Chapter 9

PRACTICAL MEDICAL ASPECTS OF MILITARY OPERATIONS IN THE HEAT

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INTRODUCTION

Military operations in hot environments present a special set of challenges to the medical personnel who must support them. Hot environments can affect both personnel and equipment performance and introduce special considerations into the planning and execution of a military operation. Vast resources have been committed to warfare in the 20th century, and in support of this, a significant body of research now exists on human performance in hot environments. Countermeasures to heat, extrapolated from physiological studies and mathematical models, have been developed and implemented by the US Army.[1,2] However, considerably less data have been gathered on how effective these countermeasures really are when used by military units under operational conditions.

It is impossible to write a textbook chapter on operations in the heat that does full justice to the wide variety of missions and challenges that are likely to be encountered by the different branches of the armed forces. Furthermore, the available countermeasures vary somewhat with mission, doctrine, and resources. For example, microclimate cooling vests may be highly practical for sailors working on the deck of an aircraft carrier, yet would be entirely inappropriate for light infantry engaged

TABLE 9-1

COMMON HAZARDS OF MILITARY OPERATIONS IN HOT ENVIRONMENTS

Hazard	Countermeasure
Decreased exercise capacity[1–7]	Prior physical fitness, acclimatization
Increased requirements for	
Water	Water discipline
Sodium and other electrolytes[8,9]	Acclimatization, food intake; supplementation is rarely necessary
Increased risk of certain types of injury	
Heat injuries	Water consumption, acclimatization, work/rest cycles, shelters, proper clothing, etc
Sunburn	Sunscreen, shelter, protective clothing (hats)
Miliaria rubra ("heat rash")	Personal hygiene, availability of cool environments
Decreased psychological performance on some tasks[10]	Work/rest cycles, cross-checking (buddy system), redundancy in key assignments
Involuntary dehydration*	Water consumption, cross-checking (buddy system)

* The tendency of individuals to replace less than their complete fluid deficits when allowed to drink ad libitum[11–15]

(1) Galloway SDR, Maughan RJ. Effects of ambient temperature on the capacity to perform cycle exercise in man. *Med Sci Sports Exerc*. 1997;29:1240–1249. (2) Klausen K, Dill DB, Phillips EE, McGregor D. Metabolic reactions to work in the desert. *J Appl Physiol.* 1967;22:292–296. (3) Rowell LB, Brengelmann GL, Murray JA, Kraning KK, Kusumi F. Human metabolic responses to hyperthermia during mild to maximal exercise. *J Appl Physiol.* 1969;26:395–402. (4) Saltin B, Gagge AP, Bergh U, Stolwijk JAJ. Body temperatures and sweating during exhaustive exercise. *J Appl Physiol.* 1972;32:635–643. (5) Sen Gupta J, Dimri P, Malhotra MS. Metabolic responses of Indians during sub-maximal and maximal work in dry and humid heat. *Ergonomics.* 1977;20:33–40. (6) Sawka MN, Young AJ, Cadarette BS, Levine L, Pandolf K. Influence of heat stress and acclimation on maximal aerobic power. *Eur J Appl Physiol.* 1985;53:294–298. (7) Brown AH, Towbin EJ. Relative influences of heat, work, and dehydration on blood circulation. In: Adolph EF, ed. *Physiology of Man in the Desert*. New York, NY: Intersciences; 1947: 197–207. (8) Wenger CB. Human heat acclimatization. In: Pandolf KB, Sawka MN, Gonzalez RR. *Human Performance Physiology and Environmental Medicine at Terrestrial Extremes*. Carmel, Ind (now in Traverse City, Mich): Cooper Publishing Group; 1986: 153–197. (9) Hubbard RW, Armstrong LE. The heat illnesses: Biochemical, ultrastructural, and fluid-electrolyte considerations. In: Pandolf KB, Sawka MN, Gonzalez RR. *Human Performance Physiology and Environmental Medicine at Terrestrial Extremes*. Carmel, Ind (now in Traverse City, Mich): Cooper Publishing Group; 1986: 305–359. (10) Hygge S. Heat and performance. In: Jones DM, Smith AP, eds. *Handbook of Human Performance*. San Diego, Calif: Academic Press; 1992: 79–104. (11) Greenleaf JE. Problem: Thirst, drinking behavior, and involuntary dehydration. *Med Sci Sports Exerc*. 1992;24:645–656. (12) Engell DB, Maller O, Francesconi RP, Drolet LA, Young AJ. Thirst and fluid intake following graded hypohydration levels in humans. *Physiol Behav.* 1987;40:229–236. (13) Rothstein A, Adolph EF, Wills JH. Voluntary dehydration. In: Adolph EF, ed. *Physiology of Man in the Desert*. New York, NY: Intersciences; 1947: 254–270. (14) Epstein Y. Heat intolerance: Predisposing factor or residual injury? *Med Sci Sports Exerc.* 1990;22(1):29–35. (15) Greenleaf JE, Broch PJ, Keil LC, Morse JT. Drinking and water balance during exercise and heat acclimation. *J Appl Physiol: Resp Environ Exerc Physiol.* 1983;54(2):414–419.

in jungle warfare. Nonetheless, the success of all military operations requires careful attention to the fundamental problems of personnel, intelligence, training and operations, and logistics; and a detailed analysis of how ground forces cope with these problems may be enlightening to medical officers (MOs) in other branches of the armed forces. Accordingly, this chapter will detail practical considerations for the battalion-level MO who is supporting a unit deployed to a hot weather environment.

HEAT AS A THREAT TO MILITARY OPERATIONS

Many studies have measured the incidence of heat casualties among military personnel in a training environment.[3–8] The reported incidence of heat injury at basic military training facilities is typically about 5 to 8 cases per 10,000 troops per week,[3,5,7] although higher rates were reported in the Marine Corps prior to implementation of heat-related training restrictions.[4,7] New recruits and reservists typically have the highest rates of heat injury[3,4,6,7,9]; reservists appear to be at particularly high risk. Reported incidences of heat illness among reservists range from 33 to 49 cases per 10,000 troops per week (in the era before heat-related training restrictions)[4,7] to as high as 210 to 455 per 10,000 troops per week over a 2-week annual training period.[8]

By contrast, less is known about the incidence of heat illness during actual military operations, in part due to underreporting bias and the lack of uniformly accepted case definitions.[8] As a result, estimates vary widely; for example, the reported incidence of heat casualties was 11 per 10,000 per week in the Persian Gulf Command during World War II, whereas in Vietnam it ran as high as 378 per 10,000 per week.[8] Because these figures do not include soldiers who were adversely affected by heat but did not come to the attention of the reporting system, the true incidence of heat illness may have been much higher.

The effects of heat on personnel performance have been reviewed in detail elsewhere in this section of heat chapters. Table 9-1 recapitulates some of the most significant hazards encountered by units deployed to hot environments and some of the countermeasures available. As in all aspects of military operations, leadership and training are key to successful implementation of these countermeasures. Even in the best-trained unit, however, there is always a risk that the high motivation that soldiers typically bring to a mission will override the protective behaviors needed (water intake, rest, shelter, etc) to overcome the environmental threat. In this regard neither commanders nor troops seem to have changed—certainly not since this anonymous mid-19th century passage was written:

> At this season it is especially necessary for commanding officers to be alive to the dangers of prolonged over-exertion. ... Commanding Officers of volunteers are very apt to err in this particular: and the spirit of their men is such that they shrink from complaint, and persevere in efforts which may easily, under a burning sun, become dangerous to life.[10(p627)]

Soldiers and their leaders must understand that—no matter how motivated they may be—failure to take protective measures against hot environments may result in mission failure. For example, it takes four troops to carry a single heat casualty any kind of distance. Thus, one heat casualty effectively means the loss of a fire team; two casualties mean the loss of a squad; four to six casualties can significantly degrade the combat power of an entire platoon (Exhibit 9-1).

PLANNING FOR DEPLOYMENT TO HOT ENVIRONMENTS

In the US Army, a battalion-level MO serves three roles: staff officer, leader in the medical platoon, and healthcare provider. Each of these roles affords the MO an opportunity to help the battalion cope with the environmental threat. As a staff officer, he is an advisor to the commander and is involved in the planning and day-to-day management of operations. As a leader in the medical platoon, he has a duty to make the platoon proactive and competent in preventing and treating heat casualties. Finally, as the primary healthcare provider to the battalion, he can help educate individual soldiers and leaders about the medical aspects of operations in hot environments. Obviously, as healthcare provider, he will also be involved in the medical management of heat- and sun-related injuries.

When planning for a deployment to a hot environment, it is important to remember that most of the threats that a military unit faces in temperate climates will still be present in a hot environment. A unit that is well-prepared to perform in the heat will nonetheless find its mission performance unduly hampered if inadequate provisions have been made for managing the illnesses and injuries that occur in all climates. Accordingly, although heat must be treated as a very serious threat to any op-

EXHIBIT 9-1

THE MOTIVATED POINT MAN

During a summer field training exercise in 1996 in Puerto Rico, a light infantry platoon was to conduct a surprise evening raid on the camp of (simulated) guerrillas. The approach to the camp required cutting a path through brush with machetes. This particular platoon was reputed to have some of the most fit and motivated soldiers in the battalion. They had been careful to increase their activity slowly over several days, to allow for acclimatization; had been briefed by a medic on the environmental threat; and were diligent about water supplies and intake.

The weather that evening was hot and humid when the lead squad left the staging area to cut through the brush. The soldiers were wearing summer-weight battle dress uniforms and ranger caps, and were encumbered with a typical combat load. Good progress was made initially, thanks to the vigorous efforts of Private Smith,* the point man (who was wielding the machete). The squad leader reportedly enforced water consumption and, to prevent Private Smith from overheating, replaced him as the point man when he started to look fatigued. Unfortunately, the replacement point man, Private Jones,* did not progress as rapidly as was desired in cutting through the brush. After considerable insistence on the part of Private Smith, the first point man, the decision was made to switch them. After a few minutes as point man, Private Smith complained of severe fatigue, muscle cramping, and light-headedness. He could no longer walk. The medic was called, who noted that Private Smith had an oral temperature of 101°F. Now a casualty, Private Smith was doused with cool water, and the medic started an intravenous infusion. It was also decided to evacuate the casualty to the battalion aid station. Access to the nearest road required further travel through uncut brush, which required the assigning of four soldiers as litter bearers and yet another as point man. Unfortunately, in the effort to evacuate their colleague promptly, one of the litter bearers developed symptoms of heat exhaustion, and four more troops had to be detailed to carry him. Having now lost an entire squad and recognizing that the loss of two soldiers to heat raised the possibility of even more heat casualties, the platoon leader decided to call off the exercise. Because the environmental threat to the light infantry platoon was inadequately managed, the opposition force prevailed that night without having to fire a single shot.

The foregoing illustrates how unforgiving the environmental threat can be. Even though the unit had been taking reasonable precautions against heat all along, the decision to allow a soldier who had already shown signs of fatigue to prematurely resume high-intensity activity in the heat led to a series of events that eventually resulted in scuttling the mission. Medical officers need to wonder whether Private Smith's insistence on being allowed to resume the point position was not itself an indication that his judgment was clouded by overheating and dehydration. Because individuals can be poor judges of their own hydration status[1] and core temperature,[2] medical officers must not allow a soldier's assurances (vehement as they may be) to be the sole deciding factor when making a duty assignment.

* Pseudonym

Sources: (1) Sawka, MN, Modrow HE, Kolka MA, et al. *Sustaining Soldier Health and Performance in Southwest Asia: Guidance for Small Unit Leaders.* Natick, Mass: US Army Research Institute of Environmental Medicine; 1994. Technical Note 95-1. (2) Yaglou CP, Minard D. Control of heat casualties at military training centers. *AMA Arch Ind Health*. 1957;16:302–316.

eration, we must not allow the attention given to planning for heat to cause us to neglect other important operational issues. The general and environmental issues relating to deployment are discussed in Volume 3 of this textbook, and in another volume in the Textbook of Military Medicine Series, *Military Preventive Medicine, Mobilization, and Deployment.* For now, however, we shall focus on issues specific to hot environments.

Battalion MOs can and should play an integral role in the planning of military operations. An MO can provide a battalion staff with meaningful input into all four areas of staff concern: Personnel (S-1), Intelligence (S-2), Operations and Training (S-3), and Logistics (S-4).

Personnel Issues

In preparation for a deployment, the adjutant (S-1) of the battalion will need to provide the commander with an estimate of the number of combat-ready personnel available in the battalion and to identify any critical unfilled positions. Therefore, in addition to advising the S-1 about the deployability of soldiers with known medical problems, the MO should also aim to identify personnel who may be at risk for heat or solar injury. Risk factors are listed in Exhibit 9-2; some of these (such as obesity and poor physical fitness) are modifiable and should be identified and managed as part of a unit's routine,

EXHIBIT 9-2

RISK FACTORS FOR POOR HEAT TOLERANCE AND HEAT-RELATED INJURY

- Obesity[1–4]
- Lower level of physical fitness[3,5,6]
- Prior history of heat injury[7,8]
- Being a new recruit or reservist[1,2,4,9,10]
- Febrile illnesses[11]
- Dehydration from any cause[12] (including diarrhea)
- Skin disorders:
  - Miliaria rubra (heat rash)[13,14]
  - Sunburn[15]
  - Psoriasis[16]
  - Burns
- Older age*[17,18]
- Medications that decrease sweating:
  - Anticholinergic agents
  - b-Blockers[19] (these also act by decreasing cutaneous vasodilation)
  - Antihistamines
  - Phenothiazines
- Medications that increase heat production:
  - Amphetamines
  - Cocaine
  - Neuroleptics
- Medications that decrease thirst:
  - Butyrophenone
  - Angiotensin-converting enzyme (ACE) inhibitors†[20]
- Medications that cause hypohydration:
  - Alcohol
  - Diuretics

*Age may not be a risk factor for heat illness per se, once adjustments are made for confounders such as lower level of aerobic fitness, higher adiposity, etc.[21] However, because older individuals often do have one or more of these confounding risk factors, it is prudent to view them as belonging to a population that is at increased risk for heat injury.

†ACE inhibitors have been shown to decrease thirst in dialysis patients; if this holds true in normal patients, it could theoretically increase the risk of heat injury.

(1) Stallones RA, Gauld RL, Dodge HJ, Lammers TFM. An epidemiological study of heat injury in Army recruits. *AMA Arch Ind Health.* 1957;15:455–465. (2) Schickele E. Environment and fatal heat stroke: An analysis of 157 cases occurring in the Army in the US during World War II. *Milit Surg.* 1947;100:235–256. (3) Gardner JW, Kark JA, Karnei K, et al. Risk factors predicting exertional heat illness in male Marine Corps recruits. *Med Sci Sports Exerc.* 1996;28:939–944. (4) Chung NK, Pin CH. Obesity and the occurrence of heat disorders. *Mil Med.* 1996;161:12:739–742. (5) Wenger CB. Human heat acclimatization. In: Pandolf KB, Sawka MN, Gonzalez RR. *Human Performance Physiology and Environmental Medicine at Terrestrial Extremes*. Carmel, Ind (now in Traverse City, Mich): Cooper Publishing Group; 1986: 153–197. (6) Engell DB, Maller O, Francesconi RP, Drolet LA, Young AJ. Thirst and fluid intake following graded hypohydration levels in humans. *Physiol Behav.* 1987;40:229–236. (7) Epstein Y. Heat intolerance: Predisposing factor or residual injury? *Med Sci Sports Exerc.* 1990;22(1):29–35. (8) Hubbard RW, Armstrong LE. The heat illnesses: Biochemical, ultrastructural, and fluid-electrolyte considerations. In: Pandolf KB, Sawka MN Gonzalez RR. *Human Performance Physiology and Environmental Medicine at Terrestrial Extremes*. Carmel, Ind (now in Traverse City, Mich): Cooper Publishing Group; 1986: 305–359. (9) Yaglou CP, Minard D. Control of heat casualties at military training centers. *AMA Arch Ind Health*. 1957;16:302–316. (10) Minard D. Prevention of heat casualties in Marine Corps recruits: Period of 1955–60, with comparative incidence rates and climatic heat stresses in other training categories. *Mil Med.* 1961;126:261–272. (11) Epstein Y. Heat intolerance: Predisposing factor or residual injury? *Med Sci Sports Exerc.* 1990;22(1):29–35. (12) Sawka MN. Physiological consequences of hypohydration: Exercise performance and thermoregulation. *Med Sci Sports Exerc.* 1992;24:657–670. (13) Pandolf KB, Griffin TB, Munro EH, Goldman RF. Heat intolerance as a function of percent body surface involved with miliaria rubra. *Am J Physiol: Reg Int Comp Physiol.* 1980;239:R233–R240. (14) Pandolf KB, Griffin TB, Munro EH, Goldman RF. Persistence of impaired heat tolerance from artificially induced miliaria rubra. *Am J Physiol: Reg Int Comp Physiol.* 1980;239:R226–R232. (15) Pandolf KB, Grange RW, Latzka WA, Blank IH, Kraning KKI, Gonzalez RR. Human thermoregulatory responses during heat exposure after artificially induced sunburn. *Am J Physiol: Reg Int Comp Physiol.* 1992;262:R610–R616. (16) Lebowitz E, Seidman DS, Laor A, Shapiro Y, Epstein Y. Are psoriatic patients at risk of heat intolerance? *Br J Dermatol.* 1991;124:439–442. (17) Pandolf KB. Aging and human heat tolerance. *Exp Aging Res.* 1991;23:69–105. (18) Drinkwater BL, Horvath SM. Heat tolerance and aging. *Med Sci Sports Exerc.* 1979;11(1):49–55. (19) Pescatello LS, Mack GW, Leach CN, Nadel ER. Thermoregulation in mildly hypertensive men during beta adrenergic blockade. *Med Sci Sports Exerc.* 1990;22:222–228. (20) Oldenburg B, MacDonald GJ, Shelley S. Controlled trial of enalapril in patients with chronic fluid overload undergoing dialysis. *BMJ.* 1988;296:1089–1091. (21) US Army Center for Health Promotion and Preventive Medicine. Heat injuries in active duty soldiers, 1990–1996. *Med Surveill Monthly Rep.* 1997;3(6):16–19.

ongoing healthcare program. Others, such as a prior history of difficulty acclimatizing to heat, may not be easily modified but are often manageable with proper preparation and planning.

Furthermore, the S-1 will probably want to review the unit's medical personnel assets. Although a well-maintained personnel roster should contain the names and military occupational specialties of all medical personnel in the battalion, a realistic assessment of the unit's medical capabilities should include an evaluation of the professional strengths and weaknesses of the medical personnel available. The MO is, by training and experience, in a position to provide valuable insight into these capabilities. By identifying areas of weakness early, the medical platoon can design an intensive and focused training effort in preparation for deployment.

One important but commonly overlooked medical asset in the US Army is the combat lifesaver. Combat lifesavers are nonmedical troops trained to perform advanced lifesaving tasks as a secondary mission.[11] They are given advanced first-responder training and additionally are taught how to start intravenous (IV) lines as an early step in the management of shock. They are issued a small medical kit that includes two 500-mL bags of saline for IV infusion. Although combat lifesavers cannot replace a medic, they do serve as important medical capability multipliers. This is especially important in units that have a limited number of medics. For example, in a light infantry battalion, the table of organization and equipment assigns only three medics to each rifle company; this means that each rifle company medic is responsible for an entire platoon of soldiers. Three or four combat lifesavers acting under the guidance of a medic can greatly enhance the platoon's ability to cope with heat casualties, which typically occur in clusters,[3–5,12] and to treat soldiers in a mass casualty situation. The training of combat lifesavers can be accomplished during peacetime with little extra effort; course materials and guidance on how to set up a training program are available from the Army Institute for Professional Development (Exhibit 9-3).

Intelligence Issues

To better assist the planning process, the MO will need intelligence on the environmental and medical threats the unit is likely to face in the theater of operations. An excellent source of this information comes in the form of country dossiers prepared by the US Armed Forces Medical Intelligence Center (AFMIC) located in Fort Detrick, Maryland (see Exhibit 9-3). Among other information, the dossiers include ambient temperatures (maximum, minimum, and average) by month, average monthly precipitation, geographic and demographic information of medical importance, discussions of medically significant plants and animals, and lists of endemic and epidemic diseases. The MO should plan to obtain a country dossier and summarize its contents for the battalion staff early in the planning process.

The battalion MO will also need to discuss how weather information is to be obtained and transmitted to medical personnel during the operation. It is well within the capabilities of the medical platoon to set up wet globe temperature (WGT) monitoring at the battalion aid station (BAS),[1] and this can provide timely and immediately accessible information. This can be done with a Botsball device (National Service Number [NSN] 6665-01-103-8547), a field-expedient instrument that measures the WGT.[1] It should be remembered, however, that the Botsball device can significantly underestimate the actual wet *bulb* globe temperature (WBGT) under some conditions (eg, hot, dry, windy weather) and should always be corrected accordingly, using the following formula[1]:

$$\text{WBGT (°F)} = (0.8)\ \text{Botsball temperature} + (0.2)\ \text{dry bulb temperature} + 1.3$$

However, weather forecasts will also be needed. Possible sources include the intelligence (S-2) sections of supporting units, air force weather liaison teams, national meteorologic agencies, civilian sources (newspapers, almanacs), and even Internet

EXHIBIT 9-3

USEFUL RESOURCES FOR THE BATTALION MEDICAL OFFICER

Combat Lifesaver Course Materials and Guidance:
Army Institute for Professional Development
Newport News, Virginia 23628-0001

Medical Intelligence:
Armed Forces Medical Intelligence Center
Fort Detrick
Frederick, Maryland 21702-5004

Environmental Medicine Resources:
US Army Research Institute for Environmental Medicine
42 Kansas Street
Natick, Massachusetts 01760

sources (when available).

Training and Operations Issues

Every heat casualty prevented thanks to peacetime training will potentially be one less patient who needs acute care during a deployment, and thus one more soldier available to accomplish the mission. Accordingly, MOs should help train the unit for the hot weather threat, as part of the unit's preventive medicine program. In addition, during a field deployment, the MO may be asked to provide ongoing advice on how to cope with the heat threat. Training and operations planning for a battalion are coordinated by the S-3 section; therefore, an MO who learns how to work effectively with this section will be in a position to have a broad impact on unit performance. Although the staff position is named Operations and Training (S-3), training occurs before deployment; so for purposes of this textbook, training is discussed before operations planning.

Predeployment Training

Table 9-2 describes a training program for hot weather operations. Some of the elements of this program (such as how to avoid insects and diarrheal diseases) should be a routine part of any unit's ongoing training plan, but they take on extra importance when a unit is faced with a deployment to a hot environment. Others, such as training that is specifically directed at acclimatizing the troops to heat, can be implemented if there are 7 to 10 days of advance notice. The preventive measures listed here have been discussed in greater detail in Chapter 6, Prevention of Heat Illness; we shall, therefore, highlight only a few important points.

Acclimatization Training. The most practical way to acclimatize troops to the heat remains a program

TABLE 9-2

GUIDELINES FOR PREDEPLOYMENT TRAINING FOR HOT WEATHER OPERATIONS

Training Component	Description
Physical Training	Safe, daily exercises in the heat of sufficient duration and intensity to produce profuse sweating
Water Consumption Practices	1–2 L/h of monitored water intake while physically active (depending on activity, environment, and protective clothing being worn). Consider prehydration with 300–500 mL of water prior to starting physical activity. Thirst: *not* a reliable indicator of dehydration. Urine: should be clear, colorless. Avoid massive water ingestion, as this can precipitate hyponatremia. Symptoms that do not respond to ingestion of 2–3 L water should be referred to a medic. Water consumed is far more effective as a coolant than water splashed on the skin. Water discipline is the first but by no means the only measure needed to prevent heat injury
Other Protective Measures Against Heat	Use work/rest cycles whenever possible. Keep clothing dry, loose. Use shelter and entrenchment (ground is cooler below the surface)
Skin and Eye Care	UV protection (sunscreen, sunglasses, lip ointment). Daily personal hygiene. Goggles in sandy or dusty terrain. Foot care
Countermeasures to Diarrheal Diseases	Hand washing. Daily personal hygiene. No eating or drinking from unapproved sources. Review field sanitation and hygiene practices
Countermeasures to Insects	Use of insect repellent. Shake out bedding, clothing, and boots before using. Use of insect netting
First Aid for Heat Injuries	Water intake. Rest. Shelter. Field-expedient cooling methods. Early evacuation, if indicated. Assess others in the unit for signs of impending heat injury
Environmental Awareness	Beware of sandstorms, flash-floods, nighttime cold
MOPP Training	Training in all levels of MOPP gear

MOPP: mission-oriented protective posture
UV: ultraviolet light rays

of daily exercise in hot weather, with increasing intensity and duration. The goal of each daily exercise session should be to produce profuse sweating without causing heat injury; it is therefore important for leaders to monitor their troops carefully during this period and to reduce the intensity at the first sign of trouble. Individuals vary in their rate of acclimatization, but substantial acclimatization will occur in most soldiers after 7 to 10 days of exercise in the heat.[13]

As part of acclimatization training, it is important to point out to troops that indigenous forces and allied units who have deployed earlier to the hot environment may, at least at first, be much better acclimatized than they are themselves. Underestimating the advantage that an acclimatized enemy has over unacclimatized friendly troops can be lethal. However, even when not faced with immediate enemy opposition, the period that follows a deployment tends to be very busy and physically demanding as the unit secures and establishes an area of operations. Under these circumstances, unit pride and high-spiritedness may lead soldiers who are not yet fully acclimatized to adopt activity levels that produce needless heat casualties, sometimes in an effort to impress others with their prowess and strength. Unit leaders may need to be reminded that troops will not be able to perform at their optimum level until full acclimatization takes place, and that taking heat casualties probably does very little to enhance a unit's reputation for ferocity and toughness.

Water Consumption Practices. The days preceding a deployment to a hot weather environment are an excellent time to review water consumption practices, particularly if this is done concurrently with acclimatization training. This training should include, first and foremost, a strong emphasis on monitored intake of water. The amount of water consumed should be at least enough to make the urine colorless and may range from 4 to 14 liters per day for active troops.[14–17] Troops should be reminded that thirst is not a reliable indicator of dehydration, as exercising soldiers who are allowed to drink ad libitum will typically not drink enough to replace a significant portion of their water deficit.[18–22] Accordingly, troops should use the "buddy" system to ensure that sufficient quantities of water are being ingested. Forced overhydration provides no extra advantage in the heat,[23] however, and has resulted in cases of life-threatening and even fatal hyponatremia.[24] Accordingly, the US Army's current water replacement guidelines for hot weather training[17] state that hourly intake should not exceed 1.5 qt (1.4 L), and that daily intake should not exceed 12 qt (11.4 L). Soldiers must also be trained to understand that water consumption alone may not be enough to prevent heat injury, and that other protective measures should be used as well (see below).

In addition to ongoing water intake, prehydration with 300 to 500 mL of water prior to engaging in the day's activities can be useful to replenish any underlying deficits.[14,25,26] It should be made clear to the troops that this is a replacement of accumulated deficits, as the human body cannot "store up" water for future use.

Other Important Protective Measures. Whereas troops generally recognize the importance of water consumption as a countermeasure to heat injury, the importance of scheduled work/rest cycles is often underestimated. Troops and their leaders need to incorporate planned rest periods into their training and operations whenever circumstances permit. Tables of recommended work times under various heat conditions are found in a 1999 article by S. J. Montain and colleagues, "Fluid Replacement Recommendations for Training in Hot Weather,"[17] and in Chapter 3, Physical Exercise in Hot Climates: Physiology, Performance, and Biomedical Issues, of this textbook. Although the tables offer useful guidelines, they suffer from several important limitations:

1. The tables are inherently conservative, as they are designed to protect most soldiers from heat injury and cannot therefore account for individual variations in tolerance to heat and degree of acclimatization.
2. They are based on mathematical models and reasonable inferences made from controlled laboratory conditions,[17,27–31] not from data obtained from in the field, where conditions may be more or less strenuous than in the laboratory and where levels of activity may vary considerably during the work cycle.
3. The models used to construct these tables may be less accurate at extremes of temperature and humidity.

Accordingly, these tables should be used as a reference point for planning and training but should not replace common sense and close monitoring of the troops for signs of heat injury once they are deployed.

Operations Planning

A detailed description of the process by which the battalion staff develops a plan is beyond the scope of this chapter, but it can be summarized as follows. First, on receiving a mission from a higher headquarters, the commander will develop a general concept of what the unit is expected to accomplish and how (the Commander's Intent). The battalion staff will then develop a number of different possible courses of action, each of which must be analyzed in detail to determine the manpower, combat support, and logistical requirements needed. A final recommendation is made to the commander, who has the option to accept it, modify it, or adopt a different course of action. The course of action chosen is then refined further to produce the battalion's Operational Order.

To have an impact on the final plan, the MO should strive to develop a close working relationship with the rest of the battalion staff so that he knows and understands well each of the proposed courses of action. The MO should help analyze each proposal to determine its likely medical implications for the troops. It is appropriate at this stage to recommend changes that would enhance both the welfare of the troops and the medical platoon's ability to care for them. Some factors to consider when evaluating a proposed course of action in a hot weather environment are found in Exhibit 9-4. This list is by no means comprehensive, but it should serve as a guideline to the MO who must advise a combat unit's staff.

Once a recommended course of action has been chosen and a tentative plan developed, the MO may be asked to brief the commander on the medical implications of the proposed and recommended courses of action. It is important to remember that medical implications of an operation are only one of many factors the commander weighs when deciding on a final course of action. Also, it is the commander, not the MO, who is ultimately responsible for the welfare of the troops. MOs must therefore master the art of advising without appearing to be second-guessing or undermining the commander's authority.

EXHIBIT 9-4

PLANNING FACTORS TO CONSIDER IN A HOT WEATHER ENVIRONMENT

- Mission, enemy, troops, terrain, time
- Water availability:
  - Sources of water
  - Water supply lines
- Water requirements, based on:
  - Weather and other environmental conditions
  - Intensity, duration, and punctuation of proposed activities
  - MOPP level and other protective clothing
  - Likely enemy courses of action
- Are work/rest cycles possible? If so, are they planned for?
- Predicted numbers and types of casualties (national and foreign)
- Location and capabilities of medical support assets
- Primary and alternate means and routes of evacuation
- Primary and alternate means of resupply
- Communications
- Chain of command
- Special medical requirements (equipment, supplies, drugs)
- Management of prisoners of war

MOPP: mission-oriented protective posture

Logistical Issues

MOs should be familiar with how hot weather affects some of the unit's key logistical requirements. For example, the MO should know how much water a soldier needs to survive in hot weather, and be able to provide this information to the S-4 officer on request. MOs may also be asked about the advisability of certain practices that have an effect on the unit's supply requirements (eg, Is salt supplementation necessary? Should caffeinated beverages be forbidden?). Finally, although a professional medical logistician (the medical service corps officer) is assigned to every infantry medical platoon, the MO must be able to articulate clearly the special medical supply requirements that the platoon will have during a hot weather deployment. Some of the common logistical issues that arise during deployment to hot weather (water, caffeine, IV solutions, supplemental salt, protection from the sun and heat, the effects of heat on medical equipment and supplies, and latrines) are discussed below.

Water

Water is always a key and limiting factor, and is even more so than usual in hot environments. Depending on the environmental conditions, the work load, and the uniform and protective clothing worn, it has been estimated that individuals will need between 2.5 and 14 liters of potable water per day when the mean ambient temperature is above 27°C (81°F).[14–17] The lower amount (2.5 L/d) is appropriate only for troops at rest in weather cooler than 35°C (95°F); with even mild work, each soldier should be supplied with at least 3 to 4 liters of water per day. Furthermore, during brief periods of intense activity, water requirements may increase to as much as 1 to 1.5 liters per *hour*.[2,14,25,26] Finally, we must consider the effect of acclimatization. As individuals acclimatize, their sweat rate with activity tends to increase,[13,22] as does their average water intake.[22] Because the effect of even a moderate increase in water intake per individual is multiplied by dozens of troops, a unit's water requirements may increase substantially during the first 2 weeks of deployment to a hot environment.

Whenever feasible, additional water rations should be provided for personal hygiene (ideally enough to allow handwashing and a daily sponge bath). The medical and mess sections of a battalion have special needs that logisticians must plan for, such as handwashing stations, food washing, wound cleansing, equipment cleaning, and the cooling and oral rehydration of heat casualties. Guidelines for estimating water supply requirements in a theater of operations can be found in Field Manual 10-52.[32]

Procurement of water does little good if distribution methods are ineffective. Planning to equip each vehicle (medical and nonmedical) with several 5-gal containers of potable water is an easy way to facilitate ongoing resupply efforts, and, in addition, gives each vehicle at least an inherent minimal heat and dehydration treatment capability.

Lyster bags (standard US Army equipment) may enhance the palatability of drinking water and hence its consumption.[2] These containers use an evaporative process to cool the contents down to the prevailing wet bulb temperature. Some water is lost in this process, however. Other strategies to enhance palatability include providing soldiers with citrus flavoring and sweetening for their water[14]; the beverage base powder contained in the prepackaged Meals, Ready-to-Eat (MREs) is an example of this. It may be counterproductive to provide carbonated beverages, however, as these tend to produce a sensation of stomach fullness, which may inhibit drinking. Furthermore, carbonic acid can itself stimulate both diuresis and sweating.[14]

It has long been known that in the desert, much of an individual's total daily water intake occurs during meals.[33] This is presumably true in other hot weather environments as well. It is therefore very important to make sure that an ample supply of water is available to troops at meal times. Providing extra water at meals also allows troops to refill their canteens before resuming field operations.

Caffeine

The MO may be asked whether caffeine consumption should be banned during a deployment to hot weather, owing to caffeine's reputation for having diuretic properties. While it is true that any degree of dehydration is undesirable in hot environments,[34] caffeine is at most a mild diuretic, and unless water is in very short supply, it should be possible to compensate for any additional urinary losses by increasing water consumption. Caffeine may also have desirable ergogenic effects on physical performance.[35,36] Furthermore, abrupt cessation of caffeine intake by even moderate users can produce a withdrawal syndrome[37] that might adversely affect performance. Thus, until outcome data are available that specifically address this issue, a ban on moderate caffeine consumption during hot weather operations does not appear to be necessary (and may even be detrimental), unless the unit's ability to meet a small increase in water requirements is in question.

Intravenous Solutions

Extra IV fluids and infusion sets should be planned for and procured; both the medics and the combat lifesavers in the unit must be supplied. The unit's total on-hand stock of IV fluid can be greatly enhanced without unduly encumbering the aid station section, the medics, or the combat lifesavers by simply procuring and distributing extra IV bags to individual line soldiers in the unit. Soldiers who are asked to carry IV bags should be given basic instructions on how to care for them. For example, they should be told that the IV bags should not be removed from their outer wrapping until just before they are used, and that care should be taken to avoid accidental puncturing of the bag. However, even under the best of circumstances, saline for IV infusion tends to be a limited resource. It is therefore prudent to plan to attempt oral rehydration of heat casualties whenever feasible, reserving the IV saline for the emergency cases and for those who cannot take liquids by mouth. Field-expedient oral rehydration solutions can be made by adding one salt packet and one beverage base powder from a standard MRE to a 1-qt canteen of water[2]; medics and combat lifesavers should be trained to prepare and use this solution.

Supplemental Salt

Although unacclimatized soldiers will lose a significant amount of sodium and chloride (as well as some potassium and magnesium) in their sweat, supplemental salt administration is generally not necessary. Most diets (and US military rations in particular) will supply more than enough to meet a soldier's needs, even in a hot weather environment.[13,38] Furthermore, supplemental salt administration may be deleterious, as it may (for example) force obligatory urinary losses of water to excrete the excess sodium load.[38]

Protection From the Sun and Heat

A unit deploying to a hot environment will need to procure an ample supply of sunscreen, ultraviolet ray–blocking sunglasses and lip ointment, bandanas, insect repellent, mosquito netting, and skin and foot powder. Broad-brimmed hats ("ranger," "jungle," or "boonie" caps) can provide better protection from the sun than standard battle dress uniform caps[39] and should be authorized and obtained if possible.

Shelter from the elements is an important aspect of the prevention and treatment of heat injury. Shelters that are entrenched can be cooler than those that are erected on the surface, as ground temperature drops fairly quickly below the surface.[2] For static facilities that are likely to treat a large number of heat casualties, air-conditioning units can be useful. However, even an infantry BAS can be equipped with a fan, provided a generator is available. Furthermore, many ground ambulances are equipped with air conditioning in the patient bay. These units should be checked and be working properly before deployment; if they are not working, repair should be a high priority.

Effects of Heat on Medical Equipment and Supplies

Medical equipment and supplies can be highly vulnerable to the conditions faced in a hot weather environment. For example, sand, dirt, and dust can clog filters and tubing, and can damage or disable medical equipment. Bacteria and fungi may proliferate in hot, humid climates and can rapidly degrade untreated fabric and rubber components. Critical equipment should therefore be inspected and cleaned frequently to identify and correct problems before they become disabling.

Drug shelf life may be significantly reduced, especially once a container has been opened; it may therefore be preferable to obtain some drugs in blister packs instead of bottles. Medics must also understand that dressings and other items packaged in paper sleeves are no longer considered sterile if the sleeve gets wet. A torrential rain can soak an aid bag or an incompletely sealed medical supply box and ruin much of its contents. A practice of wrapping individual moisture-sensitive items in airtight plastic sandwich bags prior to deployment can help salvage supplies under even the worst conditions.

Latrines

Latrines should be procured or built for unit elements that are expected to remain in relatively static positions. Latrines are obviously important for sanitary reasons. They are also important because when clean, sanitary latrines are not available, some troops may drink less (to void less).

In the desert, care should be taken to avoid placing latrines in either a flash-flood zone or in a location that could contaminate the limited water supply.

TWELVE TIPS FOR MEDICAL OFFICERS

1. Always Have a Functioning Evacuation Plan.

The best MO in the world will be of little use to the troops if there is no way to get the casualties to him. Furthermore, being able to get a casualty who needs advanced care to a facility that can provide it in a timely manner often makes the difference between life and death. A functioning medical evacuation plan is always a top priority for the medical platoon. In a hot weather environment, this should include the means to cool and hydrate a patient during transport.

2. Establish a Medical Treatment Capability as Early as Possible.

A unit deploying to a hot weather environment should be prepared to suffer some early heat casualties, when water supplies are still tenuous and troops are not yet fully acclimatized. Enemy attempts to disrupt deployment can also produce early casualties. It is therefore a top priority for a medical platoon to establish capabilities to treat casualties with trauma or heat injury as early as possible. This can be

EXHIBIT 9-5

THE CASE OF THE MISSING CANTEENS

Two National Guard infantry battalions conducted their annual training in the middle of a record-setting heat wave at Fort A. P. Hill, Virginia. For the sake of efficiency, the medical assets of both battalions were pooled into an enhanced aid station under the direction of a single medical officer. Because of the short time available for training, it was not possible to preacclimatize the troops before deploying into weather hotter than 100°F. Within 48 hours of arrival at the training site, the aid station had treated about a dozen heat casualties, several of whom also had signs of dehydration. Accordingly, the medical officer made a point of attending the evening's command briefing. During the briefing he noticed that, aside from himself and the chaplain, none of his fellow officers were carrying canteens of water, despite evening temperatures that remained in the high 90s (°F). He pointed this out to the group, in front of the commander, and posed the question: What message does this send to the troops about how seriously their officers take water discipline? The importance of being a role model for water discipline was vigorously reaffirmed by the commander; within 24 hours, the casualty rate had diminished to about one per day.

accomplished by designating a ground ambulance as a makeshift battalion aid station while the BAS tent is being erected. Distributing extra supplies to medics prior to deployment also may buy a little time.

3. Keep Track of the Number, Type, and Disposition of Heat Casualties.

Heat casualties tend to occur in clusters[3–5,12]; therefore, it is wise to view the first heat casualty as a herald of others to come. A cluster of casualties coming from the same unit should prompt the MO to seek a constructive discussion with the leadership of that unit. The focus of this discussion should not be to ascribe blame but rather to identify remediable causes of heat injuries and to find countermeasures that are tailored to the reality the unit is facing.

The adjutant (S-1) will need a daily tally of the number of casualties incurred and a rough estimate of how soon they will be able to return to duty (if at all). Furthermore, the numbers and types of casualties suffered can provide the intelligence officer (S-2) important insights into enemy activities and capabilities. It is therefore important for the medical platoon to keep a systematic count of these casualties and to provide a daily summary report to the battalion staff. Finally, keeping a log of soldiers who were evacuated to a supporting medical facility and the facility to which they were evacuated can help the process of returning them to the unit once they are treated.

4. Attend the Daily Staff Meeting and Commander's Briefing.

Participation in staff and command briefings serves several purposes:

- these gatherings allow the MO to bring key information to the attention of the commander and the staff,
- they are efficient places to get first-hand information on the unit's situation (including the weather forecast) and the latest updates to the operation, and
- they provide an excellent forum for giving general medical recommendations to the unit.

At these meetings, the MO should be prepared, at a minimum, to brief the commander and the other staff members on the numbers and types of casualties treated, any identified clusters of cases (including those that are environmentally caused), and any recommended countermeasures. The MO should be prepared to answer questions in direct, nontechnical language. Brevity and clarity are essential to effective communication in these meetings and are greatly appreciated by the nonmedical personnel who must attend them.

Exhibit 9-5 illustrates how an MO used the commander's daily briefing to improve water discipline in the unit.

5. Monitor the Weather.

Knowing the weather forecast allows the MO to tailor the recommendations for addressing the environmental threat. Methods of obtaining and disseminating weather information should be planned for prior to deployment (as discussed above) and implemented once the unit is in the field.

6. Never Pass Up an Opportunity to Resupply a Unit.

We should view every medical *evacuation* mission as an opportunity to be a medical *resupply* mission. Every vehicle in the battalion (including ground ambulances) should carry several 5-gal containers filled with potable water. This practice will afford the unit an impromptu water resupply capability that can be especially important for elements in isolated locations. Furthermore, ambulances should maintain a small surplus of items required by the frontline medics. In hot weather environments, this often means extra bags of IV fluids.

MOs must never forget that if a ground ambulance is to be used for any nonmedical purpose, the medical distinguishing characteristics (in the US Army, the red crosses) must be obscured.

7. Monitor Your Own Soldiers for Signs of Environmental Illness and Combat Fatigue.

Medical units are expected to deliver services and support around the clock and are thus highly vulnerable to the stresses of continuous operations. Furthermore, the ethic of self-sacrifice and "patients first" that characterizes medical personnel can result in self-neglect and unnecessary environmental injury. The physical demands of being a medic can be quite high (eg, when transporting casualties to and from an evacuation vehicle). It is therefore incumbent upon leaders in medical units to ensure that their own soldiers follow the heat injury prevention guidelines that are given to the rest of the unit.

Combat fatigue is an ever-present threat to medical units. In a modern battlefield, no unit is immune to attack by indirect fire. Even when spared attack, medical units often face, daily, the grisly human consequences of war: injury, illness, dismemberment, and death. The environmental threat only compounds the inherent psychological stresses of the occupation. Heat can diminish the capacity to perform physically demanding tasks[40–46] as well as some mental tasks,[47] and is often perceived as an especially unrelenting environmental condition, thus adding to any underlying frustrations. Countermeasures to combat fatigue are discussed in Volume 3 of *Medical Aspects of Harsh Environments* and elsewhere,[48] and must be tailored to the realities of the local situation. For example, in a hot environment, we must make extra efforts to find comfortable sleeping arrangements for soldiers who will be working night shifts and must therefore sleep during the hottest part of the day. Identifying a relatively cool and safe location for rest periods can also be a boost to morale. Of course, we must never pass up an opportunity to provide the troops appropriate rest and recreation, especially if it involves a chance to obtain respite from the heat. Finally, opportunities to obtain Class VI (personal need) items can provide a significant boost to troop morale.

8. Dead Medics Cannot Save Lives.

Medical personnel who do not know the fundamentals of battlefield survival quickly become a burden to those around them. Medical units must therefore pay close attention to the realities of operations in a combat zone. All personnel must maintain physical fitness and proficiency in basic soldier skills, including how to move, shoot, and communicate; how to set up and maintain a defensive perimeter; how to use mission-oriented protective posture (MOPP) gear at all its levels, and how to cope with the environmental threat.

Casualties themselves can be a serious and even lethal threat to medical personnel. For example, a single, armed grenade that a confused casualty is clutching but happens to drop while being loaded into an ambulance can result in unnecessary tragedy and loss of a limited asset. It is important to make sure that casualties are relieved of their weapons before loading them into an ambulance or bringing them into a medical treatment facility. Do not take at face value the word of a sick or injured soldier that all weapons are secured; search him. A search policy is especially important in areas where terrorist and guerrilla threats are high, as unconscious casualties may be deliberately booby-trapped in an effort to kill and injure those who may try to help them.

9. Always Be on the Lookout for Opportunities to Improve the Area of Operations.

Every day that a unit is not on the move should be viewed as an opportunity to improve the surrounding area of operations. These improvements include the quality and quantity of the water supply, field sanitation and hygiene, cooling and shelter, defensibility of the area of operations, and better access to routes of evacuation and helicopter landing zones.

10. Be a Good Role Model.

Like it or not, an MO will probably be viewed as a role model by the troops. As a result, our actions and attitudes, as mimicked by others, may have unanticipated effects. In addition, behavior that is viewed as capricious or arbitrary can rapidly sap the morale of the unit. We must therefore be careful to maintain high personal standards of conduct and ethics, to be just, and to try to set the example that we wish others to follow. This is especially important when members of the unit are under environmentally induced stresses such as those imposed by hot weather.

11. Use Your Noncommissioned Officers Wisely.

The advice offered here is often second nature to a good noncommissioned officer (NCO). Furthermore, NCOs are expected to be adept at implementing these recommendations. The MO who makes a point of identifying and developing strong NCOs in peacetime will be richly rewarded with individuals he can trust and to whom he can confidently delegate responsibility in wartime. Never be ashamed to learn from an NCO, especially one who has experienced battle firsthand.

12. Keep a Positive Mental Attitude.

Always!

SUMMARY

Hot weather poses special challenges to the MO who must support a combat arms unit. However, the elements of success are similar to those encountered in any military operation: a strong peacetime training program, careful planning, a good working relationship with the battalion commander and staff, development of and trust in the NCOs, and, above all, a very healthy respect for the threat that hot weather poses.

Although the advice given here may be helpful to the MO deploying to a hot weather environment, the ultimate test of success is whether the unit accomplishes its mission with a minimum of casualties. No amount of writing or reading can replace the need for training, resourcefulness, wisdom, and flexibility on the part of the medical personnel who must support troops in the field.

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Stretchers Medical Employment of Air Transport in the Forward. Area. 2087.Â c. With the diminished threat of a large-scale military confrontation, military force size and capabilities are being affected in countries throughout the world. Many of the major military powers are moving toward smaller, better-equipped, and better-trained forces.Â Medical intelligence is concerned with one or more aspects of foreign nations or the AO. Until medical information is processed (ordinarily at the national level by the Armed Forces Medical Intelligence Center [AFMIC]), it is not considered to be intelligence. c. For additional information on medical intelligence, refer to FM 8-10-8. Military Branches in Joint Operations. Joint or Combined Operations Other Than War. Recommendations.Â The historical approach has practical value. An understanding of how military medicine dealt with combat stress breakdown in the past can enable. mental health professionals to avoid mistakes made earlier and to devise new ways to deal with modern stress. Lessons both learned and not learned but available are outlined in Table 1-1. One example of a lesson not learned in the Russo-Japanese War is that providing a medical label for stress symptoms results in the development of such symptoms by other soldiers as an honorable way out of combat.5. PRE-20TH Century conceptions of psychiatric casualt Medical Aspects of Harsh Environments, Volume 1. INTRODUCTION. Conducting military training or combat missions in cold environments poses a dual challenge: pro-tecting the personnel from hypothermia and other forms of cold injury while also realizing the objec-tives of the mission.Â cal agents influence peripheral vasoconstriction. Most military operations in cold weather are nega-tively affected by the pronounced discomfort asso-ciated with vasoconstriction of the extremities.Â From the practical standpoint in the field, one of the only ways to assess hydration is to examine the color of the urine. Most military units insist on vi-sually inspecting the degree of darkness of each individualâ€™s urine.