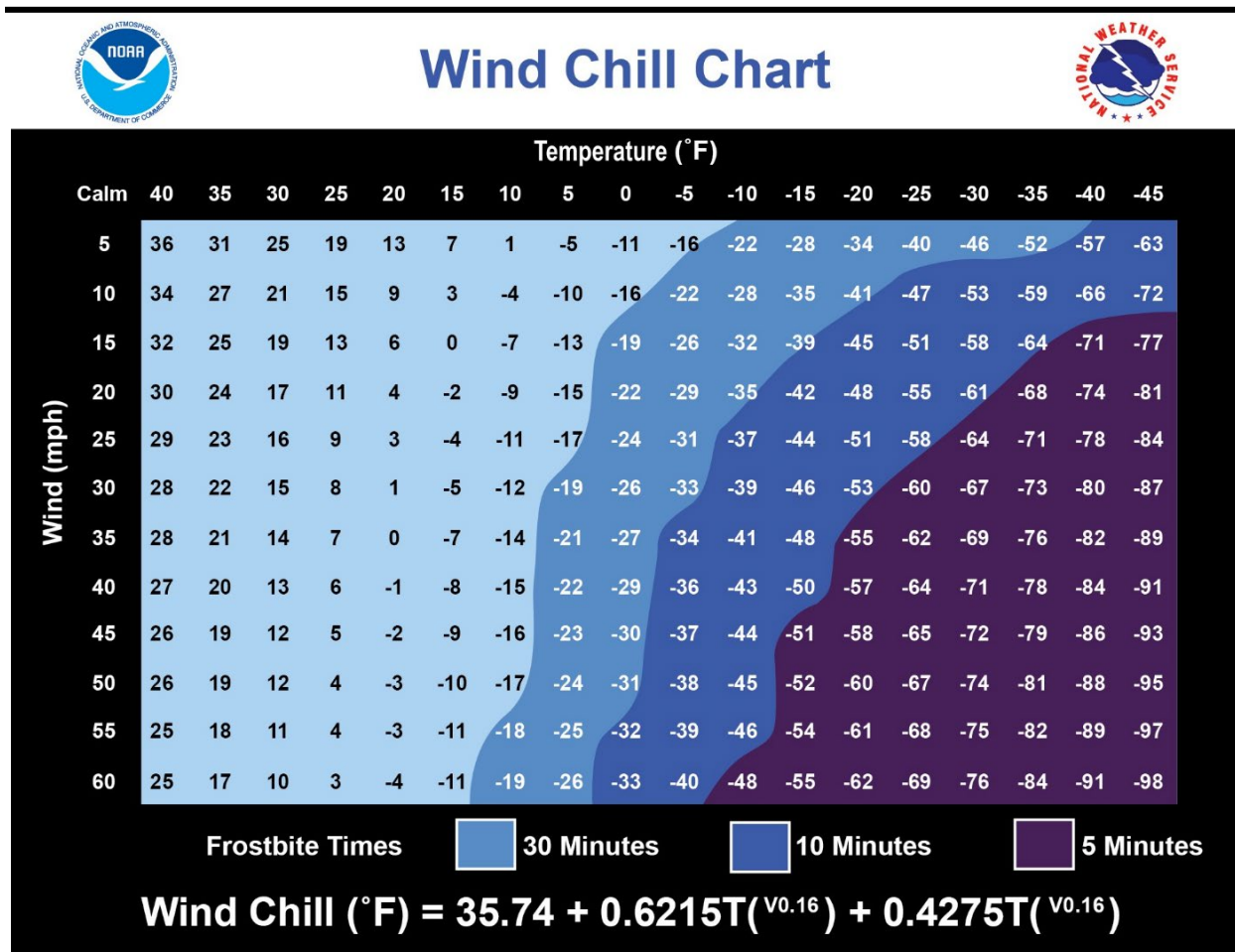


Figure 4–4. Wind chill temperature index

c. WCTs are grouped into frostbite risk zones based upon the period of time in which an individual's exposed cheek skin will freeze in more susceptible persons in the population, assuming they are using precautions (gloves, proper clothing). Table 4–6 shows the approximate times to occurrence of cheek frostbite for a given air temperature and wind speed. Cheek skin was chosen because this area of the body is typically not protected, and studies have observed that this area, along with the nose, is one of the coldest areas of the face. The risk of frostbite on bare skin is less than 5% when the ambient temperature is above 5 °F, but increased safety surveillance is warranted when the WCT index falls below -17 °F, when frostbite can occur in 30 minutes or less. Wet skin exposed to the wind will cool even faster, significantly decreasing the time for frostbite to occur.

Table 4–6

Approximate time to occurrence of cheek frostbite in minutes or hours in the most susceptible 5% of personnel

Wind Speed (mph)	Air Temperature (°F)											
	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	> 2h	> 2h	> 2h	> 2h	31	22	17	14	12	11	9	8
10	> 2h	> 2h	> 2h	28	19	15	12	10	9	7	7	6
15	> 2h	> 2h	33	20	15	12	9	8	7	6	5	4
20	> 2h	> 2h	23	16	12	9	8	8	6	5	4	4
25	> 2h	42	19	13	10	8	7	6	5	4	4	3
30	> 2h	28	16	12	9	7	6	5	4	4	3	3
35	> 2h	23	14	10	8	6	5	4	4	3	3	2
40	> 2h	20	13	9	7	6	5	4	3	3	2	2
45	> 2h	18	12	8	7	5	4	4	3	3	2	2
50	> 2h	16	11	8	6	5	4	3	3	2	2	2

FROSTBITE RISK

	LOW - freezing is possible, but unlikely
	HIGH - freezing could occur in 10-30 minutes
	SEVERE - freezing could occur in 5-10 minutes
	EXTREME - freezing could occur in < 5 minutes

d. Exposed fingers will freeze at a WCT that is ~10 °F warmer than the cheek, because there is less blood flow in the fingers compared to the face during cold exposure. Therefore, when the WCT is below -9 °F, there is an increased risk of finger frostbite and Soldiers should take appropriate precautions (put on gloves/mittens, increase physical activity). The frostbite risk is less at WCTs above -9 °F, but appropriate actions to reduce the risk should still be taken.

e. Leaders must recognize that wind speeds obtained from weather reports do not take into account man-made wind and that the local weather may vary greatly depending on the local topography. Individuals riding in open vehicles or exposed to propeller/rotor-generated wind can be subject to dangerous wind chill temperatures, even when natural winds are low. Running and skiing also produce wind across the body at the same rate the body is moving. Also, wind speeds are generally greater at high altitudes where there is little tree cover. Moving from a sheltered bivouac up to a ridgeline will increase the likelihood of being exposed to a lower WCT. Mountains can create their own weather patterns by altering wind speed and direction and influencing precipitation. All of these factors make pre-planning and route selection for Soldier movement important in order to minimize the effects of temperature, wind, and weather on frostbite susceptibility. Soldiers can monitor cloud formations, air pressure, wind direction and speed, and air temperature and humidity to predict and prepare for impending cold weather.

4–7. Field management of frostbite

a. Managing freezing injuries in the field depends on many conditions, including the treatment of other injuries, the possibility of hypothermia, the possibility of refreezing, and the

ease of evacuation. Treatment for frostbite should follow some basic rules with regard to thaw-refreeze possibilities, rewarming, and other considerations. All Soldiers with frostbite injuries should be suspected of being hypothermic.

b. If care can be reached in 1-2 hours, the risks of improper rewarming or refreezing outweigh the risks of delaying treatment for 3rd or 4th degree frostbite. If care will not be reached for > 2 hours, most frostbite injuries will rewarm spontaneously. Prevent and treat hypothermia above all else. During field management, it is more important to prevent hypothermia than to rewarm frostbite rapidly. Protect rewarmed area from refreezing.

c. Table 4–7 summarizes the treatment of frostbite in field conditions where the time to definitive care is greater than 2 hours.

Table 4–7

Field treatment of frostbite, greater than 2 hours from definitive care

1	Remove jewelry or other extraneous material from the body area
2	Remove wet clothing
3	Protect from wind
4	Rapidly rewarm in water heated and maintained between 98.6-102.2 °F (37-39 °C) until area becomes soft and pliable to the touch (~30 minutes); allow spontaneous or passive thawing if rapid rewarming is not possible. Place in armpit/groin of buddy for 10 minutes.
5	Give Ibuprofen (12 mg/kilogram/day divided twice daily) if available
6	Give pain medication (for example, opiates) as needed
7	Air dry (do not rub at any point)
8	Protect injury from refreezing and direct trauma
9	Apply topical aloe vera cream or gel if available
10	Use dry, bulky dressings
11	Elevate the affected body part, if possible
12	Maintain hydration
13	Avoid ambulation on thawed lower extremity (unless only distal toes are affected)
14	If at altitude, give oxygen if available

d. Once a tissue is thawed, it must not freeze again. If there is the possibility that tissue could be thawed and then refreeze (for example, during evacuation), do not allow the tissue to be thawed, since re-formation of ice crystals will cause increased tissue damage. In addition, further trauma to frozen or injured parts should be avoided, and this includes walking on injured feet and rubbing the affected tissue. If Soldiers must walk on a frozen extremity, they should try to do so without thawing the injury. This is a difficult decision, but it will decrease the chance of a freeze-thaw-refreeze injury due to mechanical trauma.

e. For rewarming, avoid exposure to excessive heat, mechanical trauma (for example, rubbing affected tissue), or any factor causing a circulation loss. External heat using open flames, stovetops, hot air from vehicle exhaust, steam, or directly applied heat packs should never be used. Thawed injuries should be insulated against dangerous wind chill from moving vehicles or helicopter wash so that they do not refreeze.

f. Rewarming could also expose other life-threatening factors such as blood loss, which initially stopped when the tissue became frozen. Other considerations include treating open blisters, which are susceptible to infection and should be covered by sterile bandages and treated with a topical antibiotic. Soldiers should not use tobacco products, which can cause vasoconstriction and decrease blood flow to the injured area.

g. If the decision is made to rewarm the frostbite injury, a warm water bath with temperature of 98-104 °F (37-40 °C) should be prepared. A container must be available that is large enough to accommodate the frostbitten tissue without the tissue touching the sides or bottom of the container. (It is important that hot water not be used because the local heat dissipation procedures are impaired, and tissue injury could result.) A bath thermometer that reads in the range of 98-104 °F (37-40 °C) must be used. The water needs to be gently circulated around the affected tissue between these temperature ranges. Other logistical concerns that affect the decision to use a warm water bath include risk to the unit (for example, does the Soldier need to remain on the line), availability of shelter and equipment, and the timeframe of casualty evacuation.

h. Frostbite can be thawed at room temperature or against a buddy's skin. Note that insulative clothing that was donned prior to cold exposure will now prevent rewarming, so once the victim is in a warm environment, this clothing should be removed from the area of frostbite. Obviously, first-degree frostbite is easier to treat and results in less damage than more severe frostbite, which highlights the importance of early recognition of cold injuries.

4–8. Hospital management of frostbite

a. Early care in the hospital includes correction of hypothermia if present, rapid rewarming of affected parts, and identification of other injuries.

b. Definitive care must be started as soon as possible. Many frostbite victims are hypothermic. As extremities are rewarmed, blood returning to the core causes an afterdrop (see chaps 3 and 6), so core temperature must be monitored closely.

c. Tissue rewarming must begin as soon as possible in a warm water bath (98-104 °F). However, tissue reperfusion can be very painful. This sometimes causes rewarming to be stopped before the tissue is completely thawed. Medical personnel need to ensure that proper thawing techniques are followed and that complete thawing occurs. The use of an antibacterial solution such as hexachlorophene in the warm water bath solution can be used to decrease the risk of infection. A tetanus booster is recommended.

d. Clear/cloudy blisters should be aspirated and debrided. Aspiration and debridement of hemorrhagic blisters is less clear, although it is becoming more common. Hemorrhagic blisters are indicative of damage to the subdermal plexus and drainage may promote deep dermis desiccation. After aspiration and/or debridement, aloe vera, a thromboxane inhibitor, is placed on the wounds and dressed. Ibuprofen, an arachidonic acid cascade inhibitor, should be given orally. This also aids in reducing fibrin production.

e. Post-thaw treatment includes placing cotton between digits to avoid friction. A foam or fluffy bed pad should be used under injured feet along with a sheet cradle to keep the bed cover from contacting the feet. Any surgical intervention should be delayed as long as possible until a clear demarcation line and tissue death have been established and there is no danger of further retraction of tissues. This may take 15-45 days or longer. Premature amputation may result in further retraction of tissues. Escharotomy of dorsal or lateral aspect of the digits may be necessary when the eschar is dry and limits joint movement of the digits. Fasciotomy may be helpful to relieve compartment pressure and restore circulation.

f. Imaging can be used at early stages to predict tissue viability and likelihood of amputation. Methods include duplex ultrasonography, magnetic resonance angiography, and Technetium-99m scanning to include triple-phase bone scanning.

g. Thrombolytic therapy should be used with deep 3rd or 4th degree frostbite injuries that have the potential for significant morbidity. Thrombolytic treatment should be used in facilities that are familiar with the technique and have intensive care monitoring. Best outcomes are observed if treatment begins within 12 hours of injury. Two thrombolytic therapies that have shown success are tissue plasminogen activator (tPA) and the prostacyclin analogue iloprost.

h. tPA is classified as an enzyme that breaks peptide bonds in proteins. Its main mechanism of action is to convert plasminogen to plasmin, the primary enzyme involved in dissolving blood clots. tPA is used to treat grade 4 frostbite.

i. For a comprehensive screening and treatment tool (algorithm) for using thrombolytic therapy in patients with frostbite, please refer to Freer et al. in the Textbook of Wilderness Medicine.

j. Intravenous iloprost was approved by the U.S. Food and Drug Administration in 2024 to treat severe frostbite. It has been shown to significantly reduce amputations following frostbite and is used throughout the world. It is a synthetic prostacyclin and causes vasodilation, inhibits platelet aggregation, and may reduce inflammation and ischemia. Iloprost is most effective when given in the first 12 hours but may be effective up to 72 hours after injury. Iloprost can possibly be used in a field environment at Role 1 and may continue during medical evacuation. Treatment should start after rewarming and in a location that will not predispose patients to refreezing and that can support intravenous infusion and vital signs monitoring. The treatment algorithms for iloprost use the Whitehorse Protocol. In the U.S., iloprost is available in a different formulation (Aurlumyn™) than formulations used in other countries (for example, Ilomedin™). The most updated label is available by searching the Drugs@FDA website (<https://www.accessdata.fda.gov/scripts/cder/daf/index.cfm>) for terms “Aurlumyn”, “iloprost”, or the New Drug Application number “217933”.

k. Appendix D provides more information on iloprost, calculation of infusion rates, and iloprost administration for treatment.

4–9. Return to duty, profiles, and medical board

a. Common sequelae from frostbite injury include hyperhidrosis, paresthesia, pain, hypersensitivity to heat or cold, reduced joint mobility, joint swelling, edema, nail loss or deformity, fat pad loss from digits, decreased proprioceptive sense of digit tips, and muscle atrophy. The extent of the original injury impacts which tissues have ongoing symptoms. Neurologic injury may be manifested by numbness, aching, burning or dull pain, hot or cold paresthesia, and delayed conduction velocity. Vascular injury is manifested by strong vasoconstrictor responses to even mild cooling, and extended rates of rewarming. Muscle weakness, limited range of motion, and arthritis also may be associated with severe cold injury. It should be noted that hyperhidrosis may predispose the individual to skin maceration.

b. The following is a discussion of profiles and referrals to the Disability Evaluation System (DES) according to AR 40–501:

(1) Soldiers with first-degree frostbite may require a profile. Refer to the most recent edition of AR 40–501 for specific profile guidance.

(2) Soldiers are referred to the DES for persistent symptoms. Refer to the most recent edition of AR 40–501 for specific DES guidance.

CHAPTER 5

NON-FREEZING COLD INJURY

5–1. Military incidence/epidemiology

From the 2013-2014 cold season through the 2020-2021 cold season, 1,059 non-freezing peripheral injuries occurred among U.S. Army Soldiers with an average annual rate of 2.8 non-freezing peripheral injuries per 10,000 Soldiers (range 1.7-3.4 per 10,000 Soldiers) (see figure 5–1). These injuries account for almost 40% of the total number of cold weather injuries observed over the 8-year surveillance period.

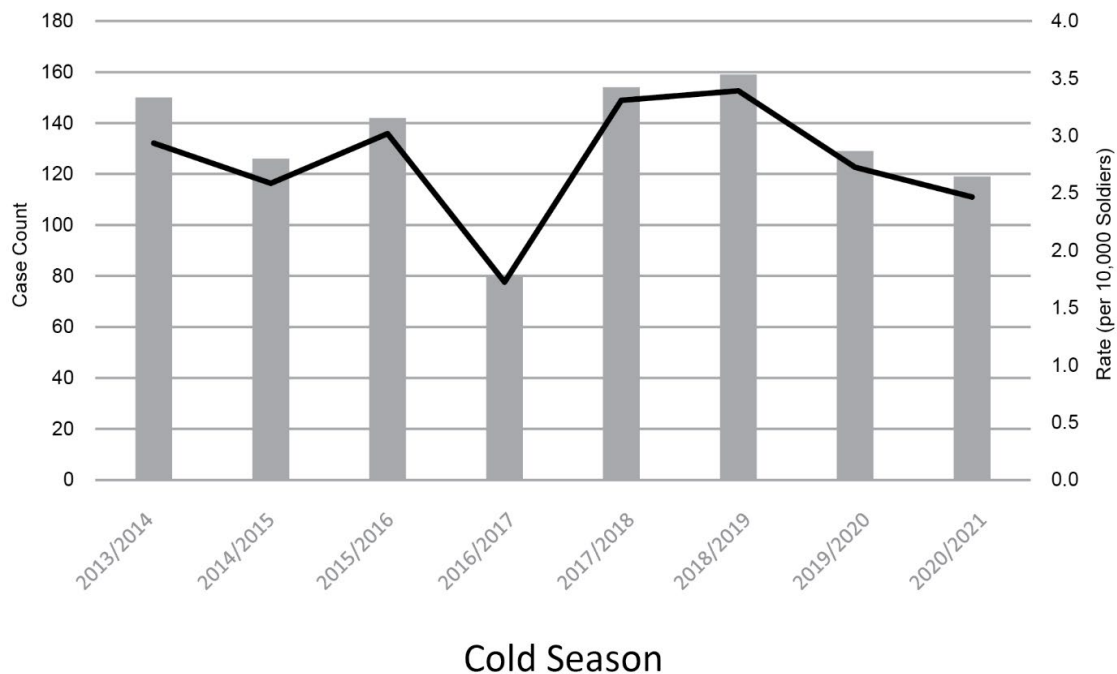


Figure 5–1. Peripheral non-freezing cold injuries in U.S. Army Soldiers from 2013-2021

5–2. Definition/pathophysiology

a. Non-freezing cold injury (NFCI) is a clinical syndrome that results from the damage caused to tissues exposed to cold temperatures from 32-59 °F (0-15 °C). NFCI does not involve tissue freezing, which distinguishes it both clinically and pathologically from frostbite. Although most commonly associated with the feet (“trench foot”, “immersion foot”), NFCIs can occur anywhere. They are also commonly observed on the hands, nose, and ears.

b. The “dose” of cold (temperature and duration) required to cause NFCI is not known, and varies between and, possibly, within individuals. Most NFCIs are reported to have occurred during exposure of days to weeks, but NFCI has been diagnosed during cold-water exposure of ~6 hours. Short cold exposures may result in NFCI if there is inadequate rewarming, long

periods of vasoconstriction and prolonged low tissue temperatures, leading to neurovascular damage.

c. Chilblain (also known as “pernio” or “kibe”) is a superficial non-freezing cold injury typically occurring after 1-5 hours in cold-wet conditions, at temperatures below 50 °F (16 °C). Small erythematous papules appear on the skin, most often on the dorsal surface of the fingers, but the ears, face, and exposed shins are also common areas for occurrence. The lesions are swollen, tender, itchy, and painful. Upon rewarming, the skin becomes inflamed, red, hot to the touch, and swollen, with an itching or burning sensation that may continue for several hours after exposure. There are no lasting effects from chilblain.

d. Figure 5–2 presents a simplified schematic of the factors and mechanisms contributing to NFCIs. Cold-wet exposure has three effects: it causes breakdown of the skin, directly cools nerves in the area of exposure, and causes prolonged vasoconstriction. NFCIs are primarily caused by prolonged vasoconstriction, and this causes direct injury to vessels (specifically, the endothelium) that supply blood to nerve, fat, and muscle cells. Pain, fear, constrictive footwear, and immobility affect vasoconstriction either through a heightened sympathetic nervous system response or mechanically limiting blood flow. Nerve cooling has also been suggested to contribute to the etiology of NFCI by causing direct nerve damage and sensory impairment with large, myelinated fibers (C fibers) being most susceptible to prolonged cold exposure. The current hypothesis is that prolonged cold affects blood vessels serving these large, myelinated fibers with subsequent ischemia causing a decrease of oxygen to the nerve and the appearance of a primary nervous system injury. NFCIs affect many different types of tissue. Pathologic examination of specimens that sustained NFCI during World War II displayed a variety of lesions to the skin, muscle, nerve, and bone. Muscle specimens displayed separation of the cells and damage of the muscle fibers. The healing muscle then appears to undergo replacement with fibrous tissue.

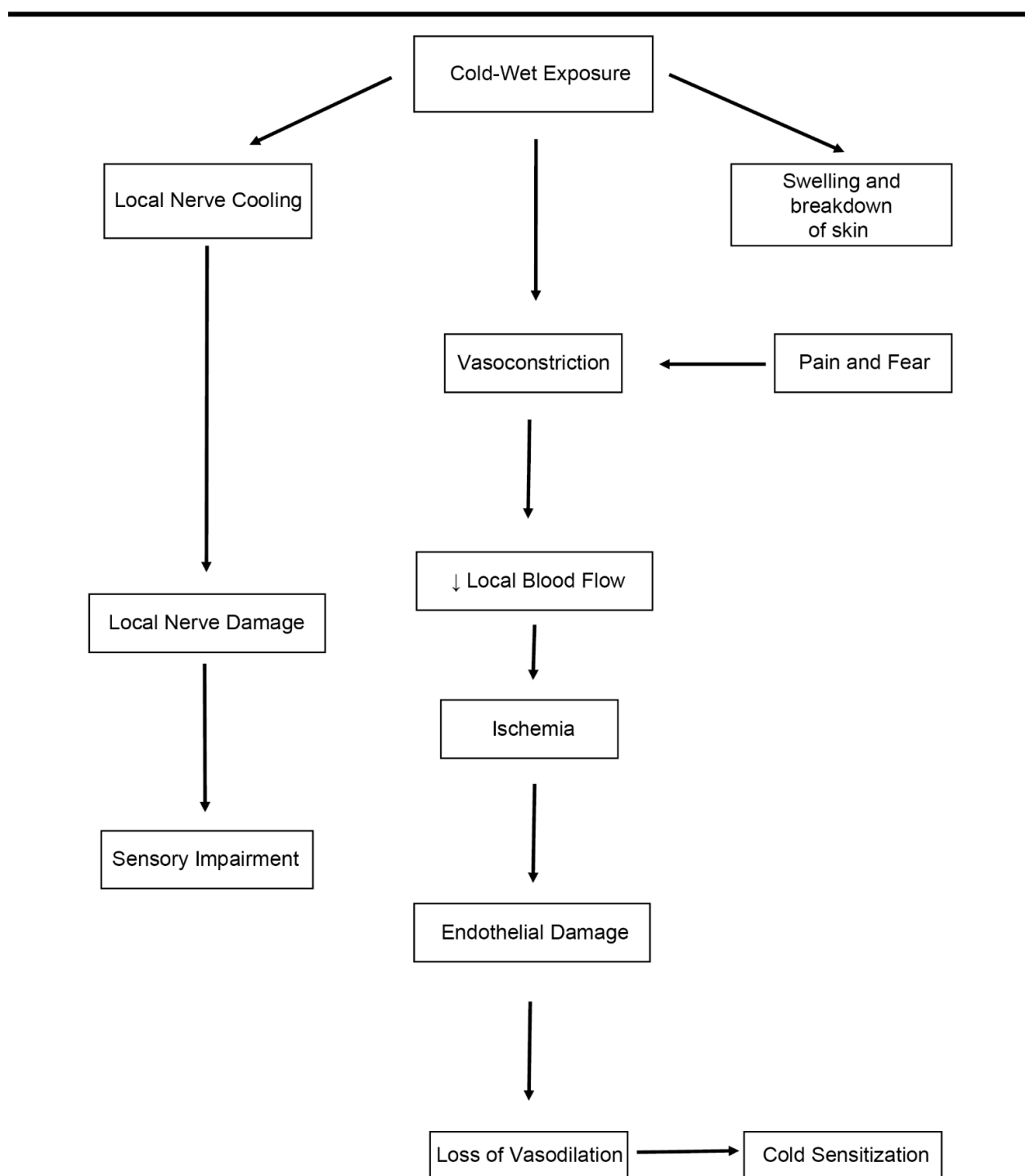


Figure 5–2. Factors and mechanisms that contribute to non-freezing cold injuries

e. The etiology of NFCIs is multi-factorial. Vasoconstriction is mediated by pre-synaptic vesicle release of norepinephrine and neuropeptide Y from sympathetic nerve fibers that interact post-synaptically on smooth muscle with α_2 -adrenergic and Y1 receptors, respectively.

The prolonged decrease in blood flow caused by vasoconstriction leads to a direct injury to the epithelial cells that form the endothelial lining of capillaries. Studies indicate that the endothelial lining pulls away from the underlying cells leaving “gaps”. Leukocytes and platelets have been found to fill in these “gaps” and accumulate to such a degree to further decrease capillary blood flow, leading to ischemia and eventually tissue hypoxia.

f. There is also some evidence that NFCIs are due to the cascade of events following ischemia-reperfusion. Reperfusion of previously ischemic tissues causes free radical formation, leading to further endothelial damage, along with subsequent edema formation.

g. One of the most prominent and consistent findings with the etiology of NFCI is the absence of CIVD with prolonged cold exposure. CIVD is initiated by direct cooling of peripheral tissues and is characterized by periodic oscillations of skin temperature following the initial decline during cold exposure.

5-3. Classification

a. The injury classification of NFCI is determined by the symptoms and stages of recovery that occur days and weeks after the exposure (see table 5-1). Stage 2 occurs ~1-7 days after rewarming; stage 3 occurs ~2-10 weeks after rewarming; and stage 4 occurs weeks/months/years after rewarming (classifications are based on criteria established by Ungley).

Table 5-1
Classification of non-freezing cold injury

Grade A	Grade B	Grade C	Grade D
<u>Stage 2 Recovery</u> Hyperemia and slight sensory change may last 2-3 days. Rapid re-ambulation is the rule with only occasional residual cold sensitivity.	<u>Stage 2 Recovery</u> Edema, hyperemia, and definite sensory change are still present 2-3 days after injury.	<u>Stage 2 Recovery</u> Edema, hyperemia, blisters, and mottling are present 2-3 days after injury. At 7 days: Anesthesia is present on the plantar and dorsal surfaces of the foot and toes. Vibration and proprioception are diminished. Intrinsic muscles of the foot become paretic and atrophic.	<u>Stage 2 Recovery</u> Severe edema, extravasation of blood, and incipient gangrene are present after 2-3 days. At 7 days: Complete anesthesia in the entire foot is present, with paralysis and wasting of the intrinsic muscles.

Table 5–1
Classification of non-freezing cold injury—Continued

Grade A	Grade B	Grade C	Grade D
<u>Stage 3 Recovery</u> Return to duty is possible within 1-2 weeks.	<u>Stage 3 Recovery</u> At 7 days, anesthesia is found only on the plantar surface of the foot and tips of the toes, lasting 4-9 weeks. This degree of injury is associated with— 1-3 weeks of edema. 2-4 weeks of neuropathic pain. 3-7 weeks of hyperemia.	<u>Stage 3 Recovery</u> Edema persists for 2-3 weeks.	<u>Stage 3 Recovery</u> Injury often extends proximally. Deep tissue, as well as superficial tissue, is lost. Gangrene is a constant risk until tissue loss is complete. Edema in tissue that is not lost lasts 3-7 weeks.
	<u>Stage 4 Recovery</u> Hyperhidrosis and residual cold sensitivity may occur. Re-ambulation is possible when walking does not increase pain. Return to duty usually requires 3-4 months.	<u>Stage 4 Recovery</u> Pain and hyperemia persist for up to 14 weeks. Some skin sloughs, but loss of deep tissue does not occur. Hyperhidrosis and cold sensitivity are typical. Some cases will be permanently disabling.	<u>Stage 4 Recovery</u> Hyperemia and pain last up to 4 months. Prolonged convalescence and permanent disability are the rule.

b. Early diagnosis of NFCI becomes evident when these symptoms do not resolve with rewarming. With chilblain, these symptoms will resolve with rewarming on the first day of exposure and not progress further. Symptomatology after rewarming in the first few days includes hyperemia, edema, and sensory changes.

c. After about a week (stage 2), numbness persists if the injury is severe (greater than Grade A and not chilblain). The greater the area of numbness, the more likely the injury will be classified as more severe (for example, Grade D NFCI has numbness in the entire foot, whereas in Grade B, the numbness may be observed only in the toes).

d. In stage 3, hyperemia persists and may last for a few days to many months, but typically averages 6-10 weeks. The extremity is red and hot. Previously weak distal pulses become full

and bounding, but the microcirculation is still diminished (delayed capillary refill). If there is an improved sensitivity to light touch and pin pricks within 4-5 weeks, then there is a lesser chance of persistent symptoms, suggesting a Grade B injury. However, continued lack of feeling beyond 6 weeks suggests neuronal degeneration which may take longer to resolve, with the injury classified as Grade C or D. In Grade D injuries, deep tissue loss will occur in the third stage of recovery.

e. Stage 4 recovery takes months to years and is characterized by hyperhidrosis and cold sensitivity. Depending on the amount of tissue loss, Soldiers could return to duty (Grade B injury) or may become disabled or require amputation (Grades C and D).

f. The images in figure 5–3 show NFCI cases from the Falklands War. The case in the left photo occurred in a Soldier 3 days after suffering a gunshot wound. Note the demarcation line on the right leg. This casualty was also hypothermic. The photo on the right shows a case of NFCI after many weeks of wearing the same boots in cold-wet conditions. Note the injuries on the fleshy parts of the sole and toes.



Figure 5–3. Non-freezing cold injuries from the Falklands War

g. Figure 5–4 demonstrates other examples of NFCI on feet and hands. It is important to remember that NFCI, as mentioned earlier, can occur on any body part. Note the cracked skin on the feet and the inflammation/bloating on the hands.



Figure 5–4. Non-freezing cold injury of the hands and feet

5-4. Risk factors

- a. The primary risk factors for NFCIs are listed in table 5-2.

Table 5-2
Risk factors for non-freezing cold injuries

Cold-wet environments
Static/immobile
Hypothermia
Previous cold injury
African-American
Smoking

5-5. Prevention strategies

Prevention of NFCIs can be achieved by troops remaining active and increasing blood flow to the feet and hands, rotating personnel out of cold-wet environments, and keeping feet dry by continually changing socks. Changing wet socks and wet glove liners two to three times throughout the day is critical in cold-wet environments. Vapor barrier boots do not allow sweat from the foot to evaporate. These boots should be taken off each day, wiped out, and allowed to dry. Clothing that is waterproof, windproof, and breathable is critical. Even in cold-dry environments, high activity levels can cause sweat to accumulate in clothing and on skin. Moisture management in these conditions is critical to reduce the risk of NFCIs.

5-6. Clinical presentation

a. NFCIs should be considered a syndrome, with variable presentations. Clinically, NFCI is insidious in onset, with a progression from initial exposure through three distinctive phases: pre-hyperemic, hyperemic, and post-hyperemic. These phases have variable time courses and may overlap.

(1) *Pre-hyperemic phase*. During the pre-hyperemic phase, the affected limb appears blanched, yellowish white, or mottled but seldom blistered. This occurs both during and immediately after cold exposure. The degree of edema during this pre-hyperemic stage is less severe if the affected area is intermittently rewarmed during the course of exposure. Muscle cramps are common; pain is rare. The single most important diagnostic criterion is the loss of a sensory modality. With further exposure, the cold sensation leads to complete anesthesia with loss of proprioception, resulting in numbness and gait disturbances. This sensation has been described as “walking on air” or “walking on cotton wool”. Capillary refill is sluggish and pedal arterial pulses are usually absent, except through Doppler examination. Intense vasoconstriction is the predominant feature of this stage.

(2) *Hyperemic phase*. Within several hours after rewarming, the extremities become hot, erythematous, painful, and swollen, with full bounding pulses. Impairment of the microcirculation is evident through delayed capillary refill and petechial hemorrhages. Sensation returns first to proximal regions and then extends distally, rapidly progressing to a severe, burning, or throbbing pain, and reaching a maximal intensity in 24-36 hours. Affected areas have marked hyperalgesia to light touch. This pain is aggravated by heat and dependent positioning, and often worsens at night when even the pressure of sheets may become unbearable. After 7-10 days, the nature of the pain changes to “shooting or stabbing”. The

sensory deficits usually diminish, but paresthesias continue and anesthesia may be extensive on the toes and plantar foot surfaces. Vibratory sensation is reduced or lost, whereas proprioception is usually retained. Anhidrosis coincides with the extent of sensory loss.

(a) Vascular injury is evident in vessel reactivity. Skin temperature gradients are absent, with digits often as warm or warmer than the groin or axillae. When the affected limbs are lowered, blood pools, turning the extremity a deep purple-red color, whereas blanching occurs when the limb is raised. Tense edema becomes marked during this stage. Blisters containing serous or hemorrhagic fluid may form, indicating more severe injury. The superficial epidermis becomes thick, indurated, and desquamated. Eschars form and eventually slough, leaving a pink dermis. In more severe cases, the skin may become gangrenous. This is rare, and with appropriate care, gangrene is usually minimal.

(b) Muscles may show weakness with impaired electrical responses, slowing of plantar deep tendon reflexes, and intrinsic muscle atrophy. In milder cases, this stage peaks at 24 hours; in more severe cases, the hyperemic phase may take 6-10 weeks to resolve.

(3) *Post-hyperemic phase.* The post-hyperemic phase lacks obvious physical signs. In mild cases, this phase may be absent; in other cases, it may last weeks, months, or years after the hyperemic phase has subsided. The extremities transition from a consistent warmth to noted coolness, with affected areas becoming cold sensitive, remaining so for hours after exposure despite normal warming processes.

(a) After 6-10 weeks, patients often complain of spontaneous hyperhidrosis, and sweat rashes are common in areas with heavy perspiration. On a warm day, socks are quickly soaked; extremities may sweat excessively, even when cold. Hyperhidrosis predisposes to chronic paronychia infections. Sweating may be more pronounced at the margins of anhidrotic and analgesic areas.

(b) During the post-hyperemic phase, the paresthesias and extreme pains typical of the hyperemic phase have usually resolved, replaced by dull aches and anesthesia that may persist for months to years. Recurrent edema of the feet, return of paresthesia, and further blistering are common, especially after long walks. Intrinsic muscle and ligament atrophy tend to resolve, but in severe cases, fibrous scarring may lead to rigidity and permanent contracture of the toes. Decalcification of bones similar to that seen with osteoporosis is frequently observed. Immobility and pain in severe cases may lead to prolonged convalescence of six or more months.

(c) In the most severe cases, gangrene can develop and ablative surgery in the form of amputations of digits or even major lower limb amputation becomes necessary. Neuropathic tissue is susceptible to local trauma, ulceration and eventually local osteomyelitis and sinus development. Partial foot amputations will result in significant alterations in functional biomechanics of the foot. Since this is often associated with alterations in the sensory nerve supply to the feet, ongoing disabling problems can persist.

b. Diagnosing NFCIs is done primarily through history and examination findings. There are also tests (for example, cold provocation test with rewarming) that have been used to aid in diagnosis but have not been validated.

c. It is important to obtain a detailed history including environmental conditions (ambient temperature, precipitation, relative wind speed, activity, body insulation, and available shelter, food, and fluid availability), and the number of others also injured during the same exposure.

d. For examination, clinical features to look for include skin and neurological features. For the skin, look for pale/white/blotchy skin without swelling, increased nailbed capillary refilling time, mottled blue skin, with rising temperature in the hours and days after rewarming, hot and flushed skin, with possible edema and blistering in the hyperemic phase (days to months), and

hyperhidrosis after the first few weeks. For neurological evaluation, look for impaired sensory and motor function hours to days after exposure. The neurological examination should include an assessment of gait, large fiber sensory modalities (light touch, two-point discrimination, vibration sense, and joint position sense) and small fiber modalities (pin prick, heat and cold), noting the presence or absence of cold allodynia.

e. A condition that is commonly confused with NFCI is Raynaud's Phenomenon (RP). It usually presents for the first time in the late teens and twenties, typically occurring in cold conditions. The International Consensus Criteria for the Diagnosis of Raynaud's Phenomenon (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4018202>) are useful to assist the diagnosis. Advice can be sought from a rheumatologist if there are diagnostic or management requirements beyond the capability of a primary health care provider. RP should be considered as a differential diagnosis in all cases of NFCI. Differential diagnoses should also include examination for neuropraxia (from compression), hand-arm vibration syndrome (HAVS), carpal tunnel syndrome, and other alternative causes of peripheral neuropathy, such as vitamin B₁₂ deficiency, diabetes mellitus, human T-cell leukemia virus type 1, autoimmune disease, or infectious disease.

5–7. Field management

Suspect NFCI if an individual presents with numbness, tingling, pain, or swelling in his or her hands or feet associated with prolonged cold-wet exposure. First aid in the field for NFCI includes preventing further exposure; removing wet or constrictive clothing; washing and drying extremities gently; elevating limbs and covering them with layers of loose, warm, dry clothing; and evacuating to a higher-echelon medical facility. Do not pop blisters, apply lotions or creams, massage, expose to extreme heat, or allow Soldiers to bear weight on their feet, if possible. Walking will cause maceration of the tissue and worsen the injury and prognosis for recovery. Infection can be prevented by not popping blisters, keeping the affected area clean and dry, and covering the injured tissue with sterile bandages. Although not very effective, ibuprofen can be given for mild pain relief. Look for other possible casualties. If one person has suffered a cold injury, there is a high likelihood that others have suffered injuries also. If multiple cold injuries are discovered, training activities should be, if possible, suspended, and a full risk assessment undertaken, with proper control measures implemented.

5–8. Hospital management

a. Further treatment of NFCI in the hospital is not well-defined due to a limited knowledge base. Also, NFCI symptomatology can progress, and last for years. A thorough exposure history is required because diagnosis of NFCI is primarily made based on a history of environmental exposure. Hospital evaluation of NFCI may include thermography, laser Doppler flowmetry (which indicates blood flow in the skin but does not reflect blood flow in deeper vessels), and neuromuscular evaluation, including nerve conduction velocity. None of these tests, however, will change acute care.

b. Cold sensitivity should also be evaluated. Please note this can occur at any time up to 6 weeks post-injury, even in the mildest cases where there has been full resolution of neuropathic type symptoms within the first week.

c. Analgesics may be given for pain but tend not to be very effective. Sympathectomy may alleviate extreme pain in the short term but has not been effective long-term and is not recommended. Other drugs have been used (for example nifedipine, amitriptyline hydrochloride, and gabapentin) to treat patients with NFCI, but they are not routinely prescribed and their evidence-base is lacking.

d. If all symptoms have resolved and examination is normal within an hour of re-warming, this represents a normal response to cold, and the individual can be returned to full unrestricted duties. The factors supporting this decision should be clearly recorded in the clinical record.

5–9. Return to duty, profiles, and medical board

The following is a discussion of profiles and referrals to the DES according to AR 40–501:

a Soldiers with non-freezing cold injury may require a profile. Refer to the most recent edition of AR 40–501 for specific profile guidance.

b Soldiers are referred to the DES for residual symptoms or significant tissue loss. Refer to the most recent edition of AR 40–501 for specific profile guidance.

CHAPTER 6

ACCIDENTAL HYPOTHERMIA

6–1. Military incidence/epidemiology

From the 2013-2014 cold season through the 2020-2021 cold season, 409 cases of hypothermia occurred among U.S. Army Soldiers with an average annual rate of 1.1 cases of hypothermia per 10,000 Soldiers (range 0.9-1.2 per 10,000 Soldiers) (see figure 6–1).

Hypothermia is the least common injury among the three reportable cold weather injuries, accounting for less than 15% of the total number of cold weather injuries observed over the 8-year surveillance period.

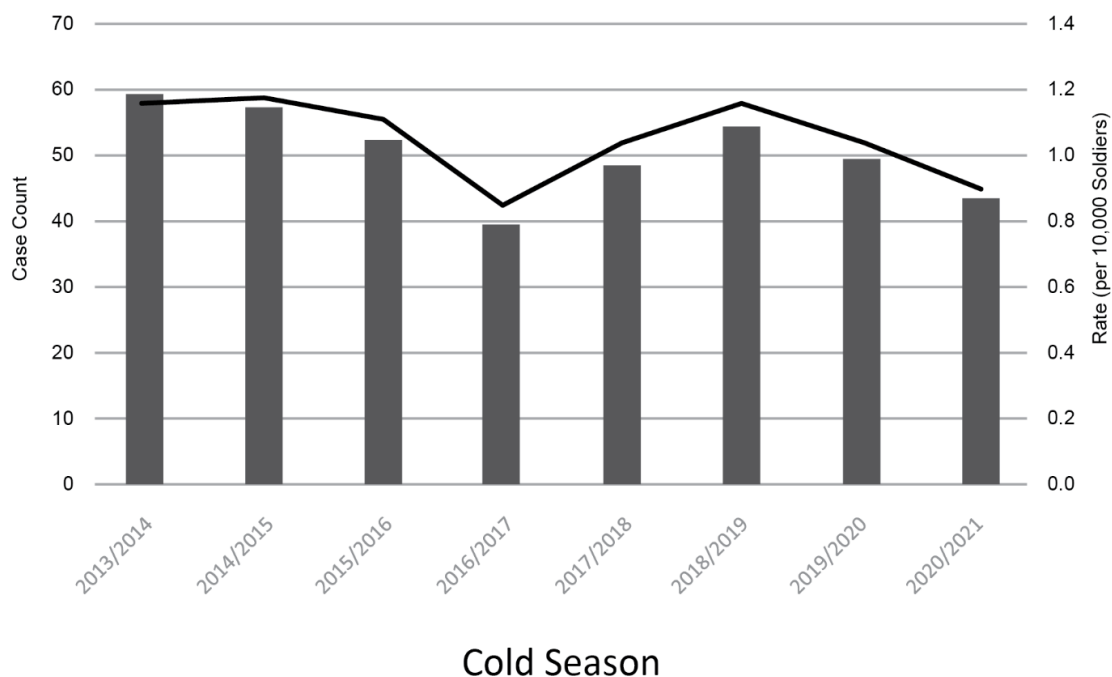


Figure 6–1. Hypothermia in U.S. Army Soldiers from 2013-2021

6–2. Definition/pathophysiology

a. Accidental hypothermia is defined as an unintentional drop in body core temperature below 95 °F (compared to intentional decreases such as lowering body core temperature after a stroke). Hypothermia is defined as a body core temperature below 95 °F (35 °C), which represents a fall from a normal body core temperature of ~3.5 °F (2 °C). Temperatures below freezing are not required for hypothermia to develop. Hypothermia is usually characterized as mild, moderate, or severe, based on body core temperature. Table 6–1 lists the body core temperatures and physiological changes and impacts typically associated with these levels of low body core temperature.

Table 6–1
Signs and symptoms of hypothermia at different levels of core temperature

Mild 89.6-95 °F (32-35 °C)	Moderate 82.4-89.5 °F (28-32 °C)	Severe < 82.4 °F (< 28 °C)
Cold extremities	Apathy, poor judgement	Inappropriate behavior
Shivering	Reduced shivering	Total loss of shivering
Tachycardia	Weakness and drowsiness	Cardiac arrhythmias
Tachypnea	Slurred speech and amnesia	Pulmonary edema
Urinary urgency	Dehydration	Hypotension and bradycardia
Mild incoordination	Decreased coordination or clumsiness	Reduced level of consciousness
	Fatigue	Muscle rigidity
	Hypoventilation	Lack of corneal reflexes
		Acid-base disturbances

b. The lowest body core temperature that an adult has survived from is 60.8 °F (16 °C); for an infant, it is 59.2 °F (15.2 °C).

c. Table 6–2 illustrates the signs and symptoms of hypothermia. Early signs typically include feeling cold, shivering, and withdrawal from social interaction. Clinically, this will first appear as a change in neurological functions. Onset of hypothermia is typically associated with the so-called “umbles”, that is, grumbles, mumbles, fumbles, and stumbles, mirroring how cold affects the body’s muscles and nerves. Symptoms of hypothermia consist of confusion, sleepiness, slurred speech, shallow breathing, weak pulse, low blood pressure, change in behavior or in appearance, shivering or loss of shivering, stiffness in the arms or legs, or poor control over body movements or slow reactions. Soldiers may often note behavior changes in buddies that seem out of character (“grumbles” and “mumbles”), as well as withdrawal from social interaction. These are all important signs that should be taken seriously, and prompt immediate action to treat the Soldier should be initiated.

Table 6–2
Signs and symptoms of hypothermia by system

Neurological System	Decreased levels of consciousness Ataxia Antinociception Amnesia Initial hyperreflexia Hyporeflexia
Cardiovascular System	Tachycardia Arrhythmias Decreased heart tones Jugular venous distension Hypotension
Respiratory System	Tachypnea Adventitious sounds Bronchorrhea Progressive hypoventilation Apnea
Gastrointestinal System	Ileus Constipation Abdominal distension Gastric dilatation
Genitourinary	Anuria Polyuria
Psychiatric Signs	Impaired judgment Mood changes Altered mental status Paradoxical undressing Distress Psychoses
Musculoskeletal System	Increased muscle tone Shivering Rigidity Compartment syndrome
Dermatological Conditions	Erythema Pallor Cyanosis Frostbite Sclerema Cold urticaria Necrosis Edema
Head, Eye, Ear, Nose, Throat	Decreased corneal reflexes Facial erythema Facial edema Rhinoorrhea

d. Intense shivering is one of the first signs of body cooling and requires increased attention from leadership because early intervention can prevent the development of hypothermia. The symptoms become progressively worse as body core temperature falls, and if a Soldier becomes sufficiently cold, shivering may actually decrease or even cease altogether, resulting

in reduced heat production and a more rapid fall in body core temperature. Neurological changes are manifested by changes in mood and suggest a person is now clinically hypothermic (< 95 °F). Note that resuscitation efforts have been successful down to body core temperatures as low as 60 °F. Because life signs at these temperatures are almost impossible to obtain, no one should be pronounced dead until he or she has been rewarmed; hence the use of the adage, “nobody is dead until warm and dead”.

e. In accidental hypothermia, body heat loss exceeds heat production. The rate of cooling depends on factors including clothing worn, environmental conditions (for example, water exposure, temperature, wind), and exercise intensity. For example, sitting in 50-61 °F water causes cooling rates of 1.8-3.2 °F per hour, about 4-5 times faster than in air of the same temperature. Being buried in avalanche snow has reported cooling rates up to 16.2 °F per hour.

f. Hypothermia causes profound changes in different physiological systems.

(1) *Cardiovascular system.* Hypothermia causes a linear decrease in heart rate (HR). At a body core temperature of 82.4 °F, HR is ~50% below normal resting values. Blood pressure (BP) also decreases. One component of BP, cardiac output, is ~45% lower at a body core temperature of 77 °F. Cardiac instability, as shown by electrocardiographic changes, is common with hypothermia, and in some cases may precipitate death by cardiac arrest. Electrocardiogram changes often seen with hypothermia include bradycardia, prolongation of PR and QT intervals, widening of QRS, junctional rhythms, and Osborne waves (J waves). Hyperkalemia occurs at body core temperatures less than 86 °F and can increase the risk for ventricular fibrillation. Therefore, potassium levels should be measured as soon as possible, and continuously monitored. The reperfusion of tissues that have had little blood flow brings acidotic, hyperkalemic, and cold blood back to the central circulation and can further increase the risk of fibrillation.

(2) Slowed orthostatic reflexes in combination with hypovolemia may result in hypotension when victims are rescued from the water. The risk of sudden death can be moderated during rescue by keeping the casualty quiet and supine, avoiding sudden movement during rescue, and not allowing exertion by the casualty during rescue.

(3) *Nervous system.* Cerebral metabolism decreases by 6% for every 1.8 °F fall in body core temperature. The electrical activity in the brain is altered at temperatures below 92.3 °F (33.5 °C) and is not detectable at or below 68 °F (20 °C). However, one should not assume that the person cannot be resuscitated or regain neurological function. Decreasing cerebral metabolism and activity may provide some protection, enabling the brain to recover from hypothermia. Memory losses occur at body core temperatures below ~93 °F, with poor judgement, ataxia, and apathy as temperatures decrease below 91 °F. Loss of consciousness occurs below 85 °F.

(4) *Respiratory system.* After an initial stimulation of respiration with mild hypothermia (leading to respiratory alkalosis), there is a progressive decrease in tidal volume as metabolic activity decreases. Carbon dioxide (CO₂) production can decrease by as much as 50% of normal at a body core temperature of 85 °F, but because ventilation is significantly lower, metabolic and respiratory acidosis occur. However, interpreting CO₂ and pH values in a hypothermic patient is difficult. Blood gas analyzers warm blood up to 98.6 °F, resulting in higher CO₂ values and lower pH values than the actual values in a hypothermic patient. Aggressive treatment with bicarbonate to reverse this condition is contraindicated because as the person rewarms, the patient will often have a pronounced alkalosis that must then be treated.

(5) *Coagulation.* Hypothermia prolongs clotting time because it depresses the enzymes involved in the clotting cascade. Platelet levels are also lower and may be caused by either

depressed bone marrow production or sequestration in the spleen and liver. This thrombocytopenia increases the risk of hemorrhage in the hypothermic patient. Reduced clotting time reverses upon rewarming. This is important as clinical tests are done at 98.6 °F and enzymatic activity will return to normal during testing.

(6) *Afterdrop*. During body cooling, a temperature gradient develops between the internal organs and the tissues between the core and the skin. Blood flow to the skin and muscles decreases during severe cold exposure, and these tissues will cool more than the core. During rewarming, colder blood returning from the muscles and skin may contribute to an afterdrop, or a continued fall in body core temperature which may be as large as 1-3 °F (0.5-1.5 °C). Rewarming techniques that induce peripheral vasodilation are associated with larger afterdrops by increasing the blood flow to the coldest tissues (that is, the skin), and sometimes are associated with significant falls in mean arterial pressure. Depending on body core temperature, the duration of hypothermia and the type of cold exposure (water vs. air), the afterdrop may be sufficient to induce syncope or ventricular fibrillation. For this reason, body core heating methods are preferable to peripheral heating in cases of severe hypothermia. Afterdrops also occur in hypothermic patients who experience frostbite and have their extremities thawed before the body core temperature is stabilized. Figure 6–2 shows the afterdrop and rewarming curves during an experiment following cold water immersion (46.4 °F (8 °C), different exposure times) where body core temperature was reduced to 93 °F. Note that shivering alone leads to a small afterdrop and causes the body core temperature to increase to the same level as exercise after 45 minutes of rewarming. Exercise afterdrop is often greater because of the increase in blood flow to the periphery.

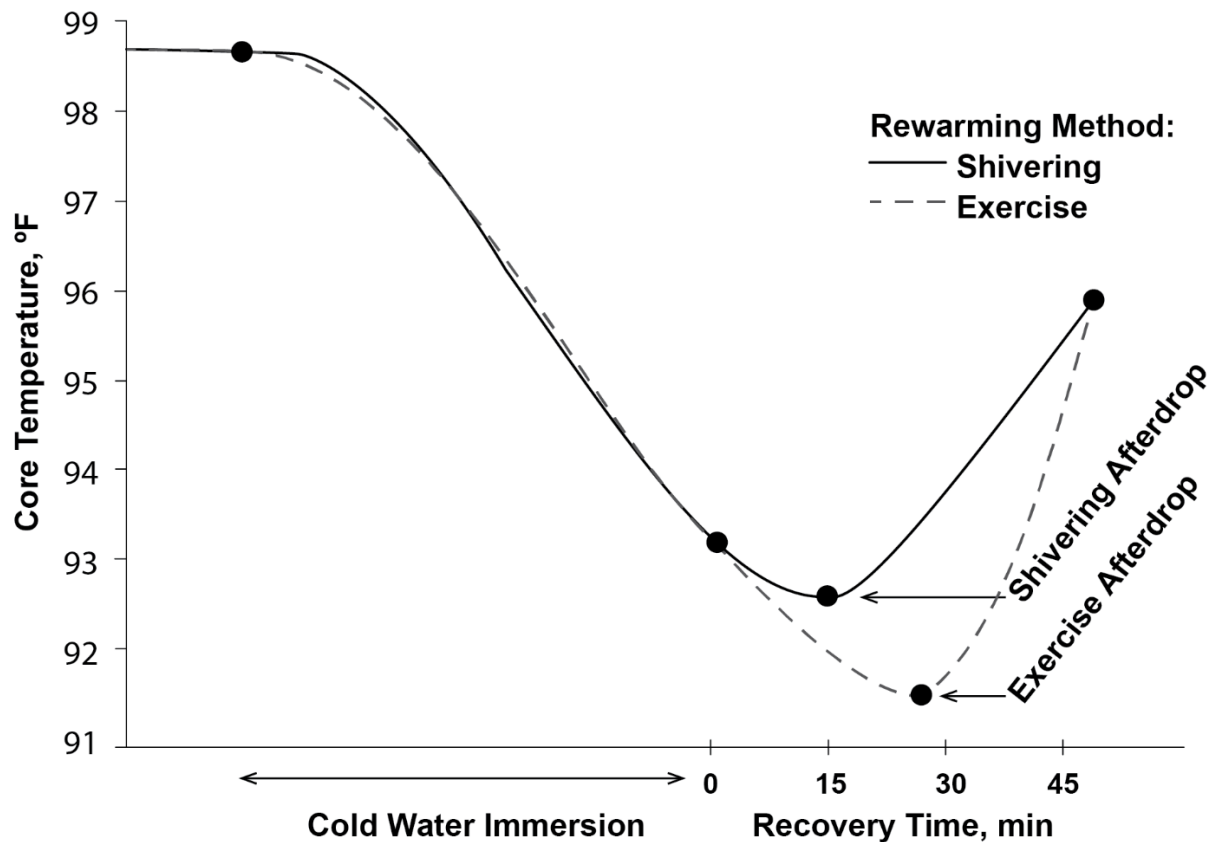


Figure 6-2. Rewarming curves for shivering and exercise following cold water immersion

(7) *Facial Cooling, Cold Shock, and Autonomic Conflict.* Sudden cold water face immersion causes a simultaneous diving (bradycardia, apnea) and cold shock (tachycardia, vasoconstriction, hyperventilation) response and activation of both sympathetic and parasympathetic branches of the autonomic nervous system. This simultaneous activation is known as “autonomic conflict” and is associated with potentially fatal arrhythmias.

6-3. Classification

Table 6-3 presents two classification systems for hypothermia with categories based on body core temperature. These systems use symptoms to estimate the body core temperature.

Table 6–3
Two clinical classification systems for accidental hypothermia

Swiss System

Category	Clinical findings	Estimated body core temperature
Stage 1	Clear consciousness with shivering	95-89.6 °F (35-32 °C)
Stage 2	Impaired consciousness without shivering	< 89.6-82.4 °F (< 32-28 °C)
Stage 3	Unconsciousness	< 82.4-75.2 °F (< 28-24 °C)
Stage 4	Apparent death	75.2-53.2 °F (24-11.8 °C)
Stage 5	Death due to irreversible hypothermia	< 53.2 °F (< 11.8 °C)

Wilderness Medical Society

Category	Clinical findings	Estimated body core temperature
Mild	Normal mental status, shivering, but not functioning normally/able to care for self	95-89.6 °F (35-32 °C)
Moderate	Abnormal mental status with shivering, or abnormal mental status without shivering, but conscious	< 89.6-82.4 °F (32-28 °C)
Severe/profound	Unconscious	< 82.4 °F (< 28 °C)

6–4. Risk factors

a. Table 6–4 presents the predisposing factors for hypothermia. These factors can be broadly categorized into those that decrease heat production, those that increase heat loss, those that impair thermoregulation, and other miscellaneous clinical states. The latter category is vague because of the many mechanisms of disease that can interfere with thermoregulation and may be more applicable in local civilian populations than in deployed forces since Soldiers are not deployed if they have been diagnosed with serious diseases.

Table 6–4
Predisposing factors for hypothermia

Decreased Heat Production	Increased Heat Loss	Impaired Thermoregulation	Other Clinical Factors
<u>Mission Factors</u> Inactivity Fatigue Energy depletion <u>Endocrine</u> Hypoglycemia Hypothyroidism	<u>Mission Factors</u> Immersion Rain Wet clothing from sweat Wind Fatigue <u>Erythrodermas</u> Burns Psoriasis Sunburn <u>Iatrogenic</u> Cold infusions Heat illness treatment	<u>Peripheral Failure</u> Trauma Acute spinal cord transection <u>Central Failure</u> Central nervous system (CNS) lesions and trauma Subarachnoid hemorrhage Hypothalamic dysfunction Pharmacologic Toxicologic Drug and alcohol abuse	Infection Multisystem trauma

b. Mission factors are the most important for the Soldier to consider because they both decrease heat production and increase heat loss. Early recognition is critical so that preventive measures can be used to minimize the potential impact of mission factors. Another important area is impaired thermoregulation caused by an injury to the brain or peripheral nervous system or other acute battle trauma. Soldiers with such an injury or trauma need to be kept warm and removed from the cold environment as soon as possible.

6–5. Prevention strategies

a. Cold Air.

(1) Body core temperature during cold exposure reflects a balance between heat production (physical activity, shivering) and heat loss. Increasing heat production and decreasing heat loss will reduce the risk for hypothermia. The environmental conditions (whether cold-dry or cold-wet) affect the relative risk for hypothermia. For example, wet clothing (from rain or sweat) and immersion increase heat loss substantially, increasing the likelihood of hypothermia. The primary means to prevent hypothermia are proper clothing, staying dry, and remaining active.

(2) Cold-weather clothing provides insulation, protection from precipitation, and allows moisture transfer from the skin to the environment. The amount of clothing needed to prevent hypothermia is a function of the environmental conditions (that is, air temperature, wind speed, humidity) and the physical activity level of the Soldier. Less clothing is required as the physical activity levels increase. Likewise, clothing requirements become greater as the air temperature decreases and/or the wind speed increases. Chapter 8 presents the Army's cold-weather clothing system. Below is guidance on what to wear based on the environment and activity levels.

(3) The United States Army Research Institute of Environmental Medicine (USARIEM) has developed the Cold Weather Ensemble Decision Aid (CoWEDA) to illustrate how clothing choices and combinations affect risk of cold injury. CoWEDA is a prediction tool that enables users to input environmental parameters such as air temperature and wind speed, specific items of clothing, and activity level, and receive output that includes the risk of hypothermia and frostbite, as well as onset of sweating. For clothing inputs, there are preset selections available from across the different services. Users can also input the clothing for each body area (for example, based on what they have available) by using the drop-down menus. Figure 6–3 presents the interface for CoWEDA. For more information please contact: usarmy.natick.medcom-usariem.mbx.usariem-webmaster@health.mil.

Body Section: Number of Hours Until Critical Temperature		
Exposed(Frostbite)	0.6 Hrs	Inadequate
Feet(Frostbite)	1.3 Hrs	Limited
Hands(Frostbite)	2.5 Hrs	Adequate
Body(Hypothermia)	4 Hrs	Ideal
Comfort (Until Sweating)	4 Hrs	

Figure 6–3. Interface of Cold Weather Ensemble Decision Aid

(4) For example, if a Soldier is wearing a fleece cap on the head, lightweight underwear, fleece mid-layer, and soft-shell outer layer on the upper body, lightweight underwear and soft-shell outer layer on the legs, wool socks with the Army intermediate cold-wet boot on the feet, and the Army leather glove with cold-weather insert; the air temperature is -10 °F, the wind speed is 5 mph, and the activity level is light, the risk of hypothermia is very low, but the risk of frostbite on exposed skin could potentially occur in ~30 minutes and possibly in the hands in ~3 hours (see figure 6–3). Cold injury risk will change based on activity levels, clothing worn, and environmental conditions, and CoWEDA provides a way to evaluate the influence of each.

(5) Table 6–5 provides examples of military tasks and their associated levels of work that can be used for determining activity levels in CoWEDA.

Table 6–5 Intensity of exercise for selected military tasks	
Level of Work	Military Task
Rest	Sleeping Sentry duty Gate duty
Light Work	Weapon maintenance Walking on hard surface at 2.5 mph, < 30 lb load Marksmanship training Drill and ceremony Snowmobiling
Moderate Work	Walking in loose snow/sand at 2.5 mph, no load Walking on hard surface at 3.5 mph, < 40-lb load Calisthenics Patrolling Individual movement techniques such as low or high crawl Defensive position construction Walking on hard surface at 3.5 mph, ≥ 40-lb load
Heavy Work	Walking in loose sand at 2.5 mph with load Field assaults Cross-country skiing Snowshoeing Downhill skiing

(6) Commanders need to provide some flexibility in allowing Soldiers to choose their own clothing combinations based on the Soldier's individual responses. Training in different environments at different activity levels will allow Soldiers to understand how they respond to different clothing and activity levels and adjust accordingly. For example, if the Soldier begins to sweat, he or she should remove clothing so that the skin still feels "cool to comfortable" and sweating stops. Likewise, if the wind velocity increases, the Soldier may need to add another insulating layer or a wind-resistant shell. Also, shivering is the first indication that a Soldier is becoming cold. If Soldiers are shivering, then action must be taken to warm them through preventive actions (for example, increase clothing, increase activity, provide shelter, hot meal).

(7) An important planning consideration is not only knowing how much clothing is needed during activity in the cold, but also recognizing that as soon as physical activity stops,

body heat loss will be significant. Exercise increases peripheral blood flow resulting in greater heat transfer to the environment. Sweating that may occur with heavy exercise, even in cold conditions, will also increase heat loss when activity stops. This highlights the problem of needing less clothing during a movement, but then needing more layers after being forced to remain stationary in a foxhole or defensive position. Other clothing items always need to be available to be put on if Soldiers cease physical activity.

(8) Heat loss from the bare head can be up to 50% of the total loss in 25 °F air, when Soldiers are adequately clothed over the rest of their bodies. Watch caps and balaclavas can decrease this heat loss substantially, particularly since there is little vasoconstriction in the head and face, unlike in the extremities. Hats should be put on before the Soldier feels cold and before he or she has incurred a significant loss of body heat. Likewise, as physical activity levels increase, hats can be removed to allow greater heat loss through the head and decrease overheating and sweating.

(9) Similarly, gloves and mittens should be donned before the hands become cold. As physical activity increases and the hands become warm, gloves can be removed to allow cooling through the large surface area of the hands and to limit sweat accumulation in the fabric. Through experience and training, Soldiers will learn when to wear and remove gloves and hats. These clothing articles are very versatile and should always be easily accessible. The same principles of layering should be followed for gloves and mittens as for other clothing.

(10) Choosing the right uniform for the environmental temperatures and activity levels must be based on where training will occur (garrison or field), how long the Soldiers will be exposed, and whether physical activity will be continuous or intermittent. For example, if physical readiness training consisted of marching around base at 3.5 mph in 20 °F air in light winds carrying a light load (moderate work, see table 6–5), wearing an Army combat uniform (ACU) would provide the necessary insulation to protect against hypothermia. But this assumes that exercise is continuous. What would the requirements be if 30 minutes into the march, the Soldiers stopped to perform weapons maintenance (light work, see table 6–5)? The recommended insulation would now increase. One possible choice to meet the new level of insulation would be to put on a soft shell jacket (Extended Cold Weather Clothing System Generation III (GEN III ECWCS), Level 4) (see chap 8). A hat might also be required to decrease heat loss through the head. Contact gloves would be needed to handle the cold metal of the weapons. However, if the march continues and Soldiers begin to sweat, they may need to increase ventilation (for example, open buttons, unzip zippers) or take off the jacket, and remove the hat. This example demonstrates the continual reevaluation of required clothing depending on the operational scenario.

b. Cold water.

(1) Soldiers cool two to five times more quickly during immersion in cold water, compared to when they are exposed to air at the same temperature. This is due to higher conductive and convective heat loss in water. This is further demonstrated by comparing the temperatures where humans remain in heat balance or thermoneutral conditions. In water, the thermoneutral temperature is about 95 °F. In comparison, heat balance is achieved during air exposure at an ambient temperature of about 79 °F. Therefore, a resting person will be unable to maintain his or her body core temperature when immersed in water at a temperature regarded as thermoneutral in air. A person could sit in 50 °F air for 3-4 hours and not experience a fall in body core temperature, whereas immersion in 50 °F water could cause a person to become hypothermic in 1-2 hours. The reason for these differences lies in the physical properties of air and water; the thermal conductivity of water is 25 times that of air. Therefore, cooling is extremely effective, even in moderately cool water and results in rapid

dissipation of the heat that is delivered to the skin by conduction and convection from the deeper tissues.

(2) Soldiers must be aware of potential changes in weather that can increase susceptibility to hypothermia (for example, going from 70 °F with sunshine to 55 °F air with heavy rain). It is important that Soldiers carry a rainproof outer layer for rainy conditions in air temperatures below 60 °F. If Soldiers are sedentary or doing light physical activity in the rain, this outer layer may be worn. If Soldiers are engaged in moderate to high physical activity levels, then this outer layer is typically not worn, because Soldiers can easily begin to raise their body core temperatures and start to sweat.

(3) The trade-off between becoming wet from rain versus increased sweating by wearing a waterproof layer must be considered with respect to the environment and mission. For example, if Soldiers will be returning to garrison where they are able to dry out and rewarm, clothing dampness due to sweat may be less of a problem. However, if Soldiers stay in the field overnight and the air temperature goes below freezing, an outer layer that has become wet on the inside due to sweating will freeze and lose its effectiveness. These changing weather conditions must be planned for by ensuring that Soldiers have enough dry clothing and access to shelter.

(4) Water immersion causes profound physiological changes and challenges to body temperature homeostasis. Body core temperature cooling during immersion is dependent on both the water temperature and the immersion depth. Cold water temperatures have higher radiative, convective, and conductive heat losses compared to warm water temperatures. Deeper immersion covers a greater amount of the body surface area and significantly increases body core temperature cooling rates and risk for hypothermia. Fast-moving streams increase convective heat loss and cause body temperatures to cool faster than still bodies of water.

(5) Table 6–6 presents the allowable exposure time during immersion at various water temperatures and immersion depths. These exposure times reflect the time it takes the body core temperature to fall to 95.9 °F (35.5 °C). The immersion time limits in table 6–6 are based on average Soldiers wearing ACU, carrying a 77 lb (35 kilogram (kg)) rucksack, and moving slowly at 0.5 mph. Static immersion may increase risk of hypothermia, while faster movement may decrease the risk. Leaders must recognize that some Soldiers will cool faster than the time limits predicted by the table. Soldiers who have low body fat and a high surface-area-to-mass ratio are more susceptible to faster cooling rates. Also, Soldiers who have not eaten in over 24 hours are more susceptible, as are those who are fatigued due to physical exhaustion or sustained operations. For immersion times greater than 6 hours, the risk of non-freezing cold injury substantially increases.

Table 6–6
Immersion time limits (hours) at different water temperatures and immersion depths

Water Temperature	Knee-Deep	Waist-Deep	Chest-Deep
50-54 °F (10-12 °C)	12.8	1.9	1.3
55-59 °F (13-15 °C)	15.6	7.5	2.2
60-64 °F (16-18 °C)	22.2	10.2	7.9
65-69 °F (18-21 °C)	33	13.8	10.5

(6) A good rule to follow for accidental cold-water immersion (for example, falling though ice) is the “1-10-1” rule. In this concept, once a person falls into the water, he or she needs about 1 minute to get over the “cold shock” response and resume breathing normally. Most people die from drowning in this first minute, primarily caused by hyperventilation. They then have ~10 minutes to get out of the cold water before they experience skeletal muscle fatigue caused by low muscle temperatures. Finally, they have about an hour before moderate to severe hypothermia sets in.

6–6. Field management

a. The goals of field management of hypothermia are to rescue, examine, insulate, and rapidly transport. Hypothermia is a true medical emergency and requires evacuation.

b. Measuring body core temperature is difficult in a field situation. In such a situation accidental hypothermia should be diagnosed by measuring tympanic temperature with an insulated thermistor-based probe, allowing readings of < 89.6 °F (32 °C). Rectal temperatures can be obtained later, when practical.

c. Without accurate temperature measurements, the diagnosis and classification of hypothermia must rely on medical history and clinical findings (for example, trunk feels cold, quality of vital signs; see table 6–2 above). A revised hypothermia staging/classification (Revised Swiss System) has been proposed, which correlates the level of consciousness with the risk of hypothermia-induced cardiac arrest. Young and healthy casualties may have vital signs still present at body core temperatures < 75.2 °F (24 °C). Signs of breathing or cardiac activity (and/or respiratory and pulse rate) should be sought for at least 1 minute because respiratory rates may be as low as 3-4 breaths per minute, pulse rates as low as 10-15 beats per minute, and pulse volume low and breaths shallow.

d. The immediate goal during field treatment is to limit further heat loss. All wet clothing should be replaced with dry clothing/other insulation systems/materials and the patient moved to a sheltered area. Patients can be wrapped in sleeping bags, bubble wrap, plastic, blankets, and newspapers. If minimal shelter is available, insulation from the ground is especially important with foam pads, branches, and leaves used to insulate the patient so he or she is not lying directly on the ground. For responsive patients, shivering (endogenous rewarming) is effective once heat loss has been reduced. Warm, sugary drinks should be given with supervision. Physical exercise is also effective for increasing metabolic heat production, but could cause an afterdrop, particularly after cold water immersion. Rewarming with exercise should be done only in stable patients with no sign of cardiac arrhythmias.

e. Whether to provide heat (either external or internal) in a field setting is a decision based on multiple factors that include body core temperature, type of exposure, and available transport. Direct delivery of heat to the core (active internal rewarming) is typically performed only in a hospital setting.

f. Active external rewarming techniques (for example, radiant heat, hot water bottles, electric blankets, forced hot air, warm water immersion) should be applied only to individuals who have ceased shivering or have a traumatic or toxicological vasodilation that exacerbates the rate of heat loss, since increasing skin temperature will blunt shivering and reduce the rate of rewarming. As body core temperature falls to ~90 °F (32 °C), shivering ceases and rewarming is difficult in the field.

g. Individuals with cardiac irritability need to be handled gently so that arrhythmias do not convert to ventricular tachycardia, ventricular fibrillation, or asystole.

h. In unresponsive patients, it is essential to assess peripheral pulses. Although these pulses are very difficult to detect, they must be determined before cardiopulmonary resuscitation (CPR) is initiated. Even slow heart rates may provide enough blood for the low metabolic demand of the patient. If CPR is initiated in a hypothermic person with a pulse, chest compressions could convert sinus bradycardia into a ventricular arrhythmia.

i. Pre-hospital life support for hypothermia is dependent on whether the casualty is responsive or not. If responsive, the patient is provided insulation to protect against the cold and 5% dextrose in normal saline administered, possibly in conjunction with heated humidified air. The patient is then handled gently and transported to higher levels of medical care. If not responsive, but respirations are present, the patient is also given 5% dextrose in normal saline and taken to more definitive care. If the casualty is not responsive, heated humidified air is given and cardiac monitoring is started. No cardiac activity/non-perfusing rhythm will trigger chest compressions. If there is electrical activity (and a pulse), the patient will be transported to higher care levels. If no pulse is detected, chest compressions will be initiated and the casualty evacuated.

j. For a complex hypothermia treatment algorithm, see the following paper, "Treatment algorithm for patients with accidental hypothermia, from European Resuscitation Council Guidelines 2021: Cardiac arrest in special circumstances". Resuscitation. 2021;161:152-219.

6–7. Hospital management

a. Out-of-hospital casualties with stage 1 hypothermia (see table 6–3) should be transported to a hospital and treated for other illnesses or injuries. With colder patients, the risk of imminent cardiac arrest must be evaluated (that is, systolic blood pressure < 90 mm Hg, ventricular arrhythmia, body core temperature < 86 °F). If only one risk factor is present, the patient should be transported to a hospital with the possibility to rewarm him/her with extracorporeal life support (ECLS). Without any risk factor of imminent cardiac arrest, the patient can be carefully and gently transported to the closest appropriate hospital and rewarmed actively, for example, forced warm air. If a patient has suffered a hypothermia-induced cardiac arrest (stage 4), CPR should be initiated immediately. Modifications to CPR have been proposed for hypothermia-induced cardiac arrest patients, for example, at a body core temperature < 86 °F (30 °C), no epinephrine and a maximum of three shocks should be attempted. Transport of a hypothermic patient in cardiac arrest should be directly to a hospital with ECLS rewarming capability.

b. In the hospital, prognostication of outcome after ECLS rewarming should be performed with specific scores (hypothermia outcome prediction after extra-corporeal life support (HOPE))

or International accidental hypothermia extracorporeal life support (ICE)), which are more reliable than the traditional potassium triage.

c. Managing the hypothermic patient in the hospital includes obtaining a reliable body core temperature measurement, cardiac monitoring, inserting intravenous (IV) catheters as needed, obtaining blood laboratories, maintaining fluid volume levels, using active internal rewarming techniques for the most serious hypothermia cases, and drug administration to manage arrhythmias.

d. Initial stabilization may require intubation unless the patient is alert with intact protective airway reflexes. In moderate and severe hypothermia, a nasogastric tube is indicated following intubation. The patient must be evaluated for pancreatitis, ileus, or other trauma. Initial laboratory tests include blood glucose, uncorrected arterial blood gases, complete blood count, electrolyte panel, serum amylase/lipase levels, prothrombin time, platelet count, fibrinogen level, blood urea nitrogen, and creatinine. Poor responders should have cervical or spine x-rays to rule out trauma not indicated in a patient history.

e. Active internal rewarming techniques include inhalation rewarming, heated intravenous fluid infusions, lavage (gastric, colonic, mediastinal, thoracic, peritoneal), diathermy, hemodialysis, venovenous and arteriovenous extracorporeal blood rewarming, and cardiopulmonary bypass. These techniques are quite invasive and should be performed by well-trained personnel with extensive experience.

f. Moderate or severe hypothermia is often associated with volume depletion, and increased blood viscosity may make patients susceptible to thromboembolism. Most hypothermia patients with a body core temperature below 90 °F should receive an IV infusion of 250-500 milliliters (mL) of heated 5% dextrose in normal saline. The temperature of the fluids should be between 104-108 °F. Lactated Ringer's should be avoided because the liver cannot metabolize lactate efficiently in someone with hypothermia. Patients should be followed for signs of fluid overload, such as rales and jugular venous distention.

g. Drug use during resuscitation of the hypothermic patient is complicated. Many drugs are temperature-dependent, and overmedication may be required for a response. Upon rewarming, these drug levels may then be toxic. If hypoglycemia, alcohol, or opiate intoxication is contributing to hypothermia, intravenous glucose (10-25 grams), thiamine (100 mg), and naloxone (1-2 mg) may be indicated. Managing the patient's heart rate or blood pressure pharmacologically should be avoided. Vasoconstrictors may increase arrhythmias, and vasodilators could abolish peripheral vasoconstriction and induce a severe afterdrop.

h. Post-warming complications include infection, rhabdomyolysis, myoglobinuria, and renal failure. Antibiotics must be administered if any sign of infection is present. However, the classic signs of infection are not present in hypothermia, and patients must be aggressively screened for infection prior to antibiotic use. Fever is absent and many laboratory tests are unreliable. Immune function is degraded at body core temperatures below 88 °F, so the likelihood of a bacterial infection increases and must be managed. Early laboratory tests can indicate whether rhabdomyolysis and impaired kidney function (which can be followed over the course of hospital treatment) are likely to occur. Patients who also have frostbite are at higher risk of compartment syndrome and rhabdomyolysis.

6–8. Return to duty, profiles, and medical board

The following is a discussion of profiles and referrals to the DES according to AR 40–501:

a. Soldiers with hypothermia may require a profile. Refer to the most recent edition of AR 40–501 for specific profile guidance.

b. Soldiers are referred to the DES for significant symptoms of cold intolerance or a recurrence of hypothermia after an episode of accidental hypothermia. Refer to the most recent edition of AR 40–501 for specific DES guidance.

CHAPTER 7

COLD WEATHER-RELATED PROBLEMS

7-1. Carbon monoxide poisoning

a. CO is a poisonous gas which cannot be seen or smelled. CO binds to red blood cells more readily than oxygen so less oxygen is available to vital organs and tissues. It is contained in the exhaust from stoves and vehicles. CO can build up in closed spaces that are poorly ventilated. Early signs of CO poisoning are headache, confusion, dizziness, and drowsiness. Persons found unconscious in a closed shelter or vehicle may be victims of CO poisoning, especially if the lips and skin are bright red.

b. CO poisoning can be prevented by maintaining adequate ventilation. Shelters should not be airtight. Soldiers should not remain stationary in idling vehicles for long periods. Under no circumstances should anyone sleep in an idling vehicle. Occupants of idling vehicles should ensure that exhaust pipes are not blocked by snowbanks, and the windows of the vehicle are slightly opened.

c. Use of a CO detector in shelters is highly recommended. These detectors can provide an early warning to occupants that CO levels are elevated and countermeasures need to be taken to reduce the risk of CO poisoning.

d. *Treatment.*

(1) Move to fresh air immediately.

(2) Seek medical aid promptly.

(3) Provide mouth-to-mouth resuscitation if victim is not breathing.

(4) Administer 100% oxygen until the patient is symptom-free, usually about 4-5 hours.

Serial neurologic exams should be performed to assess progress, and to detect the signs of developing cerebral edema.

(5) Consider hyperbaric oxygen therapy (HBO) therapy when the patient has a carboxyhemoglobin level of more than 25-30%, there is evidence of cardiac involvement, severe acidosis, transient or prolonged unconsciousness, neurological impairment, abnormal neuropsychiatric testing, or the patient is ≥ 36 years in age.

7-2. Cold urticaria

a. Cold urticaria is a disorder characterized by the rapid onset of itching, redness and swelling of the skin within minutes after exposure to a cold stimulus. It is probably the most common form of urticaria (hives). In extreme cases, anaphylactic shock may occur. This condition can begin at any age, affects both men and women, and is most prevalent in young adults (18-25 years old).

b. There are two forms of the disorder: essential (acquired) cold urticaria and familial (hereditary) cold urticaria. The symptoms of the acquired form become obvious in two to five minutes after exposure to the triggering substance or situation, while it takes 24-48 hours for symptoms of familial cold urticaria to appear. Also, symptoms tend to last longer with the familial form, typically about 24 hours although they may remain for as long as 48 hours. With the acquired form, symptoms tend to last for 1-2 hours.

c. Diagnosis of cold urticaria is made by placing a thin plastic bag with a freshly-melted ice cube on the skin, producing a wheal.

d. Management of cold urticaria includes:

- (1) Patient education on the risks of systemic reactions.
- (2) Prescribing an antihistamine for prophylactic use, if indicated.
- (3) Prescribing epinephrine pen if life-threatening anaphylactic reaction is possible.

7–3. Cold-induced bronchoconstriction/asthma/respiratory illness

a. Cold weather leads to a host of possible complications for the respiratory system. Problems include bronchospasm, nasal discharge, and upper respiratory tract infections. Allergy-prone Soldiers are most susceptible to bronchospasm during heavy exercise (exercise-induced bronchospasm (EIB)) in very cold air and must be watched carefully. Bronchospasm can also be caused by fumes from fuel-fired heaters. Proper ventilation and maintenance of these heaters is crucial as pollutants are also a trigger for EIB. Use of a nasal spray consisting of water or sterile saline solution relieves the dryness and discomfort from breathing heated air.

b. EIB has an incidence rate of ~4-20% in the general population and 11-50% in elite athletes. Cold exposure has been implicated as a trigger for bronchoconstriction and asthma-like symptoms. Cold-weather athletes have an increased prevalence of EIB (23% of Olympic winter athletes) with cross-country skiers reportedly having an incidence rate of 33-50%. The incidence rate of EIB in Soldiers stationed in cold-weather areas is not known. Additionally, women are reported to have higher rates of EIB than men.

c. Healthy Soldiers can experience an increase in respiratory passage secretions and decreased mucociliary clearance when breathing very cold air during exercise, and any associated airway congestion may impair pulmonary mechanics and ventilation during exercise.

d. Crowding and poor ventilation in tents and other shelters increase dissemination of respiratory infections. Influenza vaccination is an essential preventive measure. Medical officers should perform aggressive surveillance, particularly for streptococcal infection. Early intervention with appropriate treatment and infection control can curtail the spread of respiratory infection. Control measures include appropriate pre-deployment immunization and prophylaxis, early detection of respiratory infection by examination and culture, head-to-toe sleeping in tents, and adequate ventilation.

7–4. Snow blindness (solar keratitis) and sunburn

a. Snow blindness and sunburn are caused by exposure of unprotected eyes and skin to ultraviolet (UV) radiation. The threat of snow blindness and sunburn depends on the intensity of sunlight, not the air temperature. Snow, ice, and lightly-colored objects reflect the sun's rays, increasing the risk of injury.

b. Snow blindness results when solar radiation "sunburns" unprotected eyes, primarily from reflected UV light. Symptoms begin 4-10 hours after exposure and range from a "gritty" sensation to severe pain, blurred vision, uncontrolled blinking, headache, eye-watering, photophobia, and blepharospasm. Symptoms last < 48 hours, or several days if severe. Injury can be compounded by corneal swelling, which results from altitude-and wind-related hypoxia and corneal evaporative drying, with hypoxia worsened by contact lens use. A fluorescein eye stain test can locate corneal injuries.

c. The use of protective eyewear or goggles that block > 95% of UV radiation will help to prevent snow blindness. Sideshields or deeply-wrapped lens designs should be used. Soft contact lenses which block UV-light are protective. If sunglasses are not available, opaque eye covering (for example, tape-covered eyeglasses) with narrow horizontal slits provide adequate field-expedient eye protection. Brimmed hats also offer some protection.

d. For treatment, have the Soldier close the eyes and rest until pain eases. In a first step, cool gently through the closed eyelid. In a next step use oral analgesics (for example, acetaminophen, up to 1000 mg, four times a day). If available, administer a topical lubricant (for example, antioxidant artificial tears), and apply non-steroidal anti-inflammatory eye-drops (for example, diclofenac 0.1%). Topical anesthetics slow corneal recovery and should not be used outside emergency situations (for example, descent from high-altitude). Consider topical antibiotics in severe cases to prevent infection. Cycloplegic eye-drops (cyclopentolate 1%) may relieve pain but impair vision.

e. Sunburn to the skin increases heat loss during cold exposure, increasing susceptibility to hypothermia. It also leads to uncomfortable/painful feelings that decrease Soldier performance. Sunburn can be prevented by using a sunscreen that contains para-aminobenzoic acid (PABA) of at least a 15 sun protection factor (SPF). For cold weather, an alcohol-free sunscreen lotion should be used that blocks both UVA (longer wavelength, associated with skin aging) and UVB (shorter wavelength, associated with skin burning) rays.

7-5. Altitude sickness

a. High-altitude environments are typically cold. In personnel not acclimatized to altitude, hypoxia can cause pathologic conditions that are distinct in their symptoms. These conditions include acute mountain sickness (AMS), high-altitude pulmonary edema (HAPE), and high-altitude cerebral edema (HACE).

(1) AMS occurs in Soldiers from low altitude (< 3,937 feet (< 1,200 m)) who ascend rapidly to high altitude (> 8,202 feet (> 2,500 m)) or from high to higher altitude and remain there for several hours or more. AMS is caused by the decreased amount of oxygen available to the body in the low-pressure atmosphere at high altitude. The pathophysiology of AMS is thought to be the result of mild cerebral edema and subsequent brain swelling. Although not life-threatening, AMS is the most common altitude illness, and its symptoms, when severe, can degrade physical and mental performance such that large numbers of troops may be completely incapacitated in their first few days at altitude. In a few Soldiers, AMS can progress to life threatening HACE or HAPE, both of which require evacuation.

(2) HAPE is a non-cardiogenic, potentially fatal accumulation of fluid in the lungs, which occurs in Soldiers that rapidly ascend from low (< 1,200 m) to high altitude (> 2,500 m) or from high to higher altitude and stay there for a few days or more. It also occurs in long-term high altitude residents who reascend rapidly to high altitude following a stay at low altitude lasting several weeks. The edema is caused by the combination of hypoxia induced pulmonary vasoconstriction and increase in permeability of the pulmonary capillary endothelium. The end result is overflow of fluid from the bloodstream into the lungs, hindering the normal exchange of gases between the lungs and circulating blood. Untreated, HAPE can be rapidly fatal (6-12 hours) and is the most common cause of death among the altitude illness syndromes. It is often preceded by AMS and is frequently seen in individuals with HACE, but most cases of HAPE occur without concomitant HACE. Although the incidence of HAPE is relatively low, its impact on military units can be significant because of the serious prognosis and need for rapid evacuation.

(3) HACE is a potentially fatal accumulation of fluid in brain tissue that occurs in Soldiers who rapidly ascend from low (< 3,937 feet) to high altitude (> 8,202 feet) or from high to higher altitude and stay there for a few days or more. The pathophysiology of HACE is thought to involve a hypoxia-induced vasogenic edema, in which protein-rich fluid spreads into the extracellular space through a compromised blood-brain barrier, or cytotoxic edema, in which intracellular fluid accumulates in neurons and neuroglia, or a combination of both. HACE is the

more severe end of the spectrum of altitude-induced edema in the brain with subclinical cerebral edema manifested as AMS at the other end. HACE can have a significant impact on military units operating at high altitude due to its serious prognosis and the need for rapid evacuation.

b. Altitude acclimatization is the most effective way to prevent these injuries (see TB MED 505 (2010) for the proper methods to acclimatize to altitude and reduce the risk of high-altitude injuries).

7–6. Musculoskeletal injury

There is an increased susceptibility to falls, broken bones, sprains, and strains due to frozen ground and ice. Proper footwear and education about this hazardous environment are essential.

CHAPTER 8

CLOTHING, EQUIPMENT, CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR OPERATIONS, FOOD & FLUID

8–1. Generation III Extended Cold Weather Clothing System

a. The GEN III ECWCS provides Soldiers with a multi-layered, versatile insulating system that is adaptable to varying operational and environmental conditions, including cold, wind and rain. GEN III ECWCS is a 12-piece kit that enables Soldiers to utilize seven different layers, depending on the mission and environment. The system functions through insulation, layering, and ventilation. Insulation resists the transmission of heat, traps air, and wicks moisture away from the body. Layering increases air space and allows easy adjustment to a Soldier's activity level, while ventilation allows moisture to escape. By mixing and matching GEN III ECWCS components, Soldiers can protect themselves from temperatures ranging from +40 °F - -60 °F. See the Program Executive Office-Soldier website for detailed information on the GEN III ECWCS (<https://www.peosoldier.army.mil/Equipment/Equipment-Portfolio/Project-Manager-Soldier-Survivability-Portfolio/Generation-III-Extended-Cold-Weather-Clothing-System>).

b. The GEN III ECWCS 12-piece kit is comprised of seven levels: a lightweight base layer, a midweight base layer, a fleece jacket, a wind jacket, a “soft shell” uniform, a “hard shell” waterproof outer layer, and an insulation outer layer for extremely cold temperatures. The two base layers, which trap warm air next to skin, can be worn together or separately, as needed. The kit should be form-fitting (in other words, not too tight, as constriction will reduce the insulation properties, and not too loose, as there is too much volume to heat up). As with other cold-weather clothing, Soldiers should remember the acronym, COLD, for dressing in the cold and avoiding hypothermia. That is—

- (1) Keep it _____ Clean.
- (2) Avoid _____ Overheating.
- (3) Wear it _____ Loose and in Layers.
- (4) Keep it _____ Dry.

c. All pieces of the kit must be kept clean and in good repair to function as intended. Dirty clothing becomes ineffective because dirt compresses the insulation in the fleece and clogs the pores in breathable fabrics. Soldiers must clean their clothing according to the manufacturer's recommendations. Dry rub and air out clothing when washing is not possible. Wet clothing can be hung to dry inside a tent with a stove. Figures 8–1 to 8–7 show the different layers of the GEN III ECWCS system.

(1) *GEN III ECWCS Level 1 Lightweight Base Layer.* Long sleeve top and full-length bottom garments constructed out of silk-weight moisture wicking polyester (see figure 8–1). The material aids in the movement of moisture from the skin to the outer layers both while the wearer is moving or static. The top has thumb holes at the end of the sleeves. Place your thumbs in the holes to keep the sleeves down around your wrist when donning an additional layer. The drawers have an elastic waistband and standard front fly opening. Wear the Level 1 next to skin or with the Level 2 midweight cold weather shirt and drawers for added insulation and to aid the transfer of moisture.



Figure 8–1. Extended Cold Weather Clothing System Generation III Level 1 lightweight base layer

(2) *GEN III ECWCS Level 2 Midweight Base Layer*. Long sleeve top and full-length bottom garments constructed out of polyester “grid” fleece (see figure 8–2). Provides light insulation for use in mild climates as well as acting as a layer for colder climates. Provides an increase of surface area for the transportation of moisture away from the wearer during movement. The top has a zipper that can be used to form a mock turtleneck or allow you to ventilate as workload increases. The top has thumb holes at the end of the sleeves. Place your thumbs in the holes to keep the sleeves down around your wrist when donning an additional layer. Wear either next to skin or over the Level 1 lightweight cold weather undershirt and drawers.



Figure 8–2. Extended Cold Weather Clothing System Generation III Level 2 midweight base layer

(3) *GEN III ECWCS Level 3 Fleece Jacket*. Acts as the primary insulation layer for use in moderate to extreme cold climates depending on your exertion level (see figure 8–3). Thermal Pro™, an animal fur mimicking insulation provides an increase in the warmth to weight ratio along with a reduction in volume when packed. There are two inner mesh pockets. The zipper will form a mock turtleneck or can be used to ventilate the garment as required. Wear underneath shell layers because this layer does not provide protection from the wind and snow clings to it readily.



Figure 8–3. Extended Cold Weather Clothing System Generation III Level 3 fleece jacket

(4) *GEN III ECWCS Level 4 Wind Jacket*. Made of a lightweight, windproof and water repellant material (see figure 8–4). Acts as a minimum outer shell layer, improving the moisture wicking performance of the insulation layers when combined with body armor and/or the Army combat uniform. It has two sleeve pockets, and a mock turtleneck. Two chest-level pockets are designed with mesh pocket linings to aid in ventilation while wearing body armor.



Figure 8–4. Extended Cold Weather Clothing System Generation III Level 4 wind jacket

(5) *GEN III ECWCS Level 5 Soft Shell*. Made of a highly water resistant, wind proof material that increases moisture vapor transfer over current hard-shell garments (see figure 8–5). Provides a reduction in weight, bulk, and noise signature during movement. Breathability improves performance of insulation layers by decreasing saturation due to moisture accumulation. The jacket has a storable hood that works with the ballistic helmet. It has two

hand warming pockets on the chest with a mesh lining to aid in ventilation. It has pit zips and two sleeve pockets. Draw cords on the bottom prevent snow and wind from entering the system. The trousers have a reinforced knee and drop seat. Knee length zippers help with don/doff of boots. Wear when the average temperature is below 19 °F. You will determine the base and insulation layers necessary dependent upon temperature, wind, and activity level.



Figure 8–5. Extended Cold Weather Clothing System Generation III Level 5 soft shell jacket and trousers

(6) *GEN III ECWCS Level 6 Extreme Cold/Wet Weather Jacket and Trousers.* A waterproof layer for use in prolonged cold wet conditions and/or hard rain (see figure 8–6). The jacket has two pass-through chest pockets for ventilation. It has a storable hood that works with the ballistic helmet. The trousers have reinforced seat and knees with knee length zippers for don/doff. Wear when the average temperature is above 19 °F and alternating between freezing and thawing. You will determine the base and insulation layers necessary dependent upon temperature, wind, and activity level.



Figure 8–6. Extended Cold Weather Clothing System Generation III Level 6 extreme cold/wet weather jacket and trousers

(7) *GEN III ECWCS Level 7 Extreme Cold Weather Parka and Trousers.* Provides superior warmth with high compact ability, low weight, and low volume (see figure 8–7). Highly water resistant and windproof to provide wind and moisture protection. Sized to fit over body armor during static activities requiring maximum insulation. The trouser design incorporates full

side zips for don/doff over boots and other layers. Wear in extreme cold weather and climates over any other layers being worn; it is the last layer of protection. It is meant for static positions.



Figure 8–7. Extended Cold Weather Clothing System Generation III Level 7 extreme cold weather parka and trousers

8–2. Fire resistant environmental ensemble

a. The Fire-Resistant Environmental Ensemble (FREE) is a multi-layer clothing system designed for Soldiers in areas with higher risk of encountering fuel fires such as aviation and mounted operations. It can be used in cold weather climates depending on the layers used. This system is not intended for dismounted operations.

(1) *FREE Level 1 Base Layer*. Short sleeve top and boxer garments constructed out of silk-weight moisture wicking fire resistant knit blend material (see figure 8–8). The material aids in the movement of moisture from the skin to the outer layers both while the wearer is moving or static. Worn next to skin or with Levels 2 and 3 for added insulation and to aid the transfer of moisture.



Figure 8–8. Fire-Resistant Environmental Ensemble Level 1 base layer t-shirt and boxer

(2) *FREE Level 2 Light Weight Base Layer*. Long sleeve top and full-length bottom garments constructed out of Nomex®/Lycra® mesh knit blend material (see figure 8–9). The mesh knit creates spaces to trap air close to the body to provide insulation when used with another layer. The material provides flame resistance. The top has holes in the sleeves for the

thumbs. Place your thumbs through the holes to keep the garment down around your wrist when donning an additional layer. Wear over Level 1 or next to skin.



Figure 8-9. Fire-Resistant Environmental Ensemble Level 2 base layer shirt and pants

(3) *FREE Level 3 Mid Weight*. Can be worn over Levels 1 and 2 (see figure 8-10). Features a mock turtleneck with $\frac{3}{4}$ zipper for ventilation, thumb holes in sleeves and a longer tail to prevent the shirt riding up.



Figure 8-10. Fire-Resistant Environmental Ensemble Level 3 midweight base layer shirt and pants

(4) *FREE Level 4 Army Aircrew Combat Uniform or Improved Combat Vehicle Coveralls*. Made of Nomex® flame-resistant material (see figure 8-11). Acts as a minimum outer shell layer, improving the performance of underlying layers. Has minimal wind and water resistance. Integral part of the whole FREE system. Fits over Levels 1, 2, and 3.



Figure 8–11. Fire-Resistant Environmental Ensemble Level 4 Army aircrew combat uniform

(5) *FREE Level 5 Light Weight Outer Layer (LWOL)*. Made of a fire-, water-, and wind-resistant material that increases moisture vapor transfer over current hard shell garments (see figure 8–12). The pants have one back pocket, two zippered front pockets, and two calf pockets. Knee length zippers ease donning/doffing with boots on (“boot friendly”). The jacket has one zippered pocket on the left upper arm, one zippered pocket on the right chest, two hand warmer and two forearm pockets. There is a panel across the tops of the shoulder to accommodate the safety harness. Light fleece lining provides insulation. Designed to be worn over Levels 1, 2, and 3 and Army aircrew combat uniform (A2CU)/combat vehicle crewman (CVC) coveralls. In this configuration, the temperature range is +60-0 °F depending on activity level.



Figure 8–12. Fire-Resistant Environmental Ensemble Level 5 light weight outer layer

(6) *FREE Level 6 Intermediate Weather Outer Layer (IWOL)*. Material is similar to LWOL except that the fleece lining is heavier (see figure 8–13). The pocket and zipper configuration are the same as the LWOL. Additional layer vest has two hand warmer pockets and one zippered pocket on the chest as well as the panel on the shoulders. Worn over Levels 1, 2, 3, and A2CU/CVC. The garments are not sized to fit over Level 5. This configuration is designed for a temperature range of 0-40 °F depending on activity.



Figure 8–13. Fire-Resistant Environmental Ensemble Level 6 intermediate weight outer layer with additional layer vest

(7) *Level 7 FREE Extreme Weather Outer Layer (EWOL)*. Cloth material is similar to LWOL/IWOL but with a GORE-TEX® membrane to provide water and wind proofing (see figure 8–14). This membrane makes the EWOL a dual purpose outer shell. When used in an extreme cold environment (below -20 °F), Levels 1, 2, 3, and A2CU/CVC IWOL or LWOL are worn under the EWOL. Note that IWOL and LWOL are not worn together. The fleece liner may be zipped and snapped into the EWOL jacket. When used in a cold wet environment (above 14 °F), the EWOL shell is the outer shell to guard against rain. The jacket has a zip off or roll away hood, two pockets on the upper arm, and two hand warmer pockets with hook and loop closure. The fleece layer can be zipped and snapped into the jacket for more warmth. Armpit zippers add ventilation, and the panel across the shoulders allows the safety harness to be worn. The fleece has the same shoulder panel as the other layers. Reinforced elbows and no pockets. The pants have front Pass Thru pockets as well as cargo pockets on both thighs. Belt loops and suspender loops with a draw string on the waist. Knee length zippers with hook and loop closures on the ankles.



Figure 8–14. Fire-Resistant Environmental Ensemble Level 7 extreme weather outer layer with additional fleece jacket

8–3. Headwear and neck gaiter

a. Heat loss from the bare head can be up to 50% of the total loss in 25 °F air, when Soldiers are adequately clothed elsewhere. Watch caps and balaclavas can decrease this heat loss substantially. Hats should be put on before the Soldier feels cold and before he or she has incurred a significant loss of body heat. Likewise, as physical activity levels increase, hats can be removed to allow greater heat loss through the head and decrease overheating and sweating. Hats available for military cold-weather operations include the fleece cap (worn with the physical fitness uniform) and the extended cold weather balaclava hood. All of these can be worn with a ballistic helmet, with adjustment of the pad system to thinner pads that accommodate the insulation of the headwear.

b. Gaiters can be used to reduce heat loss from the neck region. They can be adjusted to be worn six ways: head band, ski band, neck warmer, hood, balaclava or mask and hat.

c. At extreme low temperatures, the eyes must also be protected with goggles or other eye protection to reduce the chance of frostbite. The interface between the eye protection and other clothing must not have any exposed skin.

8–4. Gloves/mittens

Gloves and mittens should be donned before the hands become cold. As physical activity increases and the hands become warm, gloves can be removed to allow cooling through the large surface area of the hands and to limit sweat accumulation in the fabric. Through experience and training, Soldiers will learn when to wear and remove gloves and hats. These clothing articles are very versatile and should always be easily accessible. The same principles of layering should be followed for gloves and mittens as for other clothing.

a. A liner glove that fits directly against the skin wicks away moisture. This liner glove can also serve as a contact glove that prevents the skin from coming directly into contact with cold objects, thereby reducing the risk of contact cooling or contact frostbite at temperatures below freezing. Wearing the contact glove allows Soldiers to take off bulkier gloves to perform tasks that require fine motor skills while still protecting the hands. Each Soldier should have at least one or two pairs of spare contact gloves in case the first pair becomes wet due to sweating or handling wet or snowy objects.

b. The intermediate cold/wet glove system (NSN 8415-01-319-5112) is rated from 0-40 °F. At colder air temperatures (< 0 °F), Arctic mittens (NSN 8415-00-782-6716) provide adequate protection. Using mittens, as opposed to gloves, provide greater protection from cold injuries due to fingers being in closer proximity, reducing heat loss. Mittens should be placed inside the jacket when not in use to keep them warm and dry.

c. The Army also has a specific glove for Soldiers handling POL. The extreme cold-weather glove for POL handlers (NSN 8415-01-150-6199) is worn over the cold weather glove inserts and can be worn down to -40° F.

8–5. Socks

Feet sweat at rest and even more so during physical activity. Socks that consist of a wool or wool-blend (NSN 8440-00-153-6717) will absorb sweat from the foot while maintaining some insulation value. Socks should not be so thick that the boot fits too snugly. This reduces the sock insulation and can cause constriction of the blood vessels to the feet, resulting in colder feet, and increasing the risk of cold injury. Boots may need to be sized larger to accommodate insulated socks. Soldiers and leaders need to ensure that issued clothing and equipment fits correctly.

a Even with boots that are “breathable”, foot sweat will cause socks to become wet, increasing conductive cooling and cold injury risk. Socks therefore must be changed a minimum of two to three times throughout the day. Having wet feet for prolonged periods (> 12 hours) increases the risk for non-freezing cold injuries.

b Foot sweat can also be absorbed into boots and degrade the insulation value. How readily this can occur depends on the type of boot. Care should be taken to dry boots when possible.

c Vapor barrier socks can be effective in preventing foot perspiration from being absorbed into the boot. These socks may also help to maintain warmer feet by reducing evaporative heat loss. However, vapor barrier socks trap moisture around the foot and may not be a good choice, particularly when worn for long time periods. The use of vapor barrier socks is a clothing technique that requires practice and experience in order to understand how moisture management works; it also requires drying feet overnight or the skin of the feet will rapidly deteriorate, resulting in blisters and increased risk of infection. Vapor barrier socks can also be used during conditions when boots will become wet due to movements through wet terrain. In this case, a vapor barrier sock worn over the sock will protect the feet from outside moisture, although sweat accumulation will increase. It is important that this is done only when the water level will remain below the top of the boot and vapor barrier sock. If the water level rises above the top of the boot and vapor barrier sock, the vapor barrier sock could fill with water that becomes trapped next to the foot.

8–6. Boots

a. The Army has several types of boots for cold weather operations.

(1) The Intermediate Cold/Wet Boot (NSN 8430-01-471-8230) is designed to be worn in cold and cold-wet environments where the temperatures range from 14-32 °F. Wearing this boot for extended periods at air temperatures below 10 °F will increase susceptibility to cold injury, because considerable foot cooling will occur at these low temperatures due to insufficient boot insulation.

(2) The Cold Weather Combat Boot (NSN 8430-01-619-3512) is designed to be worn at temperatures from -20-14 °F. It is also for use in mountainous terrain. It can be used with ski equipment.

(3) The Extreme Cold Weather Boot (vapor barrier boot) is colored white (NSN 8430-00-655-5563) and can be used at temperatures from -20-60 °F. Proper fitting of the vapor barrier boot is essential because tight boots will constrict blood flow, yet loose boots can cause blisters and also allow considerable snow to fall into the boot. Soldiers need to try on several pairs of vapor barrier boots while wearing the appropriate socks to get the proper fit and should not rely on the shoe size only.

(4) Boots a limited capacity to transfer sweat, and the Extreme Cold Weather Boot allows no evaporation at all, making it necessary for Soldiers to change their socks two to three times daily.

b. Soldiers should not sleep with footwear on, for several reasons: Feet need to be dried out overnight to maintain the skin integrity and prevent nonfreezing cold injuries; and feet will continue to sweat if boots are worn while sleeping, and the boots cannot dry completely. Dry socks can be worn during sleep. Damp boots can be placed inside the sleeping bag to dry out if there is no other way to allow them to dry (inside a warm tent, for example). Boots should not be placed outside in very cold temperatures because the moisture in them can freeze, and cold injuries can occur when placing feet in cold boots.

8–7. Gaiters/overboots

Snow can fall inside any boot and melt creating a cold-wet microenvironment. Gaiters (NSN 8415-01-514-2398) and overboots can help prevent this from occurring. Gaiters and overboots also increase insulation by trapping air, helping to keep feet warmer and drier.

8–8. Shelters and heaters

a. The primary shelter in cold-weather environments is the 10-man Arctic Shelter (NSN 8340-01-651-2884 – Woodland camo; NSN 8340-01-651-2887 – Arctic camo). This is a 225 ft² fire-retardant shelter with a single center pole.

b. Only U.S. Army-approved heaters should be used in shelters. The heater authorized for the 10-man tent is the Space Heater, Arctic (NSN 4520-01-444-2375), also commonly known as the Yukon Stove. Other heaters that can be used include the Space Heater Convective 35k (NSN 4520-01-431-8927) and the Space Heater Small (NSN 4520-01-478-9207). Only properly trained Soldiers should be permitted to set up, light, refuel, and maintain stoves. Stovepipes must be kept clean and must be tall enough to draft properly. A fire guard must be posted at all times. The tent doorway must be kept clear to allow easy escape in case of fire.

c. Separate battery-operated CO and smoke detectors should ideally be placed into shelters to alert personnel to CO and fire dangers.

8–9. Sleeping bags/modular sleep system

The Modular Sleep System (MSS) is designed for a temperature range of 50–30 °F. It is comprised of an inner intermediate bag, a patrol bag, a bivouac cover, and a stuff sack (see figure 8–15). The patrol bag can be used alone in temperatures down to approximately 30 °F whereas the intermediate bag can be used alone in temperatures down to approximately -10 °F. When the patrol bag, intermediate bag, and cover are combined, the system can be used down to approximately -30 °F. Other layers of the ECWCS should be worn in this bag to increase comfort. Levels I, II, and III can be used in combination to accomplish this. Do not overdress as you may begin to overheat.



Figure 8–15. Modular sleep system

Table 8–1 provides a reference list of clothing/equipment and the National Stock Number for these items. National Stock Numbers obtained from Defense Logistics Agency.

Table 8–1 Cold weather clothing and equipment and associated National Stock Number	
Item	National Stock Number
Fleece cap	8405-01-524-2671
Balaclava	8415-01-543-0082
Neck gaiter	8440-01-387-8509
SnowHawk® Thermal Goggle	4240-01-678-2516
Wiley X Spear Thermal Goggle	4240-01-678-6131
Cold weather leather glove	8415-01-319-5112
Cold weather wool liner glove	8415-01-576-6392
Extreme cold weather mittens	8415-00-615-0464
Extreme cold weather mittens-POL	8415-01-150-6199
Extreme cold weather socks	8415-00-177-7992
Intermediate cold-wet boot	8430-01-471-8230
Cold weather combat boot	8430-01-619-3512
Extreme cold weather boot	8430-00-655-5563
Gaiters (protective leggings)	8415-01-514-2398
Overboots	8430-01-464-9453
10-man arctic shelter	8340-01-059-4075
Arctic space heater	4520-01-444-2375
Convective space heater (35k)	4520-01-431-8927
Small space heater	4520-00-269-7861
Modular sleep system	8465-01-445-6274

8–10. Chemical, biological, radiological, and nuclear considerations in cold weather

a. Wearing CBRN individual protective clothing and equipment during cold weather operations increases the risk for both cold and heat injuries. CBRN-protective clothing, gloves, and facemask can fit tightly, restricting blood flow to the fingers and face and increasing the susceptibility of these areas to frostbite. Heavy work will increase sweat accumulation in the gloves, degrading the insulation, and increasing frostbite susceptibility in the fingers. CBRN clothing also limits the ability to visually inspect for signs of cold injury.

b. Wearing the CBRN-protective Joint Service Lightweight Integrated Suit Technology (JSLIST) outer layer over heavy cold weather clothing creates the unexpected situation where heat exhaustion becomes a real possibility for Soldiers working hard, even in temperatures as low as -22 °F. The added insulation and decreased ventilation of CBRN-protective clothing can result in

heavy sweating and wetting of the clothing during hard physical activity. When this activity ceases, large heat losses ensue, and finger and toe temperatures can decrease significantly.

c. Generally, CBRN clothing is worn outside the cold weather clothing. Therefore, to prevent overheating, it may be necessary to remove insulating clothing layers before putting on CBRN clothing. Likewise, it may be necessary to add additional clothing layers over the outer garment after it is donned if changes in weather or activity warrant additional warmth.

d. For gloves, put on the cotton liners and then the rubber gloves. During winter operations in a chemical environment, use the wool glove liners (part of the black leather glove set) under the butyl rubber gloves. A proper glove fit is required to preclude restricting blood circulation and cold weather injury. In extreme cold environments, the arctic mittens should be worn over the rubber gloves to provide warmth. Decontamination of cold weather mittens (if contaminated) may be impractical and, hence, the mittens can be considered as a combat loss.

e. For the feet, the generally fielded alternative footwear solutions (AFS) overboot is gradually being replaced with the molded AirBoss® lightweight overboot (MALO), both of which are butyl-based rubber galoshes that fit over combat boots.

f. Any garment worn over CBRN equipment will become contaminated during chemical exposure and will have to be discarded and replaced with new issue clothing. Remove outer clothing before entering tents and heated shelters to avoid bringing snow containing frozen contaminants inside to thaw and create an active hazard.

g. Autoinjectors should not be carried externally when the temperature is below freezing. They should be placed in an inner pocket where body heat will keep them warm. Furthermore, when using the nerve agent antidote, ensure that it penetrates through winter clothing to the muscle.

h. When donning the protective mask in arctic conditions, personnel should stop breathing, remove the mask from under the parka, remove the gloves or mittens, lower the parka hood, and don and clear the mask according to the leader's direction.

i. The following additional guidance provides quick tips for leaders to use as a guide when assisting their personnel before, during, and after operations in cold weather environments during CBRN events:

(1) Use neutral or gray eye lens to prevent snow blindness and the fogging of field protective eye lenses.

(2) Use tape on outserts so that only slits are left if neutral or gray outserts are not available.

(3) Fill canteens to $\frac{3}{4}$ full to prevent the canteen from bursting should the water freeze.

(4) Blow remaining water out of the drinking tube to prevent ice from forming.

(5) Exhale steadily and slowly to try to prevent frosting of the eye lenses. Do not clear the mask by exhaling a large volume of air as moist air will frost the eye lens and impair vision.

(6) Wear the mask carrier in a position that permits maximum mobility.

(7) Use a small towel or cloth to wipe the inside of the mask after removal to prevent ice formation.

(8) The harness that straps on the mask should not be too tight. This will reduce blood flow to skin of the head and face and can cause frostbite.

j. Decontamination team members should train at various temperatures to gain a better understanding of the amount of layered under-clothing that is appropriate for their work level so that they are not overheated while working.

k. Cold temperatures greatly increase the risk of patient cold shock and hypothermia. Patients who are medically compromised because of blood loss, exposure to a chemical agent,

or severely ill from a biological or radiological exposure have little energy reserve to maintain their core body temperature and are therefore more susceptible to developing hypothermia.

l. Care must be exercised when moving chemically contaminated patients into a warm shelter. A chemical agent on the patient's clothing may not be apparent. As the clothing warms to room temperature, the agent may vaporize (off-gas), contaminating the shelter and exposing the occupants to potentially hazardous levels of the agent. A three-tent system is suggested for processing patients in extreme cold operations. The first tent (unheated) is used to strip off potentially contaminated clothing. The second tent (heated) is used to perform decontamination, perform emergency medical treatment, and detect off-gassing. The third tent (heated) is used to provide the follow-on care and patient holding.

m. One method for the selection of appropriate cold weather decontamination is based on ambient temperature. The closer the ambient temperature is to freezing, the more patient operations are conducted inside a heated enclosure.

n. Regardless of the ambient temperature, individuals who have been exposed to a known life-threatening level of chemical contamination should disrobe, undergo decontamination, and be sheltered as soon as possible.

o. Decontamination team members should layer clothing under their protective ensembles so that it can be removed if needed. It is best to have a warming tent on the warm side of the hot line where decontamination team members can warm themselves when needed. If a heated warming tent is not available, then blankets should be available for staff in the rest area. Just as rest breaks to cool individuals are needed in warm temperatures, rest breaks to warm workers are needed in cold climates.

p. If possible, heated triage and treatment tents or heated buildings should be used. This will reduce both staff and patient exposure to the cold. If contaminated clothing worn by patients has not been removed from them prior to their being brought into these areas, then the areas must be well ventilated so hazardous chemical vapors do not build up inside the enclosed space. Ideally, patient clothing should be removed just inside or outside the entrance to these facilities.

q. Refer to table 8–2 for decontamination methods based on ambient temperature. Sample decontamination methods based on ambient temperature are as follows:

(1) Method 1. These are standard patient thorough decontamination operations conducted without special heating tents or water heating apparatus. Decontamination operations that are conducted in the temperature range of 65 °F (18 °C) and above can be performed in this manner using existing equipment.

(2) Method 2. Here, standard patient thorough decontamination operations are conducted, but the patient is quickly transferred to a clean side area that is heated. This is typically conducted when temperatures are in the 50-64 °F (10-18 °C) range.

(3) Method 3. Patients are triaged and given lifesaving treatment outside but are decontaminated in a heated tent with heated water and then moved to a heated enclosure on the clean side of the hotline. This is appropriate when temperatures are in the 35-50 °F (2-10 °C) range.

(4) Method 4. Patient triage, decontamination, and clean side treatment are conducted in a warm area (heated tents, vehicles, or buildings). Dry decontamination is used initially, inside a decontamination tent, until the patient can be transported to a warm facility where the water is heated and the patient remains inside the warm enclosure for treatment. This is appropriate when temperatures are below 35 °F (2 °C).

Table 8–2
Decontamination methods based on air temperatures

Method	Temperature	Warm side triage and treat	Clothes removed	Decontamination water temperature	After decontamination patient moved to
1	> 65 °F (> 18 °C)	Outside	Outside	Decontamination outside	Outside clean side triage
2	50-64 °F (10-18 °C)	Outside	Outside	Decontamination outside	Heated clean side triage area
3	35-50 °F (2-10 °C)	Outside	Inside	Heated decontamination enclosure	Heated clean side triage area
4	< 35 °F (< 2 °C)	Inside	Inside	Dry decontamination (flour, sand, paper towel, reactive skin decontamination lotion) for immediate decontamination	Transport to heated indoor decontamination area, preferably in a building

Note: Method 1 is the easiest, method 2 is the most complex. Grey areas exist where activities are performed in a heated enclosure.

8–11. Energy requirements

a. An increased energy requirement (in the form of calories or kilocalories (kcal)) during cold weather operations is due to the heavy cold weather clothing and footgear, and increased effort needed for movement on snow- or ice-covered terrain. For example, walking at 3 mph on blacktop requires an energy expenditure that is 3 times greater than at rest (~210 kcal per hour versus 70 kcal per hour). In contrast, walking at 3 mph in 6 inches of loose snow increases energy expenditure to 420 kcal per hour. Figure 8–16 shows the approximate energy expenditures required to walk in various terrains (note: the term “calories” is synonymous with kilocalories when used as a measure of food). Soldiers may also be required to pull a sled with tents, heaters, or other sustainment items, adding to their energy expenditure.

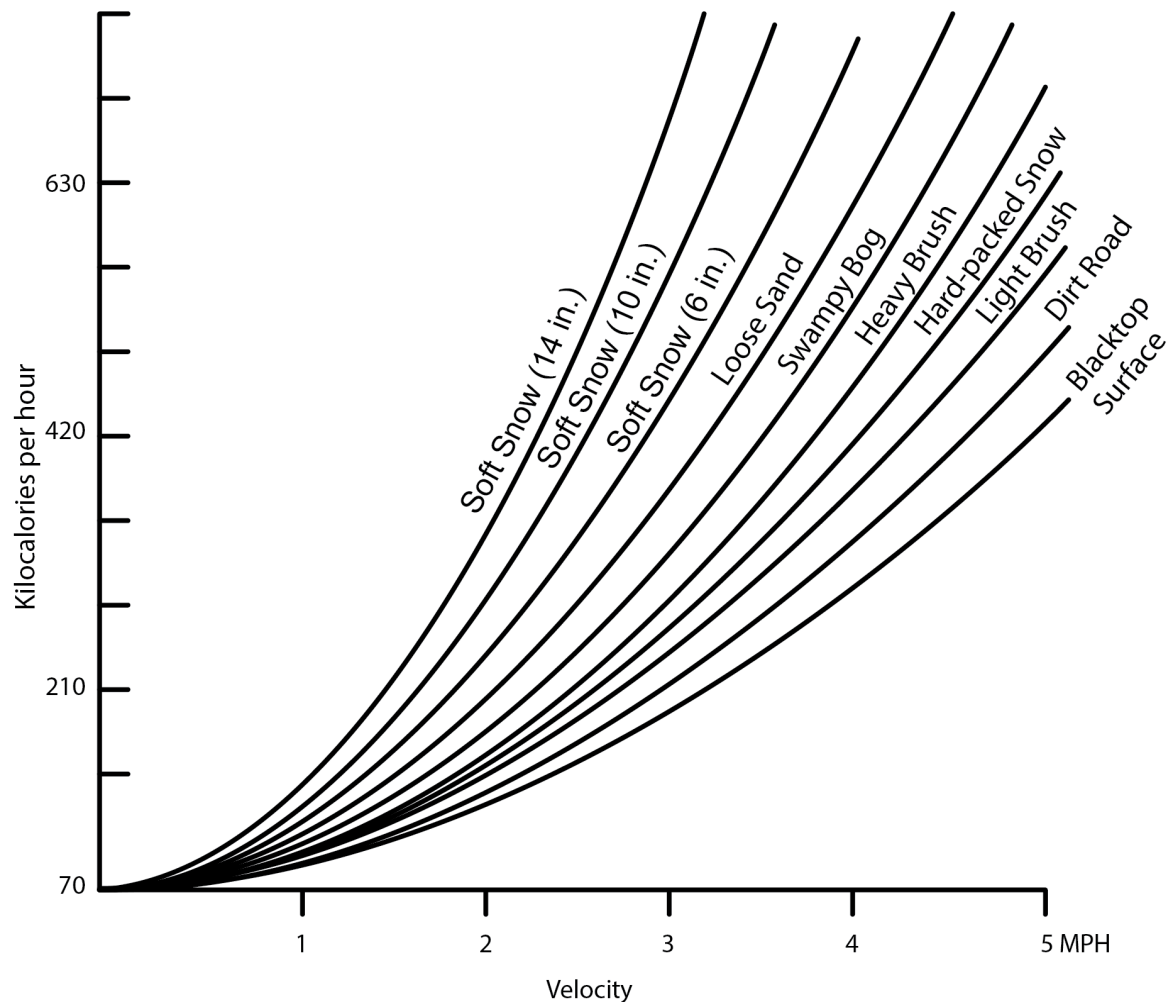


Figure 8-16. Energy expenditure while walking at different velocities (or speed) in various terrain conditions

b. Even though the Military Recommended Dietary Intakes or MRDIs (see AR 40-25) recommend a minimum of 4,700 kcal per day for men and 3,000 kcal per day for women working under exceptionally heavy activity, energy requirements for cold-weather field operations are variable and difficult to predict.

c. Table 8-3 provides the daily energy expenditures for various military activities. Note that the total caloric expenditure for military units performing field activities in the cold ranges from 4,200-6,800 kcal per day.

Table 8–3
Daily energy expenditures of military activities

Group	Activity	kcal per day
Army Special Forces	Combat exercise, temperate	3400
Army Engineers	Build road and airstrip at altitude	3549
Army Transportation Company	Garrison	3568
Marine Combat Engineers	Construction	3668
Marine	Summer high-altitude training course	3782
Israeli Infantry	Combat exercise, summer	3937
Army	Support hospital	3960
Army Ranger	Training course	4010
Army Ranger	Training course	4090
Marine	Artillery exercise, desert	4115
Marine	Combat exercise, winter	4198
Army	Artillery exercise, winter	4253
Israeli Infantry	Combat exercise, winter	4281
Army Special Forces	Combat exercise, winter	4558
Marine	Winter high-altitude training course	4596
Marine	Crucible, women	4679
Australian Infantry	Jungle training	4750
Army Special Forces	Assessment school	5183
Army Ranger	Combat exercise	5185
Marine	Crucible, men	6067
Norwegian Soldiers	Winter training exercise – ski march	6155
Norwegian Ranger	Training course	6250
Norwegian Soldiers	Winter training exercise – ski march	6851

Note: Measurement by doubly labeled water involves replacement of hydrogen and oxygen molecules with uncommon isotopes for tracing purposes, enabling measurement of kilocalories.

d. Severe environmental conditions may negatively affect appetite and thirst. In these circumstances, food and water intake may need to be encouraged to limit energy and fluid deficits. Several research studies have shown that even though Soldiers were provided with an adequate supply of rations, they did not consume enough food to meet their energy requirements. If Soldiers are able to eat ~60% of their daily requirements, they can limit the amount of muscle loss that occurs when energy deficits are high. It is important to note that the increased energy allowance does not apply to military personnel stationed in cold climates who are not engaged in field operations.

e. The additional calories most individuals need per day during cold weather operations can be obtained by eating a “normal” breakfast, lunch, and dinner, and then supplementing with frequent snacks throughout the day. Food items issued with regular meals can be saved and eaten later as between-meal snacks. Soldiers can keep items such as those found in the Modular Operational Ration Enhancement (MORE)–High Altitude / Cold Weather (Type I) enhancement pack (see figure 8–19), nut raisin mixes, dessert bars, candies, cookies and the fortified items such as beverage bases, chocolate protein drink, cheese spread, peanut butter, crackers, snack breads, pudding, fruits, and First Strike® bars in their pockets, handy for frequent snacking.

f. It is important to note that even with the intake of extra food and calories provided, these extra calories may still be less than calories expended, especially during strenuous operations. This may require that additional supplement food products be provided during cold-weather operations. Alternatively, optimized recovery nutrition feeding regimens may be required to make up for sub-optimal nutrient intake during cold-weather operations.

g. Daily energy requirements resulting from exposure to extreme environmental conditions (for example, muscle activity related to shivering) are minor relative to the added energy requirements associated with increased clothing, load carried, and maneuvers through extreme terrain. However, Soldiers should ensure they have adequate insulation when sleeping since their core temperatures decrease naturally during sleep. Soldiers who must hike, ski, or snowshoe for very long distances will benefit by eating more foods such as crackers, potatoes, cereals, bread, and noodles, which are high in carbohydrates. Carbohydrates convert quickly into usable energy or stored as fat.

8–12. Hydration

a. Maintaining hydration during cold weather operations is critical as physical and cognitive impairments can occur due to dehydration. Sweating is the principal factor contributing to body water loss in the cold because metabolic heat production still usually exceeds body heat loss. In cold and high-altitude environments, increased work intensity energy expenditure, added clothing insulation, low ambient humidity, and the diuretic response that often accompanies hypobaric hypoxia will increase fluid needs modestly.

b. Fluid requirements during cold weather training will vary according to physical activity levels, but for most people, ~3-6 quarts per day (no more than 1 ½ quarts per hour) should be consumed. This includes the water that is in food. Meal, Ready-To-Eat (MREs) average only ~7 ounces of fluid per meal (less than ¼ quart), so Soldiers will get less than 1 quart of total fluid from three MREs. The best time for Soldiers to rehydrate is at mealtime. Soldiers usually drink most of their water with meals, and eating food improves water consumption. Soldiers should be provided with adequate time (at least 15 minutes) to consume meals and fluids. Cold exposure reduces thirst, and logistical constraints in cold environments might limit fluid availability (for example, frozen drinking supplies). In colder temperatures, flavored waters, juice, and warm teas, coffee, and broths may increase voluntary fluid consumption and aid in hydration maintenance. In addition to the water from MREs, Soldiers should consume ½ quart (or 2 cups) of fluid with breakfast, lunch, and dinner. Depending on the level of physical activity, Soldiers should drink 1-4 quarts more fluid throughout the day. When using the Meal, Cold Weather (MCW) ration, 28-40 ounces of water are needed to rehydrate the food within each menu; an additional 1-3 quarts should be consumed throughout the day.

c. A Soldier should begin each training day by tracking his or her hydration status. Using a parachute cord with beads is one way to track how many times a canteen or hydration system is refilled during the day. If hydration is inadequate, encourage extra fluid in the morning and

throughout the day. Note that the observation of urine color to assess hydration status is recommended only during the first morning void. A squad “pee zone” can be designated and checked daily. If the ice or snow is dark in color, this is an indication that the Soldiers are not drinking enough.

d. Squad stoves and tent heaters can be used to boil snow or ice to make water. Snow should not be eaten as the air in it can cause gastrointestinal distress.

8–13. Fluid containers/hydration systems

a. The first and second Gulf Wars saw increasing use of hydration systems (large collapsible bladder drinking systems) in place of, or in addition to, canteen usage. Soon after, 3 L (~3 quart) systems became standard issue as a component of the modular lightweight load-carrying equipment system of load-bearing equipment and backpacks. Although hydration systems allow hands-free drinking and less frequent filling, the volume and consumption of water from hydration systems are more difficult to track than canteen consumption and may be a contributing factor to both under- and overdrinking problems. Furthermore, in cold weather, fluid in the plastic tubing or bite valve may freeze, making these bladder drinking systems unusable.

b. Canteens and hydration systems containing carbohydrate (sugar) solutions increase the growth of harmful bacteria, which increases the incidence of gastrointestinal upset. Additional canteen sanitation is needed when sugar-containing beverages are added. Canteens and hydration systems containing carbohydrate solutions should be rinsed with water daily and treated with a hypochlorite solution every 2 or 3 days. The frequency of these sanitation actions depends on the quality of water, liquid temperature, and composition of the beverage. Flavoring reduces the effectiveness of chlorine to fight microbial growth, so these beverages should be added to already purified water and consumed within several hours. Carbohydrate solutions should not be added to personal hydration systems due to added sanitation difficulties.

8–14. Individual rations

a. The selection of military rations for cold-weather operations is influenced by the tactical situation, mission, and logistical support. These factors determine length of operations, how feasible it is to carry the rations, how often resupply would occur, and how much water would be available. Thus, ration weight, size, and amount of water required for reconstitution are important considerations. Military rations used for cold-weather field feeding are nutritionally adequate in accordance with the MRDIs (AR 40–25). The MRDIs are used for evaluating the nutritional adequacy of military rations, ensuring that military personnel maintain their nutritional status, health, and performance in extreme as well as temperate environments.

b. Figure 8–17 shows the most common individual rations Soldiers receive during cold weather operations: the MRE and the MCW. The MRE provides balanced nutrition and low logistical burden, however, three to four standard MREs per day (~1,300 kcal per MRE) must be eaten to supply the 4,200–4,700 kcal that some Soldiers require during cold weather, if no other rations are provided. The MREs include liquid-containing components that can freeze during cold weather operations if these items are not kept warm by carrying them inside the clothing. Additionally, MREs have a potable water requirement of approximately 23 ounces per meal.

c. The MCW is designed to meet the nutritional requirements for missions in extreme cold weather. Soldiers should consider using the MCW during cold weather operations when temperatures are below 32 °F for extended periods, and water/snow is able to be heated. Three MCWs per day (1,540 kcal per MCW) equals a day’s worth of food and provides approximately 4,600 kcal which may be necessary to meet increased energy requirements

when conducting operations in extreme cold weather environments. The lightweight MCW contains a precooked, dehydrated entree and other low moisture foods (for example, granola, dried fruits, nuts, and ramen noodle soup) that will not freeze. Each menu includes several powdered beverages to encourage water consumption and counter dehydration during cold weather activities. Limits on protein and sodium help to reduce the risk of dehydration in cold weather environments. The MCW requires approximately 30 ounces of potable water to rehydrate the ration components within each menu.



Figure 8–17. Meals Ready to Eat (left) and Meals, Cold Weather (right)

8–15. Assault/special purpose ration

The First Strike Ration® (FSR) is a compact, eat-on-the-move individual ration intended to be consumed during the initial stages of an intense conflict and one that should be considered for short duration (for example 1-3 days), highly mobile, dismounted missions (see figure 8–18). The FSR provides a day's worth of food and is substantially lighter and more compact than the MRE, enhancing Soldier consumption, nutritional intake, and mobility. The FSR contains familiar, eat-out-of-hand foods that require little or no preparation such as pocket sandwiches, ready-to-eat tuna and chicken, energy bars, powdered beverages, caffeinated gum, beef jerky and carbohydrate enhanced applesauce. One FSR provides ~2,900 kcal per day which may be substantially less than the energy required during cold weather operations. The FSR requires approximately 30 ounces of potable water.



Figure 8–18. The First Strike Ration

8–16. Enhancement packs

The MORE is an enhancement pack that is designed to augment (not replace) operational ration use by Soldiers in extreme, demanding, operational environments when their calorie requirements exceed those provided by their daily rations (see figure 8–19). There are some instances during exceptionally heavy activity where Soldiers will need ~3,000-4,700 calories (females and males, respectively) per day. The MORE contains lightweight, compact, eat-on-the-move components that are easy to consume and digest, giving Soldiers approximately 1,000 extra calories per pack in a balance of carbohydrates, caffeine, electrolytes, and vitamins for those extreme operational environments such as high altitude/cold weather. The MORE augments the MRE, MCW, FSR, as well as the family of Unitized Group Rations with additional nutrition to help combat Soldier weight loss and decreased physical and cognitive performance. (See AR 30–22 for a description of Unitized Group Rations.) Potable water requirements for the High Altitude / Cold Weather (Type I) are 12 ounces per pack.



Figure 8–19. The Modular Operational Ration Enhancement

APPENDIX A

References

Section I

Required publications

AR 40–501

Standards of Medical Fitness, 2019

AR 385–10

The Army Safety and Occupational Health Program, 2023

ATP 3–90.97

Mountain Warfare and Cold Weather Operations, 2016

ATP 4–02.7

Multi-Service Tactics, Techniques, and Procedures for Health Service Support in a Chemical, Biological, Radiological, and Nuclear Environment, 2016

TB MED 505

Altitude Acclimatization and Illness Management, 2010

TB MED 507

Heat Stress Control and Heat Casualty Management, 2022

Section II

Related publications

AR 30–22

Army Food Program, 2019

AR 40–25

Nutrition Standards and Education, 2017

AR 40–5

The Army Public Health Program, 2020

AR 40–400

Patient Administration, 2014

AR 670–1

Wear and Appearance of Army Uniforms and Insignia, 2021

ATP 4–02.8

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ATP 4–25.12

Unit Field Sanitation Team, 2014

ATP 4–02.55

Army Health System Support Planning, 2020

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DoDD 6490.02E

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FM 4–02

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Centers for Disease Control and Prevention

Clinical Guidance for Carbon Monoxide (CO) Poisoning
(Available at <https://www.cdc.gov/carbon-monoxide/hcp/clinical-guidance/index.html>.)

Section III

Prescribed forms

No entries for this section.

Section IV

Referenced forms

No entries for this section.

Section V

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APPENDIX B

Cold Weather Deployment Tips

B–1. Prevention categories

Preventing cold weather injuries depends on several factors including prior cold weather experience; proper use of clothing, equipment, and supplies; and appropriate planning for all operational scenarios. In addition to implementing these measures, Soldiers must be carefully observed for signs of distress in the cold and monitored for development of peripheral cold injuries and hypothermia. Clothing, shelter, nutrition, and rest/work cycles must be adjusted according to observations.

B–2. Weak link rule

When the first cold casualty occurs, assess the status of the whole unit.

B–3. Prior cold weather experience

a. Classroom training is not sufficient preparation for cold weather deployment; Soldiers must learn to work in the cold before deployment to cold regions.

b. Training exercises in cold weather should initially be conducted for short periods under very controlled conditions, and progressively increase in duration and intensity to several days of mission-related tasks under supervision.

c. Training sessions should be designed to provide practical experience under cold conditions, including proper use of cold weather clothing during both work and rest periods; efficient shelter construction (with external heat source); meal preparation; and use of other mission-related equipment which may function differently in the cold. Soldiers must be able to complete these tasks efficiently even when cold and fatigued.

d. Soldiers with prior cold weather experience dress effectively to avoid overheating and excessive cooling, be more efficient at conducting tasks in the cold, and have a better understanding of their own performance in the cold.

e. Leaders gain a better understanding of the capabilities of the unit and the function of equipment in the cold.

B–4. Clothing, equipment, and supplies

Soldiers must have access to the proper cold weather clothing, including items such as balaclavas, gaiters, goggles, gloves/mittens, and cold weather boots. Layering principles must be followed for the clothing to be effective. This requires training and experience. Clothing must be kept clean and dry. Several changes of socks are necessary to keep feet dry and reduce the risk of trench foot. Equipment and supplies used in cold weather must be tested in a cold environment and must be usable by Soldiers with reduced manual dexterity due to wearing gloves. Some equipment may require special tools for assembly or use in the cold so that Soldiers will not have to take off their gloves.

B–5. Operational planning

Everything takes longer in a cold environment, and this may be exacerbated by fatigued Soldiers, poor weather conditions, and exposure that is worse than expected. The weather, unit fitness, work/rest cycles, shelter, and nutrition need to be considered during planning.

a. Weather.

(1) A reliable source for evaluating cold stress is necessary. Any weather monitoring devices relied on must be tested in extreme cold environments to ensure proper functioning.

(2) Weather patterns may change abruptly; therefore, planning must include contingencies for greater-than-expected exposure, particularly if Soldiers are immobile or could get wet.

(3) Precipitation and water immersion greatly increase the risk of cold injury. Careful planning to avoid these conditions and provide emergency evacuation/rewarming are imperative.

b. Unit fitness.

(1) Cold weather operations may be more physically demanding, due to heavier loads (for example, more clothing), walking in snow or heavier boots, and mountainous terrain.

(2) Tired Soldiers are more prone to injury and are less efficient at preparing shelter and meals which could increase their exposure and risk of injury.

c. Work/Rest cycles.

(1) The concept of work/rest cycles can be implemented to avoid overheating and sweating in Soldiers who are physically active, and to avoid excessive cooling in Soldiers who are immobile.

(2) Sweat accumulation can lead to damp or wet clothing and increase body cooling. Soldiers who have worked hard and have damp clothing should change into dry clothing as soon as possible.

(3) Immobile Soldiers must be aware of extremity cooling. Placing extra insulation on the ground will limit conductive heat loss. Even small movements (stamping feet, swinging arms) will provide some internal heat.

(4) Both wind and solar load affect body temperature and should be used to advantage. For example, an immobile Soldier located out of the wind and exposed to the sun will be much warmer than one who is in the shade and exposed to wind.

d. Shelter.

(1) Adequate shelter is imperative so that Soldiers are able to rewarm and dry their clothing.

(2) Soldiers should be able to erect shelters in adverse conditions while wearing gloves.

(3) Safety guidelines for use of external heat sources must be followed.

e. Nutrition.

(1) Fluid intake is greatest at mealtime. Providing time for meals will ensure proper hydration as well as energy intake.

(2) Warm meals are important for improving morale and will help rewarm Soldiers who feel cold but are not yet hypothermic.

(3) Tired Soldiers may skip meals to avoid having to prepare stoves and heat water, but this practice will make them more susceptible to cold injury and further fatigue.

(4) Extra precautions are necessary to prevent water supplies from freezing in cold weather.

(5) Hydration of Soldiers can be monitored by noting the color and volume of urine. Dark yellow urine and infrequent urination indicate fluid intake should increase.

B-6. First aid for cold injuries

a. Early signs of hypothermia include shivering, withdrawal, and “the umbles” (stumbles, mumbles, fumbles, grumbles). Early intervention is imperative to take advantage of the heat generated from shivering. Remove wet clothing and increase dry insulation. Move the Soldier

to a heated shelter. Provide warm food or fluid to conscious Soldiers. Soldiers who are hypothermic and not shivering must be immediately evacuated.

b. Soldiers must be encouraged to take early action to rewarm cold extremities. Removal of wet socks or gloves is imperative. Dry, loose insulation will retain heat best. Swinging the arms or stomping the feet can increase blood flow to those regions. Increasing core temperature by exercise is most effective.

c. Extremities can be rewarmed in warm water (100-104 °F), but if frostbite is suspected, the extremity must be rewarmed only if refreezing will not occur.

d. Ensure Soldiers have adequate food and fluid intake, rest, and dry clothing.

APPENDIX C

Army Cold Weather Uniform and Equipment Posture

These tables are recommendations for five temperature ranges Soldiers encounter in cold regions. This recommendation covers clothing, equipment, training, nutrition, shelter and heat sources, and other additional control measures. These tables are adapted from ATP 3–90.97.

Table C–1
Temperature Zone 1: 33-55 °F (0.6-13 °C)

Area of Consideration	Special Requirements and Recommended Actions	
Available Personal Clothing and Equipment from ECWCS Generation III	Clothing Layer	ECWCS Generation III
	Base	Lightweight cold weather undershirt and drawers AND Midweight cold weather shirt/drawers
	Insulating	Green fleece jacket
	Outer	Wind cold weather jacket (wind shirt) Extreme cold/wet weather jacket (hard shell) Extreme cold/wet weather trousers (hard shell)
Other Available Personal Clothing and Equipment	Issued GORE-TEX® gloves with liners Issued wool socks with synthetic liner sock Temperate boots; Temperate Weather Army Combat Boot or Temperate Weather Mountain Combat Boot Balaclava and neck gaiter liners Arctic necklace (lighter and lip balm worn around neck) Suspenders Knife	
Training	Knowledge of mountain and cold weather environmental hazards Knowledge of cold weather clothing capabilities and limitations Skill to use cold weather clothing and equipment to provide protection from the elements Skill to prevent, recognize, and treat cold injuries	

Table C–1
Temperature Zone 1: 33-55 °F (0.6-13 °C)—Continued

Area of Consideration	Special Requirements and Recommended Actions
Food and Water	MRE; ~1300 calories per meal One hot meal daily as mission dictates 3.5-5 quarts of water per day Water filter
Shelter and Heat	Patrol bag GORE-TEX® bivouac cover Sleeping mat Poncho Poncho liner (optional)
Additional Control Measures	Water re-supply plan Sanitation plan

Legend

C – Celsius
ECWCS – Extended Cold Weather Clothing System
F – Fahrenheit
MRE – meal, ready to eat

Table C-2
Temperature Zone 2: 14-32 °F (~10-0 °C)

Area of Consideration	Special Requirements and Recommended Actions	
Available Personal Clothing and Equipment from ECWCS Generation III	Clothing Layer	ECWCS Generation III
	Base	Lightweight cold weather undershirt and drawers AND Midweight cold weather shirt/drawers
	Insulating	Green fleece jacket
	Outer	Wind cold weather jacket (wind shirt) Extreme cold/wet weather jacket (hard shell) Extreme cold/wet weather trousers (hard shell) Extreme cold weather parka (puffy jacket)
Other Available Personal Clothing and Equipment	Issued GORE-TEX® gloves with liners Trigger finger mittens with extra trigger finger liners Contact gloves Issued wool socks with synthetic liner sock Intermediate Cold-Wet Boot (with removable liner) Balaclava and neck gaiter Arctic necklace (lighter and lip balm worn around neck) Ski goggles Suspenders Knife	
Training	Northern Warfare Training Center's Cold Weather Orientation Course Cold Weather Leader's Course Other program of instruction similar to above	
Food and Water	MREs (unfrozen); ~1300 calories per meal Meal, cold weather (MCW) 1 bag = 1 meal which provides about 1540 calories 30 ounces of heated water are required to hydrate one MCW Two hot meals per day as mission dictates 3.5-5 quarts of water per day One stove per team to heat water for rations and melt snow	

Table C–2
Temperature Zone 2: 14-32 °F (~10-0 °C)—Continued

Area of Consideration	Special Requirements and Recommended Actions	
Shelter and Heat	Individual:	MSS, all components Sleeping mat Poncho and poncho liner
	Squad:	Arctic 10-man tent Space heater Arctic
Additional Control Measures	Begin leader/medic checks for cold injuries; 2-3 times daily at minimum Water re-supply and storage plan (to prevent water from freezing) Sanitation plan No skin camouflage below 32 °F (0 °C) Contact gloves must be worn when working outdoors POL gloves must be worn when working with fuel Consider four-season, 2-4 man shelters for personnel that work away from support base	

Legend

C – Celsius
 ECWCS – Extended Cold Weather Clothing System
 F – Fahrenheit
 MCW – Meal, cold weather
 MRE – Meal, ready to eat
 MSS – Medium shelter systems
 POL – Petroleum, oil, and lubricants

Table C-3
Temperature Zone 3: -19-14 °F (-28-10 °C)

Area of Consideration	Special Requirements and Recommended Actions	
Available Personal Clothing and Equipment from ECWCS Generation III	Clothing Layer	ECWCS Generation III
	Base	Lightweight cold weather undershirt and drawers AND Midweight cold weather shirt/drawers
	Insulating	Green fleece jacket
	Outer	Wind cold weather jacket (wind shirt) Soft shell cold weather jacket (soft shell) Soft shell cold weather trousers (soft shell) Extreme cold weather parka (puffy jacket) Extreme cold weather trousers
Other Available Personal Clothing and Equipment	Issued GORE-TEX® gloves with liners Trigger finger mittens with extra trigger finger liners Contact gloves Arctic mittens Issued wool socks with synthetic liner sock Cold Weather Combat Boot Balaclava and neck gaiter Arctic necklace (lighter and lip balm worn around neck) Ski goggles Suspenders Knife	
Training	Northern Warfare Training Center's Cold Weather Orientation Course Cold Weather Leader's Course Other program of instruction similar to above	

Table C–3
Temperature Zone 3: -19-14 °F (-28-10 °C)—Continued

Area of Consideration	Special Requirements and Recommended Actions	
Food and Water	MREs (unfrozen); ~1300 calories per meal MCW 1 bag = 1 meal which provides about 1540 calories 30 ounces of heated water are required to hydrate one MCW Two hot meals per day as mission dictates 3.5-5 quarts of water per day One stove per team to heat water for rations and melt snow	
Shelter and Heat	Individual:	MSS, all components Sleeping mat Poncho and poncho liner
	Squad:	Arctic 10-man tent Space heater Arctic
Additional Control Measures	Implement all control measures from Temperature zone 2 and change/add the following: Increase frequency of leader/medic checks for cold injuries Rotate Soldiers in static positions frequently Provide warm tents and vehicles for Soldiers Provide four-season shelters for personnel that work away from support base	

Legend

C – Celsius
ECWCS – Extended Cold Weather Clothing System
F – Fahrenheit
MCW – meal, cold weather
MRE – meal, ready to eat
MSS – medium shelter systems

Table C-4
Temperature Zone 4: -40 to -20 °F (-48 to -40 °C)

Area of Consideration	Special Requirements and Recommended Actions	
Available Personal Clothing and Equipment from ECWCS Generation III	Clothing Layer	ECWCS Generation III
	Base	Lightweight cold weather undershirt and drawers AND Midweight cold weather shirt/drawers
	Insulating	Green fleece jacket
	Outer Shell	Wind cold weather jacket (wind shirt) Soft shell cold weather jacket (soft shell) Soft shell cold weather trousers Extreme cold weather parka (puffy jacket) Extreme cold weather trousers
Other Available Personal Clothing and Equipment	Issued GORE-TEX® gloves with liners Trigger finger mittens with extra trigger fingers liners Contact Gloves Arctic mittens Issued wool socks with synthetic liner sock Extreme Cold Weather Boot Balaclava and neck gaiter Arctic necklace (lighter and lip balm worn around neck) Ski goggles Suspenders Knife	
Training	Northern Warfare Training Center's Cold Weather Orientation Course Cold Weather Leader's Course Other program of instruction similar to above	
Food and Water	MCW 1 bag = 1 meal which provides about 1540 calories 3.5-5 quarts of water per day 30 ounces of heated water are required to hydrate one MCW One stove per team to heat water for rations and melt snow Two hot meals per day as mission dictates	

Table C-4
Temperature Zone 4: -40-20 °F (-48-40 °C)—Continued

Area of Consideration	Special Requirements and Recommended Actions	
Shelter and Heat	Individual:	MSS, all components Sleeping mat Poncho, and poncho liner
	Squad:	Arctic 10-man tent Space Heater Arctic
Additional Control Measures	Implement all control measures from Temperature zone 3 and change/add the following: Limit outdoor operations and training Closely scrutinize operations and training by leaders Perform hourly leader/medic checks for cold injuries Recognize risk level is high Cover all exposed skin Avoid static duty, if possible Work groups of no less than two personnel	

Legend

C – Celsius
 ECWCS – Extended Cold Weather Clothing System
 F – Fahrenheit
 MCW – meal, cold weather
 MSS – medium shelter systems

Table C–5
Temperature Zone 5: Below -40 °F (-40 °C)

Area of Consideration	Special Requirements and Recommended Actions	
Available Personal Clothing and Equipment from ECWCS Generation III	Clothing Layer	ECWCS Generation III
	Base	Lightweight cold weather undershirt and drawers AND Midweight cold weather shirt/drawers
	Insulating	Green fleece jacket
	Outer Shell	Wind cold weather jacket (wind shirt) Soft shell cold weather jacket (soft shell) Soft shell cold weather trousers Extreme cold weather parka (puffy jacket) Extreme cold weather trousers
Other Available Personal Clothing and Equipment	Issued GORE-TEX® gloves with liners Trigger finger mittens with extra trigger finger liners Contact Gloves Arctic mittens Issued wool socks with synthetic liner sock Extreme Cold Weather Boot Balaclava and neck gaiter Arctic necklace (lighter and lip balm worn around neck) Ski goggles Suspenders Knife	
Training	Northern Warfare Training Center's Cold Weather Orientation Course Cold Weather Leader's Course Other programs program of instruction similar to above	
Food and Water	MCW 1 bag = 1 meal which provides about 1540 calories 3.5-5 quarts of water per day 30 ounces of heated water are required to hydrate one MCW One stove per team to heat water for rations and melt snow Two hot meals per day as mission dictates	

Table C–5
Temperature Zone 5: Below -40 °F (-40 °C)—Continued

Area of Consideration	Special Requirements and Recommended Actions	
Shelter and Heat	Individual:	MSS, all components Sleeping mat Poncho, and poncho liner
	Squad:	Arctic 10-man tent Space Heater Arctic
Additional Control Measures	Implement all control measures from Temperature zone 4 and change/add the following: Recognize risk level is extremely high Limit outdoor operations and training to critical life support tasks only Warm tents and vehicles for all personnel Work groups of no less than two personnel	

Legend

C – Celsius
 ECWCS – Extended Cold Weather Clothing System
 F – Fahrenheit
 MCW – meal, cold weather
 MSS – medium shelter systems

APPENDIX D

Iloprost Storage, Infusion, and Administration

D-1. Storage

The U.S. formulation of iloprost has only been studied for drug stability at narrow temperature ranges. When stored, avoid sunlight and freezing, and maintain at 68-75 °F (20-25 °C), though excursions up to 59-86 °F (15-30 °C) are permitted. When reconstituted, the solution is stable for 4 hours at 68-75 °F (20-25 °C).

D-2. Infusion

Infuse through a peripheral line with an in-line 0.22 or 0.2 micron (µm) filter and with a positive pressure-driven infusion pump adjustable in increments of 0.1 mL per hour. The reservoir and infusion line sets should be made of polyvinyl chloride. Most patients require two vials per day of iloprost. Infusion rate is calculated as shown in figure D-1 below:

$$\text{Infusion Rate (mL/hr)} = \frac{\text{Dose} \left(\frac{\text{ng} \cdot \text{min}}{\text{kg}} \right) * \text{Weight (kg)} * 60 \left(\frac{\text{min}}{\text{hr}} \right)}{1000 \text{ ng/mL}}$$

Figure D-1. Iloprost infusion rate equation

D-3. Administration

- a. Obtain 1 vial of iloprost 100 mcg/mL (1 mL).
- b. Dilute 100 mcg (1 mL) in 100 mL of 0.9% Sodium Chloride for a final concentration of 1 mcg/mL.
- c. Correct hypotension before infusion and monitor vital signs prior to start of the infusion and with every dose increase.
- d. Dose by actual body weight, starting at 0.5 nanograms(ng)/kg/min and increasing by 0.5 ng/kg/min every 30 minutes to a maximum of 2 ng/kg/min.
 - (1) 6 mL/hour for patients 50 kg.
 - (2) 7.2 mL/hour for patients 60 kg.
 - (3) 8.4 mL/hour for patients 70 kg.
 - (4) 9.6 mL/hour for patients 80 kg.
 - (5) 10.8 mL/hour for patients 90 kg.
 - (6) 12 mL/hour for patients 100 kg.
- e. Continue infusion for a maximum of 6 hours.
- f. If patient experiences intolerable headaches, tachycardia (heart rate > 100 beats/minute), palpitations, hypotension (systolic blood pressure < 90 mm Hg), nausea, vomiting, or facial flushing, decrease the infusion rate by 0.5 ng/kg/min and reassess 30 minutes later (these are dose-related side effects which usually resolve quickly with dose reduction).
- g. Repeat infusion daily for up to 8 days (5 days per Whitehorse Protocol).
- h. If patient tolerates infusion well on days 1-3, may initiate infusion at the maximum infusion rate on day 4 and beyond; adjust rate as needed based on tolerability.

GLOSSARY and TERMS

Section I**Abbreviations and Acronyms****A2CU**

Army aircrew combat uniform

ACU

Army combat uniform

AMS

Acute mountain sickness

AV

Atrioventricular

AVPU

Alert, verbal, pain, unresponsive

BID

Twice a day

BP

Blood pressure

C

Celsius

CID

Cold-induced diuresis

CIVD

Cold-induced vasodilation

CNS

Central nervous system

CO

Carbon monoxide

CO₂

Carbon dioxide

CPR

Cardiopulmonary resuscitation

CVC

Combat vehicle crewman (coveralls)

ECLS

Extracorporeal Life Support

ECMO

Extracorporeal membrane oxygenation

ECWCS

Extended Cold Weather Clothing System

EEG

Electroencephalogram

F

Fahrenheit

g

Gram

GCS

Glasgow Coma Scale

HACE

High-altitude cerebral edema

HAPE

High-altitude pulmonary edema

HOPE

Hypothermia Outcome Prediction after Extracorporeal Life Support

ICE

International Accidental Hypothermia Extracorporeal Life Support

IV

Intravenous

kcal

Kilocalorie

kg

Kilogram

L

Liter

lb
Pound

LQTS
Long QT syndrome

mcg, µg
Microgram(s)

MCW
Meal, Cold Weather

MEB
Medical evaluation board

MET
Metabolic equivalent level

µm
Micron(s), micrometer(s)

mg
Milligram(s)

min
Minute

mL
Milliliter(s)

mm Hg
Millimeters of mercury

MOS
Military occupational specialty

mph
Miles per hour

MRE
Meals Ready to Eat

NBC
Nuclear, biological, and chemical

NFCI
Nonfreezing cold injury

ng
Nanogram

NSN
National Stock Number

PABA
Para-aminobenzoic acid

PGE₂
Prostaglandin E₂; hormone-like substance that contributes to inflammation

pH
Potential of hydrogen, a measure of acidity or alkalinity of a solution

POL
Petroleum, oil, and lubricants

SA
Sinoatrial

SOP
Standing operating procedure

SPF
Sun protection factor

tid
Three times a day

TN
Technical Note

rt-PA
Recombinant tissue plasminogen activator

TXA₂
Thromboxane A₂; enzyme product that contributes to blood clotting

TXB₂
Thromboxane B₂; product of TXA₂ that contributes to blood clotting

USARIEM
U.S. Army Research Institute of Environmental Medicine

UV
Ultraviolet

UVA

Ultraviolet A

UVB

Ultraviolet B

WCT

Wind chill temperature index

Section II

Terms

Acclimatization

Physiological adjustments to chronic exposure to extremes of temperature

Acid-base disturbance

Imbalance in the acidity and alkalinity of the blood serum

Acidosis, acidotic

Above-normal level of acid in blood and body fluids

Acute

Recent, and of short duration

Adventitious sounds

Respiratory noises in addition to normal breath sounds

Afterdrop

A continued fall in body core temperature as the skin and muscles are rewarmed, and colder blood from the skin and muscles returns to the body core

Alkalosis

Above-normal level of carbon dioxide in blood and body fluids

Aloe vera

Extract from a plant similar to cactus; can inhibit thromboxane (an inhibitor of wound healing)

Ambient

Relating to the immediate surroundings

Antinociception

Reduced sensitivity to pain

Anuria

Cessation of urination

Apnea

Cessation of breathing

Arachidonic acid

A polyunsaturated fatty acid that contributes to inflammation

Arachidonic acid cascade

Production of derivatives of arachidonic acid and their actions in the body, including the inflammatory process

Arctic region

Geographic region spreading around the North Pole (the Arctic Ocean, adjacent seas, and parts of Alaska, Canada, Finland, Greenland (Denmark), Iceland, Norway, Russia, and Sweden)

Arrhythmia

Abnormal heart rate or rhythm

Aspiration

Withdrawing fluid through a needle

Asystole

Cessation of electrical and mechanical activity of the heart

Ataxia

Incoordination of gait, speech, and/or eye movement

Atrioventricular node

A small mass of muscular fibers at the base of the wall between the atria that conducts the normal electrical impulse from the atria to the ventricles

Autonomic nervous system

Regulates involuntary physiologic processes including heart rate, blood pressure, respiration, digestion

Bleb

Blister filled with transparent fluid

Body core

In temperature measurement, refers to deep structures of the body, usually measured in the rectum or esophagus

Bradycardia

Below normal heart rate

Bronchorrhea

Watery mucus from lungs

Cerebral

Pertaining to the brain

Channelopathy

Disturbed function of proteins that regulate passage of ions, such as sodium and potassium, across cell membranes

Chronic

Long-lasting

Cognition, cognitive

Involving conscious intellectual activity (thinking, reasoning, or remembering)

Cold allodynia

Pain due to a stimulus that would not typically induce pain

Cold-induced vasodilation

Periodic oscillations of skin temperature following the initial decline during cold exposure, resulting from transient increases in blood flow

Cold strain

The physiological and psychological consequences of cold stress

Cold stress

The combined environmental and personal conditions that remove body heat and decrease body temperature

Compartment syndrome

Pressure within a muscle compartment in an extremity from muscle swelling, most commonly in the leg, that inhibits circulation

Conduction

Transfer of heat from the body to material in direct contact that is lower than body temperature, or from material in direct contact to the body that is higher than body temperature

Convection, convective heat loss

Transfer of heat from the body when air or liquid lower than body temperature moves over it, or from air or liquid to the body that is higher than body temperature

Corneal reflex

Blinking of eyelids in response to touch on surface of eye

Cutaneous

Pertaining to the skin

Cyanosis

Blueness of skin from decreased oxygenation

Cycloplegic

A drug that paralyzes the ciliary muscle of the eye, relaxing the eye in its work to focus on distant objects, and widening the pupil

Debridement

Removal of damaged tissue from a wound

Dermis

Layer of skin beneath the outer layer

Desiccation

Removal of moisture

Desquamation

Shedding of the outer layer of skin

Digit

Finger or toe

Diving response

Breath-holding, slowing of the heart rate, reduction of blood flow to the limbs, and a gradual rise in blood pressure

Dorsal

Upper side

Dysesthesia

Unpleasant, abnormal sensation that may be described as burning, wetness, itching, electric shock, and/or pins and needles

Edema

Swelling from excess fluid in body tissue

Electrolyte

Substance that contains electrically-charged particles, or ions, that affect fluid balance and blood pressure. The primary ions of electrolytes are sodium, potassium, calcium, magnesium, chloride, hydrogen phosphate, and hydrogen carbonate.

Emollient

A preparation that softens or soothes the skin

Endogenous

Originating from within the body

Endothelium

Thin membrane that lines the inside of blood vessels

Epidemiology

Incidence, distribution, and possible control of diseases and other factors relating to health

Erythema, erythematous

Abnormal redness of the skin

Erythrodermas

Severe inflammation of most of the body's skin surface

Eschar

Dry, dark scab of dead skin

Escharotomy

Surgical incision through an eschar

Etiology

Cause of a disease or abnormal condition

Extracellular

Occurring outside a cell or the cells of the body

Fasciotomy

Surgical incision to relieve swelling and pressure in a compartment of the body

Frostbite

Tissue freezing

Free radical

A molecule with one or more unpaired electrons in its outer shell, a type of unstable molecule that is made during normal cell metabolism. It can either donate an electron to or accept an electron from other molecules, behaving as an oxidant or reductant in the conversion of a substance to other products. Free radicals are part of the metabolism process and immune response, and the body has a number of mechanisms to control free radicals, however in conditions of disease and injury they can accumulate and cause damage to molecules and cells.

Glycogen

A carbohydrate that serves as a form of energy storage

Habituated, habituation

Decrease in the shivering and vasoconstrictor responses to cold exposure

HOPE score

Hypothermia outcome prediction after extra-corporeal life support; a survivability score based on sex, asphyxia, age, serum potassium, duration of cardiopulmonary resuscitation, and temperature.

Huddling

Coming close together in a group

Hyperalgesia

Increased pain sensitivity

Hyperhidrosis

Abnormally excessive sweating

Hyperkalemic

Above-normal level of potassium in blood and body fluids

Hyperreflexia

Over-responsive reflexes

Hyperthermia

Elevated body temperature

Hyperventilation

Rapid or deep breathing

Hypoglycemia

Low blood sugar

Hyporeflexia

Decreased response of reflexes

Hypothermia

Body temperature below 95 °F

Hypothyroidism

Under-activity of the thyroid gland, resulting in reduction of metabolism

Hypotension

Below-normal blood pressure

Hypothalamic

Pertaining to the hypothalamus, part of the brain that regulates hormonal control of body systems, including body temperature

Hypoventilation

Shallow breathing

Hypovolemia

Low volume of body fluid

Hypoxia

Insufficient level of oxygen

ICE score

Survivability score based on sex, asphyxiation, and serum potassium

Iatrogenic

Illness caused by medical examination or treatment

Ileus

Loss of contraction of the bowel

Iloprost

Synthetic prostacyclin used to treat severe frostbite

Ischemia, ischemic

Inadequate blood supply to an organ or part of the body

Jugular venous distension

Bulging neck vein

Layering

Method of placing several clothing layers on top of each other to increase insulation

Lee side

Downwind, on sheltered side

Long QT syndrome

Condition delaying repolarization (potential of the heart muscle to receive a new charge), prolonging the time between the Q wave (depolarization, or discharge of current to contract the heart muscle) and the T wave (repolarization) on an electrocardiogram

Linear relationship

A corresponding increase or decrease in two variables

Lipid

Category of biomolecule that includes triglycerides and cholesterol

Metabolic, metabolism

The conversion of the energy in food to energy available for cellular processes; the conversion of food to building blocks for proteins, lipids, nucleic acids, and some carbohydrates; and the elimination of metabolic wastes

Metabolic acidosis

Above-normal level of acid in blood and body fluids, from overproduction of acid, or failure of the kidneys to remove acid

Metabolic equivalent level

Energy expenditure during exercise relative to the resting energy expenditure (five metabolic equivalents (METs) is equal to five times the energy expenditure at rest)

Metatarsal

Long bone in the foot

Microvascular

Relating to the smallest blood vessels

Morbidity

Disease or medical condition

Motor skill

Function involving use of muscles. Gross motor skills require the use of large muscle groups (legs, torso, and arms); fine motor skills require the use of smaller muscle groups (wrists, hands, fingers, feet, and toes).

Myelin

Fatty sheath surrounding nerve fibers that insulates them and increases velocity of electrical impulses

Myocardial, myocardium

Heart muscle

Necrosis

Dead tissue in the body

Neurosis

Distress, without delusions or hallucinations

Nonfreezing cold injury

Injury sustained after prolonged exposure to cold wet conditions

Opalescent

Showing varying colors

Orthostatic reflex

Sustainment of blood pressure when standing up from sitting or lying down

Oxidation

Loss of one or more electrons in a chemical reaction, resulting in conversion of a substance to other products. The body oxidizes glucose and lipids (fats) to substances that produce energy.

Pallor

Paleness of skin

Paradoxical undressing

Removing one's own clothing despite cold temperature, due to a sudden feeling of warmth

Parasympathetic branch

Component of the nervous system that conserves energy when a person is at rest, and regulates bodily functions like digestion and urination

Paresthesia

Abnormal sensation of the skin (tingling, pricking, chilling, burning, numbness)

Pathophysiology

Disordered physiological processes associated with disease or injury

Phalanx

Section of a finger or toe

Polyuria

Overproduction of urine

Proprioception

The body's ability to sense movement, action, and location

Psychoses

Loss of contact with reality; may include delusions (false beliefs) and/or hallucinations

Prostaglandin

A hormone-like substance produced at sites of tissue damage or infection that controls inflammation, blood flow, and the formation of blood clots

Pulmonary edema

Accumulation of fluid in air sacs of the lungs

QT interval

The time from depolarization (discharge of current to contract the heart muscle) to repolarization (potential of the heart muscle to receive a new charge), producing the Q wave and the T wave on an electrocardiogram

Radiation

Transfer of heat from the body to surrounding objects with lower surface temperatures than the body, or from the sun, ground, and surrounding objects with higher temperatures to the body

Raynaud's phenomenon, Raynaud's syndrome

Condition that causes narrowing of the arteries in the fingers and toes, reducing blood flow

Relative humidity

Percentage of measured humidity relative to a maximum humidity at the same temperature

Respiratory acidosis

Above-normal level of acid in blood and body fluids, from failure of the lungs to expel carbon dioxide

Respiratory alkalosis

Low level of carbon dioxide in the blood, typically from rapid or deep breathing

Rhinorrhea

Watery discharge from the nose

Sclerema

Hardening of the subcutaneous tissue

Sequela

Consequence of a previous disease or injury

Sequestration

Separation of a part from a whole, as a portion of the circulating blood in a specific part

Sinoatrial node

A small mass of muscular fibers located in the right atrium of the heart that initiates the heartbeat

Skeletal muscle

Muscle that is attached to a bone

Subarachnoid hemorrhage

Bleeding in the space that surrounds the brain

Subcutaneous tissue

Deepest layer of skin, made up mostly of fat cells and connective tissue

Subdermal plexus

Nerve network in the deep dermis and between the dermis and subcutaneous tissue

Supine

Lying face up

Sympathetic branch

Prepares for stress by increasing the heart rate, increasing blood flow to the muscles, and decreasing blood flow to the skin

Tactile

The sense of touch

Toxicologic

Pertaining to poisons

Tachycardia

Above-normal heart rate

Tachypnea

Above-normal breathing rate

Temperate

Mild or moderate climate; temperatures between 26.6 and 64.4 °F, relative to cold weather (Köppen climate classification)

Thermistor

A sensor that measures electrical current generated by temperature

Thermogenesis, thermogenic

Production of heat

Thermoneutral

Range of ambient temperatures where the body can maintain its core temperature

Thermoregulation

Sustaining normal body temperature, even when the external temperature is very different

Thrombolytic

A drug that dissolves blood clots

Thrombocytopenia

Low blood platelet count

Thrombosis

Local coagulation or clotting of the blood in a part of the circulatory system

Thromboxane

A hormone released from blood platelets that induces platelet aggregation and arterial constriction

Tidal volume

The amount of air that moves in or out of the lungs with each respiratory cycle

Topical

Medication applied to a body surface

Tympanic

Pertaining to the eardrum

Urticaria

Red, itchy welts on the skin

Vascular

Relating to blood vessels

Vasoconstriction

Narrowing of blood vessels

Vasodilation

Widening of blood vessels

Vasomotor

Actions that alter the diameter of blood vessels

Vasospasm, vasospastic

Spasms of the small blood vessels near the surface of the skin, limiting blood flow

Wheal

Area of the skin that is temporarily raised, typically reddened, and usually accompanied by itching

Wind chill temperature index

Integration of wind speed and air temperature to provide an estimate of the cooling power of the environment; it standardizes the cooling power of the environment to an equivalent air temperature for calm conditions.

TB MED 508

09 January 2026

By Order of the Secretary of the Army:

RANDY A. GEORGE

*General, United States Army
Chief of Staff*

Official:

A handwritten signature in black ink, appearing to read 'M. Sannito', with a horizontal line extending from the end of the signature.

MATTHEW L. SANNITO

*Administrative Assistant
to the Secretary of the Army
2604002*

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