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Clinical Aspects of Cold Weather

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Clinical Aspects of Cold Weather
NAVEDTRA 13147A

This two assignment course is based on Clinical Aspects of Cold Weather Operations, revised by CAPT Stephen B. Lewis, MC, Naval Medical Research and Development Command and CDR H. Lester Reed, MC, Naval Medical Institute. It is designed to provide Medical Department personnel with the necessary knowledge and information resource to effectively participate as cold weather operations support personnel in severe climatic environments.

Check material received for completeness. Should any materials appear to be missing, notify this command immediately.

If an errata sheet is included, mark the changes indicated before starting the course.

All items are of the objective type and should be answered on the basis of the assigned readings in the text, regardless of your personal opinion or experience. The questions are intended to direct your study and test your understanding. The assignments have been arranged in sequence and should be completed in that order. Study the readings until you are familiar with the material and then answer the questions. Mark your answers on the answer sheet. Retain the booklet for reference should an assignment require resubmission.

You may find that some of the text content has become obsolete since it was written. However, since the course is based on the textbook, select the best answer from the information in the textbook. Obsolete material in the textbook will be deleted when the text is revised. This course is under revision at this time and will take effect in the near future.

To get maximum benefit from the course, complete assignments as quickly as possible. You must submit this course within 90 days from receipt of the course. If you require additional time, submit a request for extension before the due date of the assignment. Students who do not comply with this requirement are subject to disenrollment.

The passing grade for this course, or for each creditable unit, is 3.40. You may resubmit failed assignments. You must resubmit your failure within 30 days from receipt of failure letter to receive a minimum passing score of 3.40. If you should fail a second time, you will receive another failure letter and you will be automatically disenrolled from our system and may not resubmit for a period of 1 year for this course.

Naval Reserve Officers should anticipate a delay of 4 to 6 weeks in delivery of certifications of course and unit completions, since these must be forwarded via Naval Reserve Personnel Center, New Orleans, LA 70149, for recording and endorsement.

Questions, comments, and suggestions concerning this course are welcome. Submit them in letterform, reference the full course title and NAVEDTRA number, and clearly state the questioned area of the text or assignment booklet.

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NAVAL RESERVE RETIREMENT CREDIT

For the purposes of Naval Reserve retirement, this course is evaluated at 4 points. These points are creditable only to personnel eligible to receive them under current directives governing retirement of Naval Reserve personnel. After satisfactory completion of the course, retirement points will be credited by the Chief, Naval Reserve Personnel.

CLINICAL ASPECTS OF COLD WEATHER
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COURSE OBJECTIVES

Upon completing this course, and with 85 percent accuracy, the student will be able to identify:

1. The epidemiology of cold injuries.
2. The nature of the body heat transfer and the body's physiological reaction to cold exposure.
3. The specific environmental factors that impact on the human body's reaction to cold.
4. The host factors that modify the body's physiological adapting mechanisms.
5. The effects of nutrition, activity, and water metabolism on cold weather survival.
6. The etiology, prevention, symptoms, and treatment of specific freezing and nonfreezing cold injuries and other medical conditions of significance in cold weather tactical situations.

While working on this correspondence course, you may refer freely to the text. You may seek advice and instruction from others on problems, but the solutions submitted must be the result of your own work and decisions. You are prohibited from referring to or copying the solutions of others, or giving completed solutions to anyone else taking the same course. Noncompliance can result in suspensions from the course by the administering activity and disciplinary action by the Commander, Naval Military Personnel Command.

Naval courses may include several types of questions—multiple-choice, true-false, matching, etc. The questions are not grouped by type but by subject matter. They are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Not all courses use all of the types of questions available. The student can readily identify the type of each question, and the action required, by inspection of the samples given below.

MULTIPLE-CHOICE QUESTIONS

Each question contains several alternatives, one of which provides the best answer to the question. Select the best alternative, and blacken the appropriate box on the answer sheet.

SAMPLE

s-1. Who was the first person appointed Secretary of Defense under the National Security Act of 1947?

1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-1	□	■	□	□	- - -

TRUE-FALSE QUESTIONS

Mark each statement true or false as indicated below. If any part of the statement is false the statement is to be considered false. Make the decision, and blacken the appropriate box on the answer sheet.

SAMPLE

s-2. All naval officers are authorized to correspond officially with any systems command of the Department of the Navy without their respective commanding officer's endorsement.

1. True
2. False

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-2	□	■	□	□	- - -

MATCHING QUESTIONS

Each set of questions consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Items in column B may be used once, more than once, or not at all. Specific instructions are given with each set of questions. Select the numbers identifying the answers and blacken the appropriate boxes on the answer sheet.

SAMPLE

In questions s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions. Some responses may be used once, more than once, or not at all.

A. OFFICER	B. DEPARTMENT
s-3. Damage Control Assistant	1. Operations Department
s-4. CIC Officer	2. Engineering Department
s-5. Disbursing Officer	3. Supply Department
s-6. Communications Officer	

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-3	□	■	□	□	- - -
s-4	■	□	□	□	- - -
s-5	□	□	■	□	- - -
s-6	■	□	□	□	- - -

TABLE OF CONTENTS

TITLE PAGE

CLINICAL ASPECTS OF COLD WEATHER

INTRODUCTION

This publication is intended to serve as a practical presentation of information necessary for the medical officer charged with the care of units operating in cold environments. It is not intended to be a definitive cold weather text, but it does serve as a reference source for anyone interested in delving further into this area of pathophysiology. In these environments comfortable existence may be at best inconvenient and military operations extremely difficult. It should prove valuable to medical personnel who may be familiar with the cold environment by virtue of their residence or avocation. In addition, it should be helpful to the person who has had no prior cold weather experience or interest.

Cold weather has been an influencing factor on military operations since the classical period. Xenophon describes the mass freezing of Greek soldiers during the retreat from Babylon. Perhaps the most famous description of the adverse effects of cold on the combat soldier was that of Baron de Larrey, Surgeon General of Napoleon's army, who chronicled the retreat from Russia in 1812 and 1813. It was Larrey who unfortunately colored our thinking on the treatment of frostbite when he warned against rapid rewarming and advocated massaging with snow. Except for this error, understandable in his circumstances, most of his other observations were well made and appropriate.

Our own experiences in World War II and in Korea pointed out again that cold weather can take its casualty toll even in a field force supposedly well-equipped and supported. The casualty line from Valley Forge to the Chosen Reservoir, though almost 175 years long, is really much shorter in terms of the medical officer's practice. The presence of cold injuries in almost any war waged in temperate or subarctic situations is not necessarily a reflection on the medical personnel involved, their commanders, or the supply system. It is the result of the nature of warfare and of existing in a hostile environment. Man, for all practical purposes, is a tropical animal who without the technical considerations that provide us with clothing and shelters can survive only in a basically warm environment. However, education as to the prevention, early recognition, and treatment of cold weather related maladies, combined with educated, conscientious leadership will minimize casualties.

Cold weather will be more prevalent in fighting forces who are not in control of the tactical situation. This increasing incidence of cold injury is influenced by such conditions as prolonged exposure to cold temperatures; failure to rewarm, change clothing, perform personal hygiene, and obtain adequate warm food and fluids; and the accumulation of fatigue. Medical personnel must recognized these factors and consider them when planning the medical support of cold weather operations.

GENERAL CONSIDERATIONS

It may help to consider the epidemiological factors that contribute to cold injuries. A specific agent is present and a variety of environmental and host factors influence the incidence, prevalence, type, and severity of the injury. The specific agent is cold. There are variable environmental factors such as temperature, humidity, precipitation, and wind velocity. These environmental facets may be modified by donning appropriate clothing. The host factors include age; rank; history of previous cold injury; fatigue; other injuries; discipline, training, and experience; race and area of origin; nutrition and activity; and the use of drugs and medication.

Types of Cold

The two kinds of conditions that occur in cold regions are wet cold and dry cold.

Wet cold conditions occur when temperatures are near freezing. Variations in day and night temperatures as great as 30 to 40 degrees F (-1 to 4 degrees C) cause alternate freezing and thawing of the ground. This freezing and thawing is often accompanied by wet snow and rain, causing the ground to become slushy and muddy.

Dry cold conditions occur when the average temperatures are lower than 14 degrees F (-10 degrees C) during the day and night. During these conditions the ground is usually frozen and the snow is dry. These low temperatures, with strong winds, increase the need for protection of the entire body.

Heat Transfer

Many influences may either add heat to or abstract it from the body. Heat is lost by any of the classical physical routes of conduction, convection, radiation, and evaporation. A hand in contact with a cold wrench loses heat by conduction, while a near-naked swimmer in cold water loses heat largely by convection.

Conductive heat loss is usually negligible under most environmental conditions. However, it increases in importance if the body is immersed in cold water because water has a heat-removing capacity that is some 20 times that of air. The body loses heat to the environment by evaporation in a hot environment and by radiation and convection in a cold environment. Evaporative heat loss takes place at the skin from the evaporation of sweat. The process is greatly accelerated and accentuated by cold winds ("windchill") so that heat loss is much greater at all environmental temperatures if a wind is blowing than it is in still air. Heat can also be lost through evaporation within the respiratory tract. The amount of respiratory heat lost depends upon the ventilation rate as well as upon the temperature and humidity of the inspired air. Evaporative heat loss is, therefore, greater and more effective in dry atmospheres than in those with humidity.

Effects of Cold

Physiological Response to Cold

The host factors as they apply to the epidemiological concept of cold injury revolve around an understanding of the human physiological response to cold. The body operates at an optimum temperature of about 99 degrees F (37 degrees C). This refers to the body's core temperature, which comprises the central nervous system (CNS), heart, lungs, and abdominal viscera. While the shell (extremity) temperature may fluctuate safely through a wide range, the body's core functions at a peak efficiency within a narrow range. The ideal difference between the shell and core at rest is about 4 degrees C.

The control of body temperature, the balance between overcooling and overheating, is the role of the temperature regulatory center. This center keeps the temperature relatively constant in body tissues such as the brain, heart, and GI tract. Within the body the temperature of various areas is not uniform.

In the hypothalamus and adjacent preoptic region of the brain, there are clusters of nerve cells that, when cooled and heated in experimental animals, elicit the same physiological reactions in animals exposed to external environmental heat and cold. This temperature regulatory nerve center is connected by nerve pathways to specialized receptors in the skin. These receptors consist of a network of fine nerve endings specifically activated by heat or cold stimuli. The temperature receptors are especially sensitive to rapid changes in environmental temperatures. The hypothalamus behaves like a thermostat. Its set point may change during different physiological conditions. The thermosensitive receptors, particularly in the skin, contribute to the regulation of the set point.

Man and other homoiotherms regulate their internal body temperature within narrow limits by physiological control of blood flow from sites of heat production in the deep tissue to the body surface. This heat is a by-product of the metabolic processes.

The energy required to sustain all body functions, both at rest and during physical activity, is derived from the enzymatically controlled oxidative combustion of fuel substrates such as carbohydrates, fats, and proteins with carbon dioxide, water, and nitrogenous wastes as end products. These oxidative reactions are exothermic and occur predominantly in the metabolic furnace of the liver and large mass muscle tissues. Fortunately, these tissues are highly vascular structures.

At rest the average man of 154 pounds (70kg) of body weight with 2 square meters of skin produces 1.4 kilocalories of heat per minute or 90 kilocalories per hour. During periods of very strenuous physical effort, this same average man can produce up to 700 kilocalories per hour.

The human body has about 20% to 25% efficiency in converting the enzymatically released energy into productive work. The remainder is dissipated as heat.

If the heat content of the body is to remain constant, the heat product and heat gain must equal heat loss. In other words, the metabolic heat production plus or minus the radiant heat exchange, plus or minus the connective heat exchange, minus the evaporative heat loss equals the storage of heat in the body.

Physiological Effects of Cold Exposure

The physiological response to total body cooling is manifested by the conservation of thermal energy and by an increase in body heat production. With prolonged or severe exposure the body's defense mechanisms fail, heat loss exceeds heat production, and the body temperature falls.

During the initial response to cold exposure, stimulation of the sympathetic nervous system causes a reflex superficial vasoconstriction with blood shunting to the internal organs and an increase in blood pressure and peripheral vascular resistence. This is accompanied by reflex shivering, which increases muscular activity, heat production, and oxygen consumption. Oxygen saturation of venous hemoglobin falls from 60% at 24 degrees C to 30% at 4 degrees C measured at the brachial vein.

Constriction of cutaneous capillary beds is manifested by pallor, mottling, or cyanosis of the skin. In hypersensitive individuals release of histamine-like substances may cause urticaria. Blood coagulability is increased and water pooling in the extravascular spaces such as the skin, muscles, and subcutaneous tissues results in hemoconcentration. Sudden exposure to the extreme cold causes reflex muscle spasm and respiratory arrest.

A more gradual cooling process will eventually cause unconsciousness with rectal temperatures from 86 to 89 degrees F (30 to 32 degrees C). This is also accompanied by slower respiratory and heart rates and falling blood pressure. Although some individuals have survived rectal temperatures as low as 72 degrees F (22 degrees C), ventricular arrhythmias such as ventricular fibrillation (VF) and cardiac arrest may be expected whenever the rectal temperature falls below 80 degrees F (27 degrees C).

In persons exposed to rain, snow, wind, and cold, the onset of hypothermia may be insidious. The first warning may come with stumbling, violent shivering, marked fatigue, stubbornness, and hallucinations as the body temperature drops below 95 degrees F (35 degrees C). Personnel undergoing cold weather training have shivered and shook so uncontrollably they could not keep thermometers in their mouths. Unconsciousness and cardiorespiratory arrest may rapidly follow unless rewarming efforts are begun immediately.

Some researchers feel that recurrent exposure to cold and to changes in environmental temperatures may somehow lower resistance to infectious diseases; others feel that people are healthier living in a constant cold environment. Research in this area is incomplete, and definitive conclusions cannot be stated at this time.

Cold Weather and Other Stress Factors

The majority of the militarily strategic areas of the world where exposure to cold can be anticipated are rather desolate locations. In most snow-covered areas there can be a profound sense of isolation and an acute awareness of dependence on others. The effect of a cold wind with velocities up to 125 knots persisting for periods from several hours to several days can be emotionally devastating and stressful.

Frequently, these cold areas are at significant elevations above sea level so there can be a reduction in atmospheric oxygen with its added burden on the cardiorespiratory system and bone marrow. Many of these locations are close enough to the North or South Pole so there is the additional stress of 4 months of continuous daylight with the sun well above the horizon 24 hours a day and, conversely, 4 months of darkness. Indirectly, altered photoperiods may lead to changes in sleep and wake cycles resulting in the rapid eye movement (REM) thereby causing sleep deprivation. Significant sleep deprivation may alter thermoregulation and energy requirements. An additional stress factor is sunglare on snow and ice.

The need to wear many layers of special clothing, frequently weighing from 10 to 22 pounds, creates another problem. This makes the wearer very clumsy in performing many routine procedures. Even though mittens are more protective than gloves, they also are more cumbersome.

Trying to aim and fire a rifle in the cold is difficult with gusting wind buffeting you and the weapon. Shivering causes attempts to reload a rifle to be a frustrating experience. To clean or repair a rifle under these conditions is almost impossible.

The adverse effects of low environmental temperatures on the human body may be localized or generalized, or a combination of both. They may occur at temperatures above or below freezing and under wet or dry conditions. The pathophysiological features of cold injury are dependent on the environmental temperature, exposure time, and individual susceptibility.

ENVIRONMENTAL FACTORS

Windchill

Cold injuries may be produced in temperatures that are well above freezing (32 degrees F or 0 degrees C). Environmental temperature alone does not give a true indication of the relative impact of cold on the body. We know from our own experience that when a high wind is blowing it feels much colder than when it is calm. Temperature alone does not, therefore, give a true indication of the relative comfort of outdoor activities. Some scale has to be used, which is based on both temperature and wind, and a common one is the windchill scale. Human comfort depends on the rate at which heat is lost from the human body. Windchill, which is a measure of the combined effects of wind and temperature, is defined as the number of calories lost during one hour from a square meter of a surface kept at 91.4 degrees F (33 degrees C neutral skin temperature).

Thermometer readings alone will not give you a valid indication of the effects to expect on the body. A temperature of 20 degrees F (-7 degrees C) and a wind speed of 45 miles per hour produces the same effect as a temperature of -20 degrees F (-30 degrees C) and a wind speed of 4 miles per hour. Both of these conditions result in the loss of about 1400 kilocalories per hour. Therefore, both have a windchill factor of about 1400. You will find that other comparatively mild temperatures and high winds produce chilling effects on the body equal to those produced by subzero temperatures combined with light winds. With comparatively high temperatures and high winds, you must be prepared to protect yourself in the same way you would at much lower temperature readings.

The windchill scale is not strictly accurate as a measure of human comfort because it does not take into account many important factors such as activity, humidity, loss of heat in the breath, radiation from the sun, and the effects of lowered skin temperature. It is, however, a simple and practical guide that shows the conditions under which cold weather is dangerous, when exposed flesh is likely to freeze, and when special precautions must be taken. Figure 1 shows equivalent chill temperatures in relation to the ambient temperature and wind velocity.

Given a hypothetical situation, where the wind velocity is 25 miles per hour and the temperature is 15 degrees F (-9 degrees C) figure 1 shows that at the given wind velocity the temperature is -20 degrees F (-29 degrees C). In this situation exposed flesh may freeze in one minute.

One must also consider "man-made" wind velocity in all calculations. A snowmobile rider traveling at 15mph is now subject to that 15mph wind factor. Helicopter rotor down-wash and wind over the deck of a naval vessel underway can turn an otherwise calm day into a windy one; this can cause instant frostbite. As long as the temperature of the wind remains above freezing, there is no danger of freezing injury to dry exposed flesh.

Finally, it should be remembered that a person's level of activity and the presence of proper dry clothing will modify the effects of windchill.

FIG. 1 WINDCHILL CHART

WIND SPEED			COOLING POWER OF WIND ON EXPOSED FLESH EXPRESSED AS AN EQUIVALENT TEMPERATURE																				
KNOTS	MPH		Actual Thermometer Reading																				
CALM	CALM	F	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60
		C	4	2	-1	-4	-7	-9	-12	-15	-18	-21	-23	-26	-29	-32	-34	-37	-40	-43	-46	-48	-51
			Equivalent Temperature																				
3-6	5	F	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60	-70
		C	2	-1	-4	-7	-9	-12	-15	-18	-21	-23	-26	-29	-32	-34	-37	-40	-43	-46	-48	-51	-57
7-10	10	F	30	20	15	10	5	0	-10	-15	-20	-25	-35	-40	-45	-50	-60	-65	-70	-80	-85	-90	-95
		C	-1	-7	-9	-12	-15	-18	-23	-26	-29	-32	-37	-40	-43	-48	-51	-54	-57	-62	-65	-68	-71
11-15	15	F	25	15	10	0	-5	-10	-20	-25	-30	-40	-45	-50	-60	-65	-70	-80	-85	-90	-100	-105	-110
		C	-4	-9	-12	-18	-21	-23	-29	-32	-34	-40	-43	-46	-51	-54	-57	-62	-65	-68	-73	-76	-78
16-19	20	F	20	10	5	0	-10	-15	-25	-30	-35	-45	-50	-60	-65	-75	-80	-85	-95	-100	-110	-115	-120
		C	-7	-12	-15	-18	-23	-26	-32	-34	-37	-43	-46	-51	-54	-60	-62	-65	-71	-73	-79	-81	-84
20-23	25	F	15	10	0	-5	-15	-20	-30	-35	-45	-50	-60	-65	-75	-80	-90	-95	-105	-110	-120	-125	-135
		C	-9	-12	-18	-21	-26	-29	-34	-37	-43	-46	-51	-54	-60	-62	-66	-71	-76	-79	-84	-87	-93
24-28	30	F	10	5	0	-10	-20	-25	-30	-40	-50	-55	-65	-70	-80	-85	-95	-100	-110	-115	-125	-130	-140
		C	-12	-15	-18	-23	-29	-32	-34	-40	-46	-48	-54	-57	-62	-65	-71	-73	-79	-81	-87	-90	-96
29-32	35	F	10	5	-5	-10	-20	-30	-35	-40	-50	-60	-65	-75	-80	-90	-100	-105	-115	-120	-130	-135	-145
		C	-12	-15	-21	-23	-29	-34	-37	-40	-46	-51	-54	-60	-62	-68	-73	-76	-81	-84	-90	-93	-98
33-36	40	F	10	0	-5	-15	-20	-30	-35	-45	-55	-60	-70	-75	-85	-95	-100	-110	-115	-125	-130	-140	-150
		C	-12	-18	-21	-26	-29	-34	-37	-43	-48	-51	-57	-60	-65	-71	-73	-79	-81	-87	-90	-96	-101

WINDS ABOVE 40 MPH Have Little Additional Effect	LITTLE DANGER (For Properly Clothed Person) Maximum Danger Is False Sense of Security	INCREASING DANGER Danger From Freezing Of Exposed Flesh, (Flesh May Freeze Within One Minute)	GREAT DANGER (Flesh May Freeze Within 30 Secs)
	TRENCHFOOT AND IMMERSION FOOT MAY OCCUR AT ANY POINT ON THIS CHART		

Personal Clothing

In cold regions personnel must wear the proper clothing to insulate the body and to prevent body heat from escaping. Dressing for the cold is based on the layering principle. No one piece of clothing exists that will provide the flexibility necessary for the variable activities and temperatures encountered in a cold weather environment. The use of layered clothing comes closest to achieving this flexibility. When working or engaging in vigorous exercise, one can remove the outer layers to minimize perspiration. Moisture in clothing and footgear minimizes its insulating capability.

The layers of clothing are of different designs. The inner garment is porous with numerous air pockets; the outer garments are usually made of windproof, water-repellant fabrics. The outer layers minimize the displacement of the body-warmed, trapped air contained within the air pockets of the inner layers. Cold weather clothing is designed to allow ventilation and to protect against heat loss. This is necessary to prevent overheating and consequent excess perspiration. Moisture and mineral salts present in sweat reduce the insulating qualities of clothing and may add to unnecessary body cooling by evaporative heat loss.

The two types of cold weather conditions, wet cold and dry cold, dictate the kind of cold weather clothing to wear.

Footwear is exceedingly important when you are operating in cold climates. The feet may be more vulnerable than any other part of the body to the effects of cold. In cold climates the body acts to protect its core temperature, and one of those protective mechanisms is peripheral vasoconstriction. Reduced blood flow to the feet contributes to additional tissue cooling and may precipitate frostbite. For this reason, blousing garters are not worn with the cold weather trousers. In addition, the feet are supplied with sweat glands that contribute to moisture accumulation, especially in the vapor barrier boots. These factors added to the external cold explain this peculiar vulnerability.

For cold weather two versions of vapor barrier boots are available. The black (Mickey Mouse) boot is used in wet cold environments, and the white (bunny) boot is for dry cold conditions. Both boots use air as one of their insulators and are effective down to -45 degrees F (-43 degrees C). Each boot contains a valve to equalize air pressure while the troops are ascending to altitude during air transport or in mountain operations. It is important to keep the valve closed at all times except when venting the vapor lock to equalize the pressure. The boots are designed to be worn with one pair of wool cushion-soled socks.

Another type of boot is the extreme cold weather mukluk. This boot is made for use under dry, cold conditions and it is not well suited for a wet environment. It has a rubber sole and a cotton upper portion with laces at the ankle and a zipper above the instep. There are other boots available commercially, made from a light weight fabric called "Gore-tex" which may be preferred by some.

Many factors are involved in keeping feet warm and protected: boot construction, boot care, personal hygiene and proper boot wear. When extended exposure to extreme cold weather is anticipated, footwear such as the vapor barrier boot should be used.

Several different protective covers are available for the hands, which can be broken into the broad categories of mittens and gloves. Each has its own particular advantages. The gloves generally provide more dexterity and are well suited for handling and grasping tasks. Mittens, on the other hand, provide additional warmth and protection by grouping the fingers into one area, thereby reducing heat loss.

Most gloves come in a set consisting of an insulating liner and a durable exterior shell. The liner is worn next to the skin to maintain the warmth while the shell is worn over the liner to provide a wearresistant covering. Several sets of liners will be needed for each pair of gloves because the liners will tend to get wet if the outer shell gets wet. Most liners are typically a wool blend knit and the shell is typically leather.

Mittens are extreme cold weather items and come in a variety of types. The most basic is a one-piece construction with a coated cloth or leather shell that is lined and insulated. The mitten has one pocket for the four fingers and a thumb pocket which provides maximum warmth but limits the ability to grasp.

The Navy Standard extreme cold weather mitten is actually a cross between a glove and a mitten. It has individual places for the thumb, index finer and middle finger, while the ring and little fingers are grouped together. Sometimes the middle finger is also grouped with the latter two. The purpose is to maximize dexterity while ensuring the fingers not required for manipulations are kept as warm as possible. One particular version of these, the extreme cold weather mitten set, consists of a synthetic insulating liner and a chloroprene-coated outer shell. Some mittens like these also may have long cuffs which can be tucked up under the sleeve of a jacket for added protection.

One piece anti-exposure suits are designed to increase the chances of survival for someone who falls overboard and to keep a person warm and dry aboard ship. The Navy's submarine deck exposure coverall is constructed with a durable external shell, a closed cell foam insulating layer, and an inside liner. Rather than trying to keep the person dry in the water, the suit is designed with snug closures at all openings which prevent water from flushing in and out of the suit. The foam layer provides insulation and positive buoyancy. A life jacket is still required with the suit for self-righting flotation capabilities.

The suit provides excellent protection out of the water, too. It was originally used on submarine decks because the topside personnel worked very close to the water where the risk of falling overboard was high. It is now being adapted for all ships as an extreme cold weather outfit, with the added benefit of increased water survival. The one-piece design has proven to be more comfortable than comparable two-piece suits. Commercial suits are available, such as the Mustang and the Stern suits, which offer the same features as mentioned above and which provide similar protection.

Jackets and trousers are often used in combination to create a suit to cover the major portions of the body. The use of separate articles for the top and bottom allows them to be used individually or together to create the level of protection desired. Normally, these items are well-insulated and can be considered water-resistant. The trousers can be worn over normal work clothes and usually have a high waist which provides a good insulating seal. The cuffs may also have a device to seal around the ankle which minimizes cold air entry. Likewise, the mid-length jacket overlaps the trousers and will draw up tightly to form a seal at the bottom. The neck can be closed tightly and the cuffs are designed to limit cold air leakage. Some jackets are provided with hoods, which may be permanently attached or detachable, and even interchangeable with different styles of hoods. These jackets and trousers require the addition of a life jacket, which can be cumbersome.

Individual jackets (with no trousers) are also available. These are usually short waisted jackets which fit snugly at the waist for warmth, such as the cold weather flyer's jacket. When selecting jackets and trousers, remember to size them large enough to allow layering of clothing underneath.

Protective clothing for one's head is perhaps one of the single most important items in cold weather. The extremities in general (i.e. head, hands, feet) are the most difficult parts of the body to keep warm. The head, in particular, may account for up to 80% of the body's heat loss. A variety of items is available to keep this critical body area warm.

Hats and ski masks are the most familiar headgear. Wool watch caps and fire retardant face masks are readily available in the Navy supply system and ski masks usually can be purchased commercially. All provide good insulation and are comfortable to wear. Loose-knit varieties provide only marginal protection in the wind. Fleece-lined caps, like those which are part of the ensemble, with ear flaps and visors, provide better wind-resistance and protect both ears and the entire neck area.

Hoods provide excellent protection and can be used in conjunction with some hats. The hood creates a warm cavity around the head. Some hoods designed to be used with sound powered phone headsets have ear pockets built-in. There is also a hood designed for use ashore with a fur piece around the face which forms a snorkel to keep cold air out. Hoods are usually supplied as accessories to extreme cold weather jackets, either permanently attached or as detachable, interchangeable items.

A face mask is available through the Navy supply system for use in extreme cold weather which attaches to the head with elastic webbing. It has a nose piece which opens and closes to adjust nose protection. The mask provides good wind protection and is fire-retardant.

Scarves also provide good insulation for the face and neck, and can be easily adjusted for individual comfort. A drawback of the scarf is that when loose, it can quickly become a hazard to performance and to equipment. Therefore, if a scarf is worn, ensure it is well-wrapped and secured. An alternative face protector which has been favorably used underneath cranials is a commercially procured tube, referred to as a "Necker Upper".

Goggles, available commercially and from the supply system, have proven to be very effective at protecting the area around the eyes, particularly in high winds, sleet and snow conditions. Commercial ski goggles which fit over eyeglasses are particularly good for protecting those who must wear glasses.

Thermal underwear and heavy wool socks are essential items for protection from the cold. Both wool and polypropylene undergarments are available and perform essentially the same function. The most important thing to remember when using these items is to keep them dry. Because of the accumulation of perspiration within the socks, they must be changed and dried about 4 times a day. This is easily remembered by changing the socks each time you eat. The liberal use of a good foot powder such as zinc undecylenate is also strongly recommended for its antifungal and foot soothing properties.

Even if effective water-repellant clothes are worn, the body will still get wet from perspiration. It is important to note that cotton undergarments readily absorb perspiration, become saturated and thereafter conduct heat away from the body. Many synthetics cannot absorb moisture and will remain dry and warm. The biggest single threat to maintaining body warmth is wet clothing. Wetness robs the body of heat by breaking down the thermal protection of insulating clothes. It is extremely important that wet clothing be replaced as soon as possible to prevent injuries from the cold, particularly if the person is idle after a period of profuse perspiring. Many cold weather medical problems involve wet hands and wet feet, so these extremities should receive extra special care.

Cold weather clothing should be stowed in a dry secure place to reduce the possibility of mildew and prevent pilferage. Ensure all items, particularly leather ones, are completely dry prior to stowage. Temporary stowage locations and drying rooms should be established when the clothing is frequently used. Proper care of the clothing is important, so ensure it is carefully hung and aired between usage. Arctic marine regions typically have a 28-32 degree F dew point, so drying time may be slightly less than in warmer regions.

To react to the extremes (low temperatures/high moisture) of a wet cold environment, individuals must have a full issue of cold weather clothing and be thoroughly familiar with the layering method. The following list describes the layers of a typical wet cold uniform.

First Layer:

- Cotton and wool winter undershirt
  (T-shirt may be worn for added comfort)
- Cotton and wool winter drawers
  (Underdrawers may be worn for added comfort)
- Scissor-type suspenders
- Cushion-soled wool socks

Second Layer:

- Wool and flannel field shirt
- Utility trousers
- Protective body armor (when directed)

Third Layer:

- Quilted nylon field coat liner
- Wool and nylon glove inserts
- Cotton nylon oxford insulating cap

Fourth Layer:

- Wind-resistant cotton nylon field coat
- Wind-resistant cotton nylon field trousers
- Leather mitten shells (or leather glove shells)
- Vapor barrier boot (white or black)

To react to the extreme temperatures (low temperature/low moisture) of a dry cold environment, individuals must have an additional issue of cold weather clothing and be thoroughly familiar with its use. The following list describes the layers of a typical dry cold uniform. The first two layers are the same as the wet cold uniform.

First Layer: (same as wet cold)

Second Layer: (same as wet cold)

Third Layer:

- Quilted nylon field coat liner
- Quilted nylon field trouser liner

Fourth Layer:

- Wind-resistant cotton nylon field coat
- Wind-resistant cotton nylon field trousers
- White insulating boots
- Wool mitten insert

Fifth Layer:

- Quilted nylon parka liner
- White Arctic trouser liner
- Cotton nylon insulating cap

Sixth Layer:

- Cotton and nylon oxford parka
- White cotton nylon Arctic trousers
- Arctic mittens
- Arctic hood with fur ruff

Seventh Layer:

- White cotton camouflage parka
- Mittens

To achieve the maximum advantage of the layered effect, try to keep clothing as clean as possible. For example, the inner layers, T-shirt and long johns, should be changed and allowed to dry if they become moist with perspiration. However, try to avoid this moisture accumulation by removing layers or loosening the clothing as the activity or environment changes. When you are working in cold climates, it is better to be comfortably cool than too warm. Take advantage of opportunities to clean and dry your clothes. When washing the clothing, rinse the pieces in cold water (do not waste precious warm water) to remove all the soap. Soap remaining in the fabric lessens its insulating capacity.

The procedure for drying wet clothes is to hang each piece separately near the heat source inside your tent near the top is best, and do not hang clothes over steaming pots. To dry damp clothes, place damp clothes inside your shirt while on the move and sleep on your damp clothes in the sleeping bag.

HOST FACTORS

The following host factors may modify physiological mechanisms.

AGE: Within the usual age range of combat personnel, it is not significant; nor is there substantial evidence for greater susceptibility outside of the age range of combat personnel. In general, very young children and the elderly are more susceptible to cold injury.

RANK: The front line rifleman will usually have a higher risk of immersion foot and frostbite. The higher ranks have fewer cold injuries due to a lesser degree of exposure and greater receptivity to training.

PREVIOUS COLD INJURY: There is a definite increased risk of cold injury if an individual has had a previous serious episode such as immersion foot or frostbite.

FATIGUE: Mental and physical weariness can predispose individuals to carelessness and subsequent neglect of activities vital to survival in the cold. This is most commonly seen in personnel who have been on the line without relief for prolonged periods. Frequent rotation of troops from the front lines for even short periods will lessen the fatigue risk.

OTHER INJURIES: Injuries associated with tissue injury, blood loss, and hypovolemia will inhibit effective peripheral circulation and thereby predispose the person to cold injury.

DISCIPLINE, TRAINING, AND EXPERIENCE: Since cold injury is preventable, the proper use of simple preventive measures will markedly reduce its incidence. Individual and unit discipline, training, and experience are closely related in their influence upon the incidence of cold injury. Well-trained and disciplined persons suffer less than others from the cold, as they are better able to care for themselves through personal hygiene, proper foot care, change of clothing, exercise of extremities in pinned-down positions, and similar effective measures. Poorly motivated, negativistic individuals tend to be less active, pay less attention to personal care needs, and are more susceptible to cold injuries.

RACE AND AREA OF ORIGIN: There is a definite propensity for increased vulnerability to cold injury by members of the Black American race as compared to Caucasians. The data from World War II, Korean War, and Alaskan studies confirm this observation. This finding strongly suggests that blacks must be vigilant respecting hand and foot care during cold exposure. Training and proper use of protective clothing, however, will allow them to balance this physiological difference and serve in cold climates without the excessive risk of cold injury.

DRUGS AND MEDICATIONS: Certain drugs and medications, whether used on an intermittent or regular basis, may have an adverse effect on peripheral circulation or perspiration and thereby modify the *individual's response to cold. Therefore, use these medications with caution. Phenothiazines and* barbiturates can modify shivering and states of awareness and predispose the person to cold injury. Beta blocking drugs for the control of blood pressure are not effective against the pressure response to cold. Thus those who take these medicications för angina or blood pressure control, may consider alternate agents while deployed to cold climates.

The use of tobacco with its consequent vasoconstricting effects is to be discouraged during cold weather operations. Vasoconstriction diminishes the oxygen available to tissues; therefore, smoking is absolutely forbidden during the treatment of frostbite. Tobacco smoke will also further foul the air in a closed shelter, making an already less than comfortable existence downright miserable for tentmates.

The use of alcohol in cold weather has more disadvantages than advantages. The peripheral vasodilatory effect may be overrated and that vasodilation may rob the body's core of one of its essential protective mechanisms. The mental effects and distortion of judgment under the influence of alcohol are absolutely detrimental in the cold. Persons under the influence of alcohol are a distinct liability to themselves and to others.

OTHER CONSIDERATIONS

Nutrition and Activity

Special emphasis must be placed on nutrition. Almost all studies describe insufficient water intake. A supplemental ration of 1000 calories per day of a powdered carbohydrate supplement and weekly weight monitoring ameliorate weight loss for forces deployed over two weeks. Working in the cold increases caloric demands on the body. Shivering, the added weight of clothing and equipment, the toil involved in traversing snowy areas and possibly extra heat produced by muscle or metabolic means result in an expenditure of between 4500 to 6000 calories per day. Normally, a caloric intake of 3500 calories per day has proven adequate for most standard situations. However, in severe cold the body needs additional fuel to produce the heat necessary to protect its core and to prevent cold injuries. A standard to work by is 40-45 kilocalories/kg/day, translating into 50% more than for temperate climates (50% more calories for 4 degrees C than 24 degrees C). This increases the caloric requirement to 4500 or more per day. In this setting of markedly increased energy requirements, subtle energy deficits and gradual weight loss are common for military operations. The reasons for the slow weight loss are unknown, but are related to the increased energy demands, field ration palatability, limited access to regular meals, and anorexia associated with the emotional stress of the operation. Although the absolute weight loss per person may not be great, it implies a net negative energy balance that burns vital insulative subcutaneous body fat and alters thermoregulation. Dietary carbohydrates and fats are rich sources for the needed energy production. Monitoring a well hydrated body weight weekly while in field settings and adding an energy supplement can normalize body weight for short (8 week) operations and provides an excellent index of operational readiness for extended operations.

Water Metabolism

Proper water metabolism is an important factor in cold weather operations. Water deprivation will cause more problems for an individual than lack of food. With only light activity a person will lose between 2 and 3 liters of water daily. Arctic air is generally low in humidity. With the increased breathing rate associated with the exertion of movements in the snow, the insensible water loss through the respiratory system may increase dramatically as the body gives up its water to humidify the inhaled air. This water initially comes from the extracellular water pool. To maintain osmotic balance, intracellular water pools are recruited and now both pools are depleted. The total intravascular volume is compromised, and the body's vasoconstrictive response to protect itself from hypovolemia may be compounded with the normal vasoconstrictive response to cold exposure. The stage is then set for an increased risk of frostbite, and the tissue damage could be even more severe because of the disordered cellular metabolism.

While dehydration is normally thought of as a hot climate problem, its significance in cold environments is not to be underestimated. Add to this the problems involved in obtaining and carrying potable water in the cold and snow, and one can appreciate the logistic as well as the medical problem. Dehydration causes voluntary muscle performance to decline by at least 20%, impairs mental functioning, and can increase errors in judgment. In addition, gastrointestinal problems, such as constipation with related hemorrhoidal problems and nausea which inhibits fluid intake, may appear as the dehydration worsens.

Medical personnel should check the "snow flowers" or "snow spots" of the operating units. These are the terms given to the marks made by urinating in the snow. The color may vary from pale yellow (adequate hydration) to dark orange (serious dehydration). The darker the mark the more effort must be made to enhance hydration. Eating snow, an obvious source of water replacement, is strongly discouraged. Snow is generally contaminated with airborne dirt particles and human and animal excrement.

Additionally, the resulting water from the ingested snow will be warmed by the body to body temperature, causing the core areas to give up some of their heat. Eating snow will also cause painful oral mucosal lesions, which may further discourage eating and drinking for several days. If snow is used for water, melt it in a large container, and make sure it is boiled or chlorinated properly. When using this method for obtaining potable water, you must instantly mix the solid snow with the melted snow in the container. Failure to do this will produce holes in the bottom of the container from the extreme heat.

Also, consume caffeine-containing drinks with caution, since the caffeine can increase urine output and thereby compound the dehydration. Drink water or warm sweetened liquids during early dehydration. More serious problems may require intravenous fluid replacement. The following are signs and symptoms of dehydration:

Mild (1% to 5% of body weight)

- Tachycardia
- Anorexia, nausea
- Increased urine concentration, constipation
- Irritability, fatigue, drowsiness
- Thirst (may not be a noticeable symptom in cold weather)
- Voluntary muscle performance down by 20%

Moderate (5% to 10% of body weight)

- Headache, vertigo
- Labored respirations
- Paresthesia
- Decreased salivation
- Peripheral vasoconstriction (mild extremity cyanosis)

Severe (10% to 20% of body weight)

- Dry mucous membranes
- Visual and acoustic disturbances
- Loss of skin turgor
- Dysuria
- Delirium
- Death

It is important to make a conscious effort to consume water when it is available. You must make sure that those personnel under your leadership consume water periodically to avoid dehydration. Since there may be periods when it is inconvenient to obtain suitable drinking water, keep the canteens filled.

Acclimatization

More comfortable existence in the cold environment can be achieved if time is made available for acclimatization. This process enables the body's physiological mechanism to adapt to the new environment. Acclimatization is best accomplished by gradually increasing the duration of exposure in cold environments to ensure proper physical conditioning. It usually takes about 1 to 4 weeks to occur. However, extended (two - ten months) residence in cold climates has accumulative effects upon thyroid hormone metabolism and energy balance. The most active of the thyroid hormones, Triodothyronine (T3), is doubled in production and utilization with extended polar operations. The consequences, physiologic significance, and possible implications for screening of these changes are currently being studied. The characteristic physiologic markers of human cold adaptation in this setting have been called "hypothermic" cold adaptation (Journal of Applied Physiology G2:1627, 1987). Core body temperature falls slightly and the initiation of shivering requires colder skin temperatures than those non-adapted. The blood pressure elevation found acutely with cold exposure is also blunted in this setting. The cold-adapted person will utilize body heat better, will shiver less, will respond less dramatically to cold air challenge, and will be able to function much more efficiently in the cold than the nonadapted individual.

Psychological Aspects

In a discussion on the medical aspects of cold weather operations, one must consider the psychological aspects of the cold. Initially, there may be a cold weather "high" as the body output of thyroxine and catecholamine is elevated by the acclimatization process. As the novelty of the environment wears off, other reactions may become evident. If the temperatures are so low as to prevent military movements, there may be boredom and depression added to the tension involved in simply surviving in the cold. The shortened period of daylight in the winter may further contribute to the ensuing depression.

The concern of most military personnel is what threat to life or limb the next contact with the enemy or the environment will carry for that individual. Medical personnel must recognize and be ready to handle these psychological problems as they arise. No medications will take the place of a firm, reassuring, and positive attitude on the part of the medical personnel involved in a cold weather operation.

COLD INJURIES

Virtually all cold injuries are preventable if an operating unit has had appropriate cold weather training and adheres to proper preventive measures. These measures include indoctrinating all personnel to the types of cold injuries and their prevention and treatment; instructing all individuals in the proper use and maintenance of cold weather clothing and equipment; ensuring proper food and fluid intake; and establishing a rotation policy so all personnel come in from the cold periodically. Sometimes the above practices are not all possible in combat situations. Therefore, medical personnel must be prepared mentally and logistically to handle cold weather injuries.

The two types of cold injuries are nonfreezing and freezing. Nonfreezing injuries, which occur with environmental temperatures above freezing, are chilblains, immersion foot (trench foot), and hypothermia. Freezing injuries, which occur when environmental temperatures fall below freezing, are generally limited to frostbite. Other common conditions that may occur during cold weather operations are acute mountain sickness, carbon monoxide poisoning, snowblindness, and constipation.

NONFREEZING INJURIES

Chilblains (Pernio)

This is a superficial tissue injury of the hands, ears, or nose which occurs after prolonged exposure of the bare skin to temperatures above freezing. It appears most often when high winds and high humidity accompany the low but nonfreezing temperature levels. The severity depends on the temperature, wind velocity, and duration of exposure. To prevent chilblains, people must avoid prolonged exposure to the elements or protect the obvious exposure areas with adequate clothing or coverings.

Symptoms

Chilblains are recognized by initial pallor of the exposed area. On rewarming there may be