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Clinical Practice Guideline for the Prevention, Diagnosis, and Management of **Exertional Heat Illness**

PREVENTION | PREHOSPITAL CARE | EMERGENCY CARE | ADVANCED CARE | RETURN TO DUTY

A Collaborative Effort of
United States Military Joint Service Medical Providers

In Conjunction with The Army Heat Center and the
Consortium for Health and Military Performance (CHAMP)
Warrior Heat- and Exertion-Related Events Collaborative (WHEC)

The Army Heat Center at Fort Moore

CHAMP
Uniformed Services University

WHEC
WARRIOR HEAT- AND EXERTION-RELATED EVENTS COLLABORATIVE

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SECTION 1: EXECUTIVE SUMMARY

Exertional heat illness (EHI) represents a serious and ongoing threat to Service Members (SM) and unit operational readiness. EHI represents a spectrum of clinical disorders (heat exhaustion, heat injury, and heat stroke) that can present with several co-morbid conditions, including exercise-associated hyponatremia (EAH), exercise-associated muscle cramps (EAMC), exertional rhabdomyolysis (ER), and exercise collapse associated with sickle cell trait (ECAST). This military-specific clinical practice guideline (CPG) has been developed by Joint Service military medical providers, in conjunction with The Army Heat Center and the Consortium for Health and Military Performance (CHAMP) Warrior Heat- and Exertion-Related Event Collaborative (WHEC), to identify and disseminate the clinical best practice in the prevention, management, and return to duty of SM afflicted with EHI. This CPG identifies recommendations intended to optimize patient care that are informed by a review of current evidence and clinical experience. Patient and site-specific management, however, should additionally be guided with attention to local and Service-specific policy.

The occurrence of EHI, and its associated morbidity and mortality, is largely preventable. The military utilizes a deliberate five-step risk-management process for the prevention of EHI, including: identifying hazards; assessing the hazards in terms of severity and probability; developing controls and making risk decisions; implementing appropriate controls to abate the hazards; and continuing to supervise and evaluate the controls to prevent heat casualties. The cornerstone of EHI prevention is education. This CPG details the process and tools utilized in risk management to assist the medical team in the prevention and mitigation of EHI.

Management of EHI represents a well-organized chain of survival, including: prehospital field care; emergency care; advanced care, to include hospital care; and, finally, return to duty. This integrated system relies on communication to optimize SM care, and to minimize morbidity, mortality, and impact on unit readiness. The cornerstone of management is the identification of the SM at risk for EHI, and the provision of on-site and effective cooling. This CPG details effective cooling measures at each level along the chain of survival (e.g., prehospital field, emergency medical services transport, and emergency department) and details the expected time course of co-morbidities to facilitate optimal decision-making for life-saving management.

Return to duty represents the final management stage of the SM with EHI and hinges on the critical role of the military medical provider. Return-to-duty recommendations are challenging given the highly individualized nature of EHI events. This CPG outlines an evidence-based risk-stratification process for EHI severity, with appropriate guidance for return to duty. A detailed discussion is additionally provided for those SM who struggle with return to duty, to include the role of advanced testing, which may include heat-tolerance testing (HTT) as well as a metabolic myopathy and genomic evaluation.

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SECTION 3: INTRODUCTION

Exertional Heat Illness

Exertional heat illness (EHI) is a direct threat to Service Members (SM) and may degrade operational readiness in both training and deployed settings. Frequently encountered in both athletes and SM, EHI occurs most commonly in individuals engaged in high-intensity exercise in warm environments.[1-3] Reports in athletes indicate that EHI occurs in up to 4.19 per 1,000 athlete-exposures during participation in American football, and up to 54.5% of desert ultra-marathoners.[2, 4-6] EHI is a well-recognized occupational hazard in SM; in 2022, the crude incidence rates of heat stroke and heat exhaustion among active-component SM were 32.1 and 147.7 per 100,000 person-years, respectively.[7, 8] Importantly, the prevalence of EHI potentially will increase in the future due to anticipated rising global temperatures associated with the changing climate.[9]

Although a variety of medical conditions can be caused or exacerbated by exertion and/or hot climates (e.g., dehydration, sunburn, miliaria rubra or "heat rash," and exercise-associated muscle cramps [EAMC]), EHI specifically refers to a spectrum of clinical syndromes ranging from mild (heat exhaustion [HE]) to severe, and life-threatening, exertional heat stroke (EHS). These occur when the body is unable to maintain a relatively constant core temperature, and thermoregulation becomes overwhelmed during exercise.[2, 6] In HE, body core temperature is typically less than 40°C (104°F), with minimal or no evidence of end organ dysfunction, and generally recovery is rapid after appropriate treatment without any long-lasting effects.[3] On the other hand, EHS is a significant environmental illness where body core temperature usually exceeds 40°C (104°F). The hallmark of EHS is central nervous system (CNS) dysfunction (e.g., disorientation, combativeness, delirium, seizures, and coma). The incidence and severity of other end organ damage—such as acute kidney injury, liver injury, or exertional rhadomyolosis (ER)—is highly variable.[1, 3] Heat injury (HI) is a diagnosis intermediate in severity, in which the casualty displays signs and symptoms similar to HE, where there is additional evidence of end organ injury (typically evident only on laboratory evaluation), in the absence of CNS dysfunction. Recognizing these conditions promptly is crucial to ensuring good outcomes, but it can be challenging. Although HE is generally benign, it can present with symptoms mimicking EHS.[3, 10] The converse is also true: EHS can initially present with subtle or intermittent symptoms which, if unrecognized and untreated, may become serious and possibly fatal.

Despite extensive prevention efforts, EHI remains a significant threat to the military. In addition, despite Service-specific guidance on the recognition and management of EHI, diagnosis and management remain challenging (AFI 48-151[11], NEHC-TM-OEM 6260.6A[12]). Additionally, there has been no joint consensus on guidelines for treatment in the prehospital, emergency room, inpatient hospital, and intensive care settings. In absence of consensus definitions for EHS classification and severity, and with no risk-prediction algorithm to recommend the appropriate method of treatment, variation in treatment and outcomes has been significant.[13] Importantly, a lack of consensus has existed regarding recommendations for return to duty after EHI.[2] This CPG represents the first Joint Service collaborative effort to establish consensus around EHI prevention, diagnosis, management, and return to duty, while recognizing the diverse missions of the branches of the Armed Forces.

Several professional medical societies and organizations have published guidelines for EHI prevention, recognition, and treatment, while return-to-activity and return-to-duty (RTD) guidelines are limited. Incongruency exists in the policy/guidance of the various branches of the United States Armed Forces.[2] The similarities and differences reflected in Army (AR 40-501[14]), Air Force (AFI 48-151[11]), and Navy (NEHC-TM-OEM 6260.6A[12]) guidelines speak to the Services' unique missions and training paradigms, which bring varied exposures to EHI and have led to different interpretations of previously published recommendations. Although factors such as military service branch, occupation, and the details of military operations are variable in nature, an effort to update and standardize current guidelines is necessary to ensure the consistent application of diagnostic criteria across the Services and to disseminate established best practices to limit morbidity and mortality while optimizing the return-to-duty process.

This CPG serves to inform the development of Defense Health Agency (DHA) practice parameters and recommendations to improve the care of SM. Figure 3.1 recognizes and presents an EHI chain of survival, and this document follows this paradigm. A glossary of terms (Section 10) is provided to ensure consistency, and a detailed appendix (Section 11) provides guidance for heat-illness prevention. Relevant websites, materials, handouts, and other doctrinal guidance are included throughout this document. Finally, while this CPG, informed by current evidence and experience, identifies recommendations intended to optimize SM care, patient and site-specific management should importantly be guided with attention to local and Service-specific policy.

Figure 3.1. Exertional Heat Illness Chain of Survival

SECTION 4: PREVENTION

Recognize and Mitigate Risk

The occurrence of EHI, and its associated morbidity and mortality, are largely preventable.[1] This is particularly true in controlled training environments. In fact, among athletes, EHS has been recognized as arguably the most preventable cause of exertional sudden death.[2] Prevention is the result of recognition and mitigation of well-described risk factors, which are ideally addressed through leadership, policy, and on-site health care. The keys to prevention are briefly summarized in Figure 4.1. The cornerstone of prevention is education. Please see Appendix 1 for a more detailed discussion of the principles of EHI prevention.

1 Preparation

- Conduct **risk assessment**
- Create **emergency action plan**
- Develop and implement controls
- Educate instructors and commanders
- Have healthcare providers/medics and requisite equipment available
- Supervise and evaluate

2 Identify what you cannot change

Environmental conditions
Personal protective equipment
Non-modifiable risk factors of individual Service Members

3 Identify those at greatest risk

Select medications
Recent illness
Predisposing medical conditions
Previous heat event
High BMI
Highly motivated
Dehydrated
Not acclimated
Not conditioned

4 Implement mitigations strategies

Review enironmental conditions (WBGT)
Initiate appropriate work/rest cycles
Cooling and hydration stations
Identify individuals at greatest risk
Risk-stratify based on risk susceptibility
Respond to signs of EHI immediately
Educate Service Members
Engage with leadership

Figure 4.1. Summary of Steps to Prevent Exertional Heat Illness

Risk management (RM) is a critical topic in military leadership, and preparing for EHI is no exception. Each of the Services maintains current doctrine regarding the process of RM and the associated decisions and mitigations deployed (ATP 5-19[3], AFI 90-802[4], AFPAM 90-803[5], OPNAVINST 3500.39D[6], MCO 3500.27C[7]). These policies are fundamentally similar in their definition of RM and in identifying the commander as the RM authority within military operations, which includes operational, tactical, service, and training events[3] (AFI 90-802[4], AFPAM 90-803[5], OPNAVINST 3500.39D[6], MCO 3500.27C[7]). All Service RM doctrines are similar, so the Army Techniques Publication (ATP) 5-19 is cited here as an example.[3] This document identifies a five-step process for effective risk management (Figure 4.2).

A comprehensive exertional heat-injury prevention and management program should follow the principles of risk management by identifying hazards, assessing the hazards in terms of severity and probability, and developing controls, while making risk decisions, implementing appropriate controls to abate the hazards, and continuing to supervise and evaluate the controls to prevent heat casualties. Commanders conduct deliberate and real-time risk assessments for all operations and must ensure subordinate leaders and SM receive and understand the information from the risk assessment to include the controls used to mitigate risk. Spot-checking and supervision by first-line leaders should be employed to ensure control measures are being implemented. Units train using risk-management principles; therefore, it is imperative that commanders and leaders are educated on the prevention of hot-weather injuries using this terminology.

The following section applies the five-step risk management framework to the prevention of EHI. Appendix 1 provides detailed information on risk factors that increase EHI susceptibility, as well as recommendations for risk-factor mitigation. Appendix 2 presents DD Form 2297, Deliberate Risk Assessment Worksheet (A2.1), and an example of a heat-illness risk-assessment matrix (A2.2).

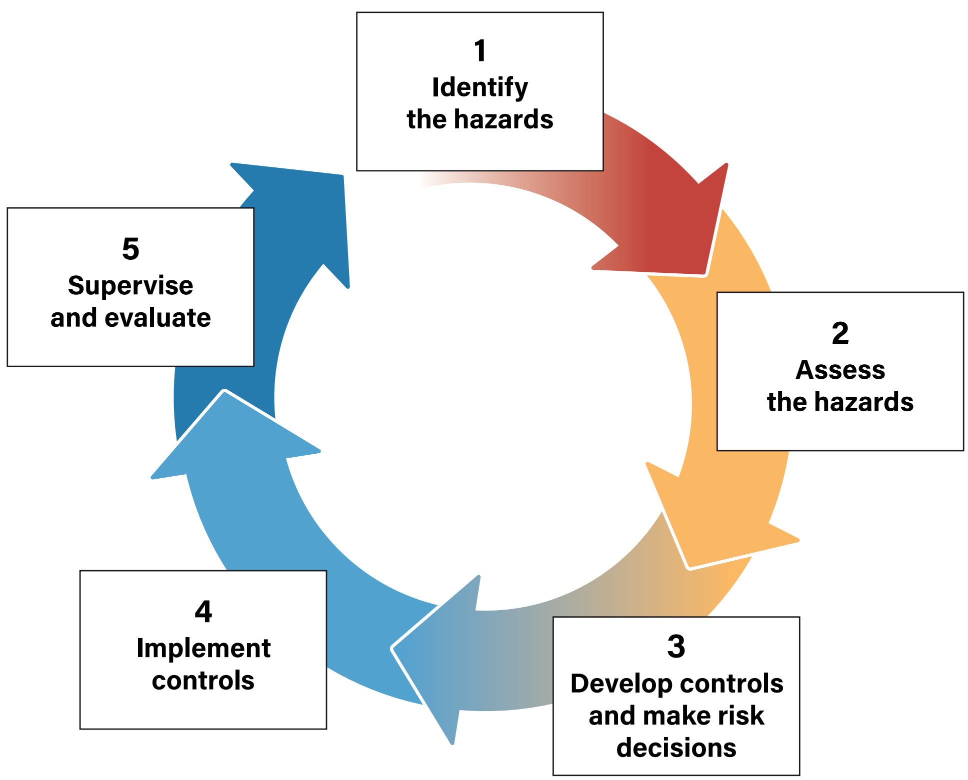


Figure 4.2. U.S. Army Five-Step Risk-Management Process

Identify the Hazards

Numerous risk factors increase an individual's susceptibility to EHI. Army TB MED 507 groups these as functional, acquired, and environmental risk factors, but for the purposes of this CPG they are categorized as either modifiable or non-modifiable. Figure 4.3 provides a flow chart for leaders to assess specific hazards, risks, and characteristics of an anticipated mission and implement mitigation strategies.[8]

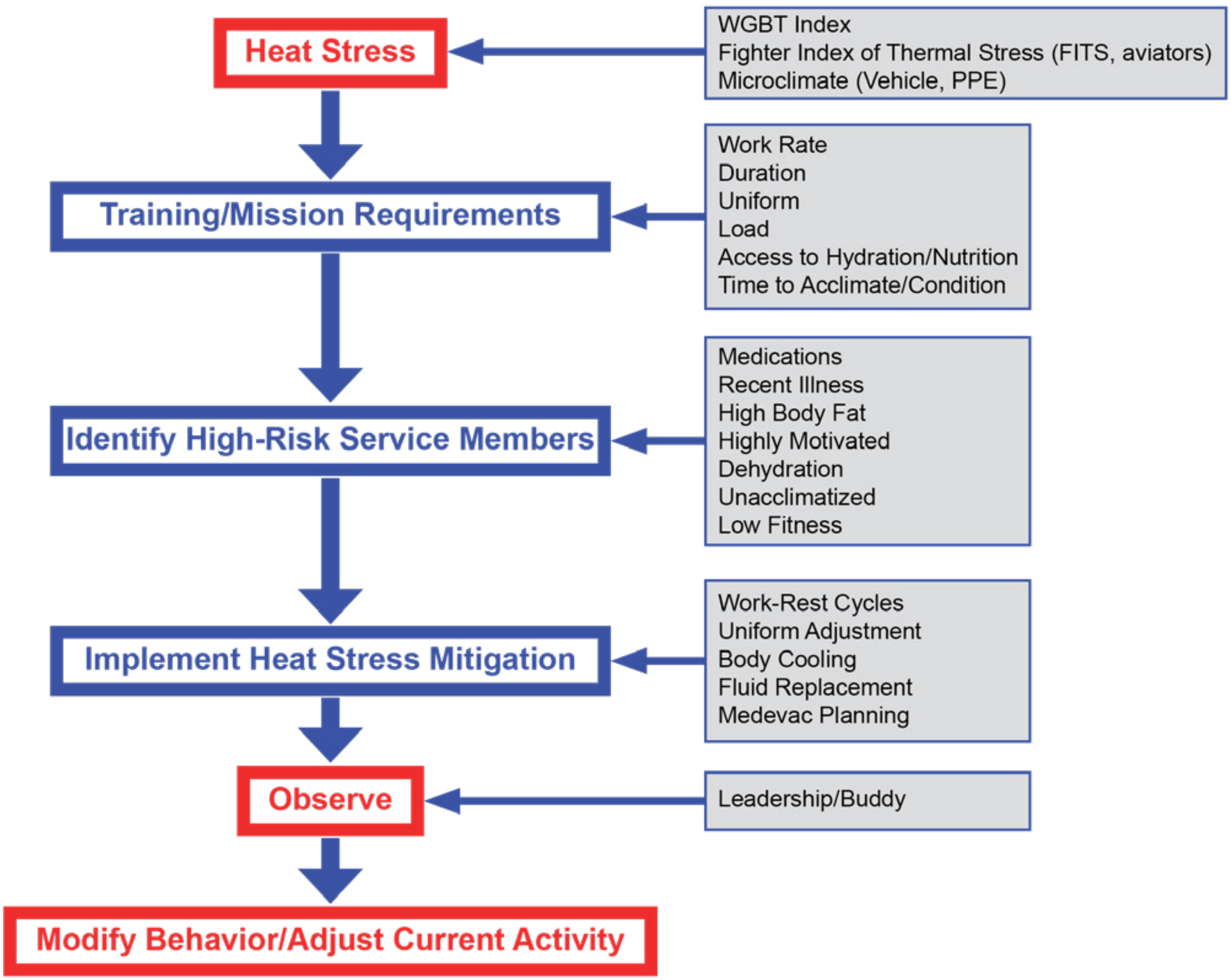


Figure 4.3. Heat Risk Assessment Process

Modifiable Risk Factors:

- Motivation
- Physical (aerobic) fitness
- Work intensity
- Lack of acclimatization
- Recent or concurrent illness
- Dehydration
- Body composition (i.e., obesity/excess adiposity)
- Clothing/Equipment
- Medications
- Inadequate or improper nutrition
- Sleep deprivation
- Dietary supplement use
- Caffeine
- Alcohol use

Non-modifiable Risk Factors:

- Environmental conditions – temperature, humidity, solar radiation, wind speed
- Sex (males > females)
- Age (e.g., age >40 carries highest risk)
- Medical conditions
- Genetics
- History of prior exertional heat injury

Assess the Hazards

The potential for heat casualties can be assessed by:

- **Using the wet-bulb globe temperature (WBGT) to determine the heat category when ambient temperature is over 24°C** (75°F). WBGT should be assessed at the training site throughout the training day; do not rely on the heat category determined elsewhere on the installation. It should also be compared to recent trends, as heat load within an individual can be cumulative over the previous days, while an abrupt increase in WBGT may not provide adequate acclimatization time for individual Warfighters.

- **Knowing your SM individual risk factors (see Appendix 1 for details).** Early identification of who will be at increased risk will aid in the application of targeted, individualized risk-mitigation actions.

- **Checking the hydration status of SM at the start of each training day.** A simple and reliable indicator of adequate hydration is clear or very light-yellow urine. If hydration is inadequate, encourage extra fluid at night or in the morning. Note: Hydration status is often emphasized, as it is easily modifiable by encouraging consumption of fluids. However, SM who are normally hydrated are still at risk of becoming a heat casualty, as other risk factors may be present.

Develop Controls and Make Risk Decisions

Those with tactical-level authority must be prepared to make appropriate risk-management decisions. The risk of heat casualties can be mitigated through several recognized strategies:

- **Education, to include:**

  - Posting heat casualty prevention information where it is easily accessible (e.g., SM hydration assessment in latrines).

  - Ensuring all SM are trained in recognition and initial field treatment of heat illness.

  - Providing guidance on appropriate pacing strategies to sustain performance while mitigating heat stress.

  - Conducting high-fidelity heat-injury response drills.

  - Establishing standard operating procedures (SOP) for EHI prevention, recognition, and management.

- **Appropriate training-event planning, to include:**

  - Minimizing consecutive days of heavy physical training when heat stressors exist.

  - Planning to perform heavy work (including physical training) in early morning or evening hours whenever possible.

  - Considering training alterations that improve heat loss (uniform modifications) and/or reduce the training intensity (pace, load) if particularly high-risk activities must be performed. If training or events are "for record" and alterations are not feasible, understand that the higher risk alters the strategy from prevention to intervention; mitigate the most serious heat-illness outcomes with proper medical coverage and body-cooling availability.

- Providing and enforcing use of shade to reduce solar load. Ensure that shaded areas have good air circulation.
- Provide on-site medical care and evacuation support.
- Provide adequate time and exposure for individuals to acclimatize to warmer environments.
- Providing means of and enforcing use of cooling, such as the arm immersion cooling system (AICS) and/or "Cool Zones" to facilitate heat loss in hot weather (see Appendix 1).
- Planning operations to include cold water resupply points every 3 hours.
- Carry as much water as possible when separated from approved sources of drinking water. Ensure that SM always have at least 1 quart in reserve; know when and where water resupply will be available.

» **Identifying the following:**

- Previous HE, HI, or EHS among SM, as this may identify those who fail to modify their pace/workload appropriately (as opposed to deficits in physiological function because of prior heat illness). Consider uniform identification of those at high risk, e.g., patch, wristband, bead on shoelace.
- Overweight SM and those who are unfit.
- SM on medications that may increase their risk of becoming a heat casualty.
- SM who may be ill. Consider having these SM report to sick call.
- Monitor the heat category hourly. The WBGT device must be positioned at the training site.

Implement Risk-Management Controls

Heat-casualty controls can be implemented through the following:

» Make risk decisions at the appropriate Command level based on local SOP.

» Plan the timing and frequency of training events with consideration of the heat stress.

» Implement work-rest and fluid-replacement guidelines based on the heat category. Before and during recovery periods, emphasize rest, shade, rehydration, and nutrition.

» Encourage appropriate fluid consumption. Forced hydration orders are discouraged and can be dangerous, increasing the risk for exercise-associated hyponatremia.

» Provide sufficient time for complete consumption of meals. Complete consumption of rations, including salt packets, will provide an adequate salt intake. Service Members may have a few days of increased salt requirements upon initial hot-weather deployment because more sodium is lost through sweating before heat acclimatization.

» Conduct random checks by unit leaders and buddy checks by fellow SM to monitor their overall well-being.

» Remove barriers to drinking. Ensure cool-water accessibility and provide enough time to drink and eat. SM consume most of their water and electrolytes with meals; improving water availability increases food consumption. Carbohydrate and electrolyte beverages (sports drinks) are not required and, if used, should not be the only source of liquid for extended periods. For healthy SM, flavored sports beverages generally provide no advantage over water; however, they can increase fluid consumption because of their improved palatability.

» Modify the clothing worn and equipment carried as necessary to reduce heat strain.

» Establish drinking schedules by using the fluid-replacement guidelines provided in Appendix 1.

» When not in direct sun (or brush), loosen and remove clothing to improve ventilation and evaporative cooling.

» Wearing the Joint Service Lightweight Integrated Suit Technology (JSLIST) or other protective overgarments decreases evaporative cooling and may dramatically increase heat strain. Wearing underwear and the complete operational uniform, with the sleeves rolled down, under the JSLIST, provides additional protection against chemical agents. However, this clothing combination will also substantially increase the risk of heat casualties. Wearing only underwear under the JSLIST should be considered, depending on mission requirements and threat level.

Supervise and Evaluate

Ensure an educated team and an evaluation plan are in place to prevent heat casualties. The final step to the risk-management process is the supervision and evaluation of the controls taken to prevent heat casualties. Examples are as follows:

» Enforce SOPs.

» Ensure subordinate leaders and SM at all levels receive the deliberate and real-time risk-assessment information and understand the required controls prior to delegating responsibilities to ensure control measures have been implemented.

» Monitor progress of implementation of control measures.

» Conduct spot checks of cadre and recruits regarding heat category, work-rest guidelines, fluid replacement, emergency response plan, etc.

» Conduct spot checks of trainees/Warfighters by asking questions while observing their mental status and physical capabilities. Look for common signs and symptoms of both minor and major heat illnesses.

» Adjust work-rest schedules, work rates, and water consumption according to conditions.

» When the first heat illness occurs, halt training and reassess hazards and controls before resuming training.

SECTION 5: PREHOSPITAL CARE

Early Recognition and Universal Training

Owing to its life-threatening nature, treatment of exertional heat illness (EHI) hinges on early recognition and rapid treatment, beginning in the prehospital setting. The consequences of EHI are greatly worsened by the amount of time the person is hyperthermic.[1-6] A prolonged duration of hyperthermia in the lower range (40–41°C [104°F–105.8°F]) can be devastating, whereas even a very high temperature (> 42°C [107.6°F]) that is recognized early, and treated immediately, may have little to no consequences.[1-13] Numerous documented cases have shown that extremely high body core temperatures, when treated immediately and properly in the field, typically have excellent outcomes without requiring hospitalization.[1-9, 12, 13]

Typically, non-medical personnel (e.g., drill instructors, cadre, battle buddies) are the first to witness the signs and symptoms of EHI. Therefore, it is imperative to train all military personnel on how to identify and provide first aid to these patients. Unit medical personnel should conduct training at least annually for medical and non-medical personnel, disseminated from the strategic level to operational and tactical levels.[1-16] When a Warfighter begins to display altered mental status or other signs of EHI, the battle buddy, wingman, or shipmate should urgently seek medical assistance rather than dismissing it as odd behavior. While waiting for medical personnel to arrive, first aid should be initiated by doing the following:

- Call for medical support.
- Remove excess clothing.
- Move to a nearby cooler/shaded location, ideally with air-conditioning.
- If water is accessible, douse the individual with water.
- Initiate tarp-assisted cooling with oscillation (TACO) cooling (ice water in a tarp) or ice-sheet cooling (bed linens soaked in ice water), if available. See below for details about these methods.

Training strategies vary by Service and region, but highly effective training programs are characterized by simplicity of content, frequent repetition, hands-on scenarios, periodic and/or unannounced "mock heat drills," as well as leadership support. These training sessions should ideally be unit/command protocol-based, teach the field treatment algorithm specifics, and include the signs and symptoms of each EHI condition, as well as other exertional injuries that may have similar symptoms of EHI, such as altered mental status due to exercise-associated hyponatremia (EAH).[1-13, 15]

Spectrum of Exertional Heat Illness and Differential Diagnosis

The spectrum of exertional heat illness includes HE, EHI (heat exhaustion with clinical evidence of injury to vital organs), and EHS. The diagnostic conditions of HE, EHI, and EHS often share overlapping features that blur their interpretation as discrete disorders with their own distinct pathogenesis.[17] Thus, clinicians must consider other similar conditions that can be identified in the Service Member (SM) with exertional collapse, or could be coexisting, namely, sudden cardiac arrest (SCA), exertional rhabdomyolysis (ER), EAH, exertional collapse associated with sickle-cell trait (ECAST), and exercise-induced hypoglycemia (Table 5.1). When coexisting with EHI, these conditions are associated with increased morbidity and mortality. Therefore, early recognition and initiation of care are critical.[1-6, 18-24] For a complete discussion of the management of exertional rhabdomyolysis, see the published CHAMP CPG.[25]

Table 5.1. Differential Diagnosis of Exertional Collapse

Condition	Core Temp	CNS Dysfunction	Timing	Muscles	Urine	Shortness of Breath	Initial Treatment
Sudden Cardiac Arrest (SCA)	Variable	Abrupt loss of conscious-ness	Var-iable	Flaccid or seizing	N/A	Apneic or agonal breathing	Activate EMS, CPR, early AED
Exertional Heat Exhaustion (HE)	≥ 38°C (100.5°F) ≤ 41°C (105.8°F) See note 1	No	Late	May have exercise-associated muscle cramps (EAMC)	Often dehydrated	Possible	Remove excess clothing, oral fluids (+/– IV fluids), simple cooling,rest See note 2
Exertional Heat Stroke (EHS)	≥ 40°C (104.0°F)	Yes (may be intermittent or subtle)	Late	May have EAMC	Possibly dehydrated	Possible	COOL FIRST, COOL FAST, COOL on site +/– IV fluids See note 3
Exercise-Associated Hyponatre-mia (EAH)	Usually < 39°C (102°F)	Yes, if severe Often headache, confusion, and/or repeated emesis	Usually late	N/A	Urination may be increased or decreased	No	Oral sodium solution, POC testing, and administer 3% saline if CNS dysfunction or cannot swallow
Exertional Collapse Associated with Sickle Cell Trait (ECAST)	Usually < 39°C (102°F). If > 40°C (104°F), must treat as EHS	Typically, intact CNS function, "conscious collapse"	Often early	Typically, flaccid lower extremity muscle groups, global pain	May be dark/bloody	Possible, may be severe	O2, AED, IV fluids, activate EMS
Exertional Rhabdo-myolysis (ER)	WNL	No	Late	May be stiff and swollen; TTP; pain with active motion	May be dark, "cola-colored" U/A + blood, but no RBCs	No	Rest, oral vs IV fluids
Exercise-Induced Hypoglycemia	WNL	Yes	Late	WNL	Variable	No	Glucose
Exercise-Associated Collapse (EAC) See note 4	WNL	+/– CNS dysfunction that recovers quickly (< 15 min)	Late, typical-ly end of event	WNL	Variable	No	▪ Rule out other causes ▪ Place patient supine with legs elevated 12–24" above the heart ▪ If not rapidly bet-ter, re-check for other causes

Notes:

1. HE is distinguished from EHS by the absence of CNS and end organ damage. Temperatures > 41°C (105.8°F) should initially be considered as EHS given the possibility of a lucid interval, and that proteins denature at temperatures > 41°C (105.8°F), thus resulting in end organ damage.
2. Simple cooling: ice packs, ice towels/sheets, fan, forearm immersion, etc.
3. Active cooling: Ice water immersion, Quantico method, TACO, ice sheets with ice packs
4. Exercise-Associated Collapse is also additionally identified as Exercise-Associated Postural Hypotension (EAPH).

Core Temperature Assessment (Rectal)

When evaluating for EHI, the only reliable indicator of body temperature is a core (e.g., rectal) temperature. With exercise, other methods of measuring temperature (e.g., oral, axillary, temporal) can be significantly different than rectal (core) temperature and may lead to a false sense of security.[1-13, 15, 17, 26-30] While esophageal temperature is accurate, it is impractical due to the gag reflex in conscious individuals.[5, 26, 27, 29, 30] Therefore, rectal temperature is the best practice of obtaining a core temperature in the prehospital setting. An indwelling flexible probe (thermistor) attached to the digital thermometer device is much preferred to repeated intermittent temperatures with small devices/metal probes. To get an accurate reading, the thermistor should be inserted at least 15 cm (6 inches) into the rectum.[5, 26, 27, 29, 30]

It is common for the rectal temperature to plateau or even increase during initial cooling.[21] This is not a cause for alarm, unless the patient cannot be cooled to T_{core} < 39.2°C (102.5°F) within 30 minutes.[1-9, 12, 13] This initial rise in core temperature during cooling is likely due to vasoconstriction in the upper and lower extremities, redirecting warm blood from the peripheral tissues to the core. A lack of trained medical personnel to obtain rectal temperature, or lack of an appropriate thermistor, should not delay cooling. A SM who collapses during or immediately following exertion (especially in hot weather), coupled with signs and symptoms of CNS dysfunction, should be treated as an EHS casualty until proven otherwise. Nonetheless, all attempts should be made to ensure well-trained and well-equipped medical personnel are readily available during high-risk events.

Rapid Treatment

The treatment mantra is "**cool first, cool fast**." Cooling should begin as quickly as possible, and the SM's core temperature should be reduced to 39–39.2°C (102.0–102.5°F) within 30 minutes of symptom onset.[1-4, 6, 10] EHS is a life-threatening medical condition; both morbidity and mortality increase significantly with delayed recognition, delayed initiation of cooling, and prolonged cooling time.[1-13, 15, 17]

EHS is one of the few medical emergencies in which transport should be delayed to prioritize rapid on-site treatment, unless aggressive en-route cooling using proven strategies is possible. The most effective cooling modalities are difficult to employ during transport; therefore, early transport may lead to delays in cooling. Some units have demonstrated success employing ice-sheet cooling during transport as an exclusive/primary means of cooling, but recommending this strategy for widespread implementation remains an area of debate, partly due to variations in techniques and tools used for ice-sheet cooling. Current evidence supports prioritizing immediate on-site cooling strategies, using either **cold water immersion (CWI)** or the similar **Quantico method** as best practice. In situations where these methods are operationally not feasible, the **tarp-assisted cooling with oscillation (TACO) method** or the **ice-sheet method** should be utilized, as they have been identified to be the best alternative cooling methods. Whenever transport is necessary for definitive cooling, initial attempts to cool should occur en route by any available means (i.e., remove excess clothing, ice sheets, ice packs, water dousing, etc.). When used properly, ice sheets with ice packs are proven to be highly effective, especially as an initial cooling modality while rapidly transporting the casualty to a cooling station for definitive cooling. See below for further detailed discussion on cooling methods.

Patients should be monitored carefully so that the active cooling stops when the core temperature reaches 39–39.2°C (102.0–102.5°F). There are times when cooling will push the core temperature below 38°C (100.5°F). It should be noted that there are no known disadvantages to cooling below 38°C (100.5°F).[4] Most SM who experience hypothermic overshoot will reach a nadir at 35–37°C (95–98.6°F), which has no adverse physiological consequences. Drying the patient and allowing passive or gentle active rewarming is generally sufficient to stabilize to a normothermic range.

Event Planning and Heat-Treatment Areas

As noted in the prevention section, every effort should be made to prevent EHI. However, even with the best prevention strategies, EHI can still occur. Therefore, planning and logistical coordination for EHI treatment should occur prior to any event. The medical team and event organizers should identify and plan for EHI treatment stations in easily accessible areas, and near the personnel at risk for heat injuries.

Cooling should be initiated as quickly as possible (ideally within 5–10 minutes of recognition), with the goal to reduce body core temperature to T_{core} 39–39.2°C (102.0–102.5°F) within 30 minutes from the time of injury.[1-4, 6, 10, 11] Therefore, heat-treatment areas should be strategically placed so that any transportation time from the work/training site does not cause the completion of cooling to exceed 30 minutes from time of injury. An ideal example of a heat-treatment strategy for an event includes cooling stations at the finish line and others within a short drive from any other part of the course. If the transportation distance (by ground or air) would exceed 10 minutes to a definitive treatment location, then more heat-treatment locations should be created.

While transporting a patient to a heat-treatment area, the most effective possible means of cooling should be initiated immediately and then continued while en route.[1-13, 15] Removing excess clothing and dousing with water (ideally chilled) is a good initial strategy that can start the cooling process. Ice packs, ice sheets, and air movement (e.g., wind, fanning) can also be helpful during the transport, if available. All these modalities, in addition to water and ice for CWI, require advanced planning and logistical organization, including coordination with local emergency medical services (EMS) for the area. When planning for a mass-participation event (especially those involving civilians), refer to protocols/algorithms based on that type of setting.[6]

Foundation/Clinical Best Practices

On-site cooling prevents treatment delays and cooling interruptions associated with transportation to medical facilities. Whole-body cooling serves two purposes: 1) reducing organ and tissue temperatures (most important); and 2) supporting tissue perfusion by vasoconstricting blood vessels in the skin and superficial tissues, thereby moving intravascular volume from the peripheral to the central circulation. The primary goal of prehospital cooling is to rapidly lower the body core temperature into the normal range, which reduces the area under the excessive temperature curve (degree-minutes) and protects the most heat-sensitive body organs. While a minimum cooling rate for achieving favorable clinical outcomes has not been established, cooling rates faster than 0.08°C/min (0.15°F/min) appear to be acceptable, yet cooling rates greater than 0.15°C/min (0.27°F/min) are desirable to reduce both morbidity and mortality.[1-4, 6, 8, 10, 11, 31]

Two cooling methods have been proven to meet the established optimal cooling rate of at least 0.15°C/min (0.27°F/min) with zero mortality when used promptly: **CWI** and the **Quantico method**.[1-4, 6, 10, 11, 21] **TACO** and **ice sheets** are highly effective interventions when CWI and the Quantico method are not available or impractical. Data from The Army Heat Center demonstrate that the practice of prehospital ice-sheet cooling resulted in an acceptable cooling rate and low mortality.[32, 33] However, CWI and the Quantico method are best-practice interventions for cooling, as illustrated in the large body of published data supporting their safety and efficacy. See below for further discussion.

When an event is anticipated to have heat casualties, the medical team/event organizers should prepare to have CWI tubs. If multiple heat casualties are expected, the team should either prepare to have multiple immersion tubs or utilize the Quantico method. Also, the team must be sure to fulfill all appropriate logistical requirements to include sufficient medical personnel, ice, water, and equipment. Regardless of the method chosen, the pool/tub should be pre-filled with water about halfway, before the event starts. Additionally, multiple coolers filled with ice should be pre-staged next to the heat treatment area(s). The amount of ice required for an event is frequently underestimated; approximately 75–100 lbs. of ice and 60–80 gallons of water are sufficient to perform CWI for one EHS casualty in a 150-gallon tub. If there is any biohazard in the water (e.g., blood), the ice water should not be reused for additional casualties, except in dire emergency situations when all other supplies are exhausted.

Regardless of which method is chosen, appropriate personal protective equipment (PPE) should be worn at all times. Glove utilization is always recommended for all medical staff. Eye protection/face shields are typically not indicated, but should be readily accessible, as there are occasions when this protection would be warranted. Similarly, masks should also be accessible.

Cold Water Immersion

The best practice for cooling is CWI.[1-13, 15, 17] When conducting this method, the patient is submersed below the neck in an ice water slurry. The water must be deep enough to allow for the patient's legs and torso to be fully submersed. Having a person holding a sheet behind the patient that is wrapped across the chest, under the armpits, is helpful to transfer the patient out of the tub after cooling and can mitigate the potential of the patient's head being submerged in water.

A team of 3 or 4 people (minimum) is required for CWI. Person A is responsible for maintaining the airway and upright posture of the patient; person B is responsible for continuously stirring the ice water slurry; person C monitors the core temperature, vitals, and vascular access if indicated; and person D ensures proper documentation. Persons C and D could be the same person. Typically, the senior medical provider assumes either role A or B. **CWI is further described in Appendix 3 (Table A3.1).**

Quantico Method (Ice-Water Dousing with Ice Massage and Ice Packs)

The Quantico method is a proven alternative to CWI.[1, 3, 4, 6, 9, 21] A mesh litter/stretcher is placed on top of a tub/pool with continuous ice-water dousing to the trunk, ice

massage of the legs from ankles to the groin, and ice packs placed over major arteries of the neck, axilla, and groin. If available, fans are also used. Whereas the cooling rate is slightly slower, the Quantico method is much more efficient for transferring patients onto and off the heat deck. A heat deck is a platform with a pool on top; the height of the stretcher on the pool should be such that the treatment team is working at a comfortable level without excessive bending, nor many people having to stand on a stool.

A 4- or 5-person team is used for the Quantico method. Person A is the senior medical provider at the head of the patient, directing the team and maintaining the airway. Persons B and C are responsible for the ice massage to the legs (an ice bag is held in each hand and the legs are massaged toward the core, with contact from the ankle to the groin over the leg muscles, and then released to start again at the ankles). Person D monitors the core temperature, vitals, and IV fluids if indicated. Person E ensures proper documentation. Persons D and E could be the same person.

When getting the patient off the heat deck, either the stretcher can be taken off the heat deck with the patient, or the patient can slide off the foot of the stretcher onto a wheelchair with assistance from medical staff to ensure the patient does not fall, and the provider holds the head of the stretcher down to avoid having the stretcher flip up.

Alternate Cooling Strategies

Best-practice cooling methods are CWI or the Quantico method, but these are not possible in some instances due to impractical operational and/or training requirements.

Field Settings

All efforts should be made to anticipate where and when EHI is likely to occur, and always ensure that one of the two proven heat-treatment methods is readily available (CWI or Quantico method).[1-13, 15] However, not every situation is conducive to having a complete heat-treatment setup. In this case, the medical planning team should include having the best possible heat-treatment method available by balancing resources with situational practicality. Commanders should be involved in risk-acceptance discussions and decisions. In extreme situations, the most important principle is that some cooling is better than no cooling. Improvised methods should be employed, adhering to the basic principle of exposing the patient to some form of cooling. As an example, patients have been successfully cooled in the field in large trash bags filled with ice water. Whatever method is used, the most important aspects of heat treatment are early recognition and early rapid treatment.

Mobile Treatment

As indicated above, the most important aspects of heat treatment are early recognition and early rapid treatment.[1-13, 15] Ideally, cooling should be initiated on the spot, but operational and training environments may not allow this. When the worksite/training location covers a great distance, a mobile heat station/heat-treatment team could be used to bring the treatment to the patient, instead of the patient to the treatment area. This could consist of a duty vehicle with a pool that could be filled quickly from water containers and ice in coolers. The TACO method below is another mobile option that does not require large quantities of water or ice, and a tarp is used instead of a pool.

Tarp-Assisted Cooling with Oscillation (TACO)

One of two preferred alternatives (next best after CWI and the Quantico method) is the TACO method, based on published cooling rates.[1, 4, 10, 11, 34-37] With this method, ice and water are placed in a waterproof tarp or body bag, and the patient is gently rolled back and forth in an ice water slurry. If a body bag (or a sleeping bag/bivy sack) is used, do not zip up the body bag further than the level of the mid-thighs. Also, the patient can be placed on a litter for easier handling and moved back and forth in a slow "shake-and-bake" manner to facilitate water circulation. If a tarp is used, ensure that the ends of the tarp are wrapped like a burrito, to prevent water and ice escaping from the ends of the tarp. Continually monitor the status of the ice, as ice can quickly melt and be much less effective. The consistency of the ice water should be a slurry. Ideally, this is done in a shaded area. The TACO method requires approximately 20 gallons of water, 10 gallons of ice, and 2 or 3 personnel.[34] This limits the practicality of this method in certain circumstances. However, the TACO method is an effective tool, especially as a backup in the event of an overflow situation, and/or can be used in situations when water and ice are readily accessible but having a full heat station is not practicable.

Commercial products are available in which the victim is placed in a "body bag," which is filled with ice and water. These products are convenient, portable, and easy to use. They appear to be similar in effectiveness to the TACO method (but more expensive). These methods are not recommended as a best practice cooling method given their lack of published outcomes data in actual EHS patients. However, small studies in healthy volunteers have shown promising cooling rates.[38] As with the TACO method, "body bag" cooling methods can be an acceptable initial cooling strategy due to their portability, supported by preliminary effectiveness data.

Ice Sheets/Towels with Ice Packs

Again, best-practice cooling methods are CWI and the Quantico method, but these are not always possible in some instances due to inflexible operational and/or training requirements. A second acceptable alternative cooling method is ice sheets with ice packs (adding ice packs to the traditional ice-sheet/ice-towel method decreases the cooling time).[1-4, 10, 11, 32, 33, 39] In this method, towels or sheets are kept in an ice slurry or frozen in a cooler. The towels or sheets are taken from the cooler and applied to the patient. A typical scenario using hand towels includes 1 or 2 towels over/around the head and neck, 1 or 2 on the back, 1 or 2 on the chest, 1 on each arm, and 2 per leg. When sheets are used, 3 are balled up and placed in the axilla and groin, followed by another draped over the entire body, except the head/face. The wet towels/sheets must be exchanged frequently, when the material begins to feel warm, which may be as long as 3 minutes or as little as 30 seconds, depending on the specific situation (e.g., amount of water contained in the towels/sheets, core temperature of the patient, the ambient weather, etc.). To accomplish this, at least 2 sets of towels/sheets should be on hand per patient. One set is used on the patient and the other is in the cooler. As the set on the patient warms up with use, the two sets are alternated. (If only one set of towels or sheets is available, simply re-immerse them in the ice water slurry and then reapply). "When in doubt, change it out."

IMPORTANT NOTE: Leaving the ice sheets/towels on too long can trap heat, reduce the cooling rate, and make the situation worse. Data show that the cooling effectiveness decreases the longer the towels/sheets are left on the patient. Therefore, the recommendation is to change the towels/sheets when they feel warm, and at least every 3 minutes. This must be emphasized to new personnel and re-emphasized in periodic refresher training. Again, "when in doubt, change it out." **The ice-sheets method is further described in Appendix 3 (Table A3.2)**.

Medications

The treatment standard for EHI is rapid whole-body cooling, with the intent to reduce the core temperature to 39–39.2°C (102.0–102.5°F) within 30 minutes from onset of symptoms.[1-13, 15] No medications have been proven to improve cooling times in EHI; specifically, there is no place for antipyretic use in EHI.[1-13, 15]

Additionally, whereas benzodiazepines and meperidine have been used historically to assist with the shivering during rapid cooling, there is no evidence to support improved outcomes with use of medication to treat shivering or seizures. Therefore, the use of benzodiazepines or meperidine for prehospital EHI treatment is not recommended, mainly due to the possible complications of sedation, muscle flaccidity, and airway compromise, possibly leading to prolonged cooling time (e.g., supporting respiration limits proper cooling). Once the patient is in the hospital setting, there is more control, and medications may be used to assist with patient comfort. Whenever medications are given, it is recommended to use the lowest possible dose to achieve the effect.

When to Transport/Seek Advanced Care

At a minimum, treatment of all heat injuries (including heat exhaustion) should have the following: 1) remove from training; 2) allow to "heat dump" indoors with AC; and 3) follow-up in clinic within 24 hours (OR non-urgent emergency department transport if clinic is not available). In the event there was initial CNS dysfunction, or if the rectal temperature exceeded 40°C (104°F), there should be urgent transport to either the ED or to a clinic able to appropriately treat exertional injuries, including lab capabilities, cardiac monitoring, and appropriate support staff. In the event of persistent CNS dysfunction, altered mental status, or any co-illness (e.g., heat illness plus current infection), the patient should be transported directly to the ED via EMS once cooled < 39.2°C (102.5°F). In all events, unless there is an active CPR situation or similar circulation/airway/breathing emergency, the patient should be cooled prior to EMS transport.[1-13, 15, 23, 30, 36, 40] As noted above, there are no known disadvantages to cooling below 38°C (100.5°F).[4] When best-practice cooling is not available/feasible on site, and particularly when en-route cooling is available, the process and timing of transfer from on-site cooling interventions to EMS should be discussed in advance and written into the site-specific EAP.

In the clinic setting, a patient with any heat illness plus any other condition (e.g., pneumonia, hyponatremia, ECAST, persistent CNS dysfunction/altered mental status, unstable vital signs, persistent temperature > 38°C [100.5°F], or signs and symptoms of fulminant rhabdomyolysis or compartment syndrome) should be transported to the ED via EMS. Otherwise, any concerning 2-hour follow-up lab will give an indication as to whether the patient should be transported to the ED.[1-13, 15, 23, 30, 36, 40] In settings without on-site medical personnel, it is prudent to err on the side of caution and transport to the ED after cooling.

Prehospital Care Summary

Clinical best practice for prehospital management is summarized in Table 5.2, with the identification of good, better, and best interventions dependent on environmental resources, personnel, and operational limitations. Treatment algorithms follow.

Table 5.2. Prehospital Exertional Heat Illness Best Practice Assessment

Good	Better	Best
Medical team and non-medical personnel rapidly recognize the signs and symptoms of EHI.	Medical team and non-medical personnel rapidly recognize the signs and symptoms of EHI.	Medical team and non-medical personnel rapidly and accurately recognize the signs and symptoms of EHI, and initiate the medical response.
All personnel have yearly body core temperature refresher training concerning the recognition and treatment of EHI.	All personnel have yearly in-person EHI refresher training concerning the recognition and treatment of EHI.	All personnel have yearly EHI refresher training, including rigorous mock heat-casualty drills.
Treatment of EHI based on signs and symptoms	Intermittent use of digital rectal thermometers	Use of indwelling rectal probe for diagnosis of EHS, with continuous temperature monitoring
On-site ice-sheet/towel rotation method with ice packs, with ability to start treatment within 10 minutes of EHI	On-site TACO method, with ability to start treatment within 10 minutes of EHI	On-site cold water immersion (CWI) or the Quantico method, with no more than 10 minutes transport time from expected EHI, and initial cooling while en route to definitive cooling area
Risk assessment with secondary prevention in place (e.g., AICS)	Risk assessment with secondary prevention and primary management plan with logistics for alternative cooling method (e.g., TACO) at training or operational area	Risk assessment with secondary prevention and primary management plan with logistics for definitive best-practice cooling within training or operational area.
Medical team in direct support of operational or training event has knowledge and treatment plan in place for EHI	Medical team and non-medical staff involved in operational or training event have knowledge and treatment plan in place for EHI	Both medical team and non-medical staff have knowledge and tiered treatment plan within command SOPs in place for EHI
EHI SOP at medical team level	EHI SOP and logistical support at lower command levels (e.g., platoon)	EHI SOP and logistical support throughout all command levels (e.g., Division, Group, Squadron, Regiment, Battalion)

Treatment Algorithms

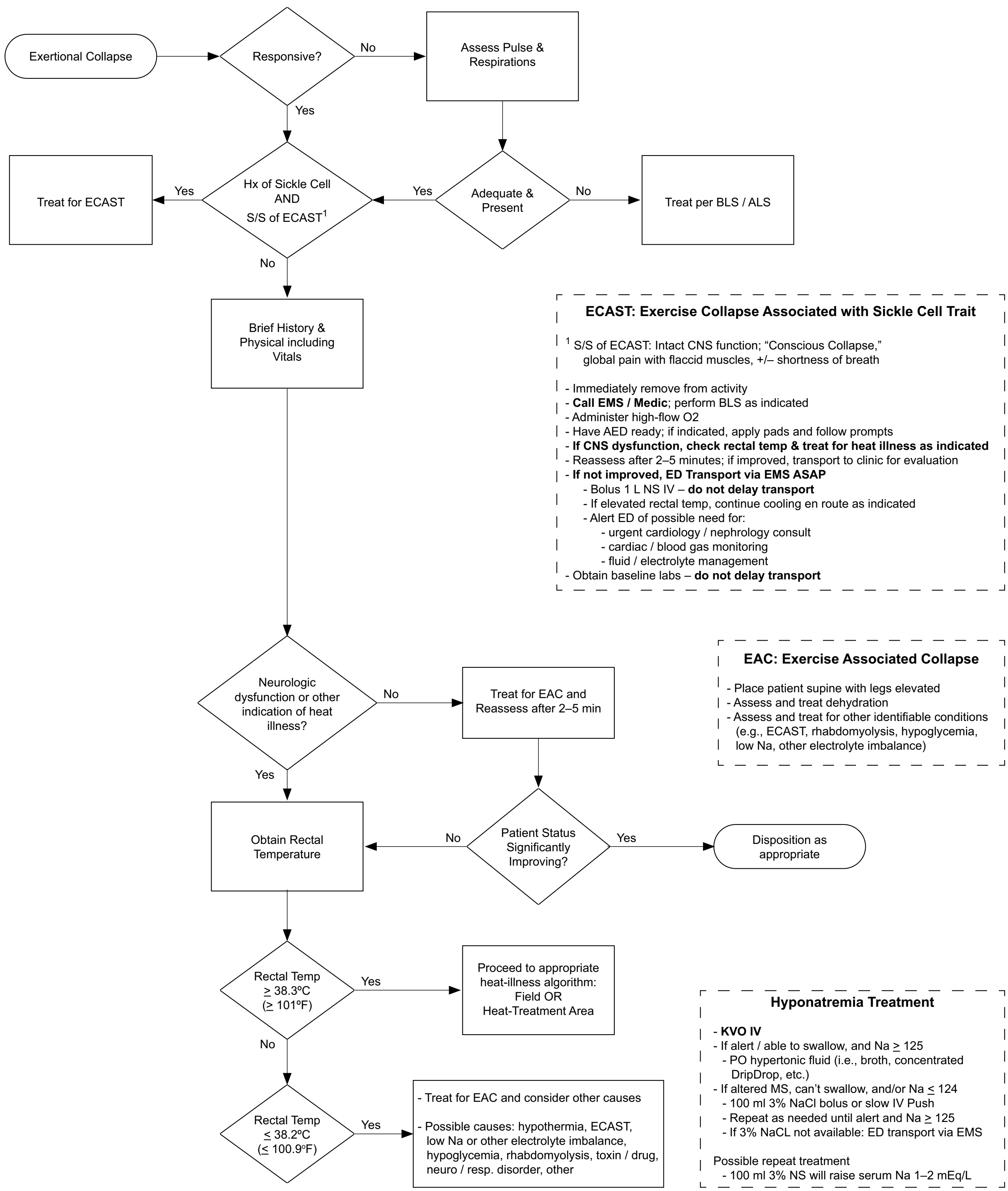
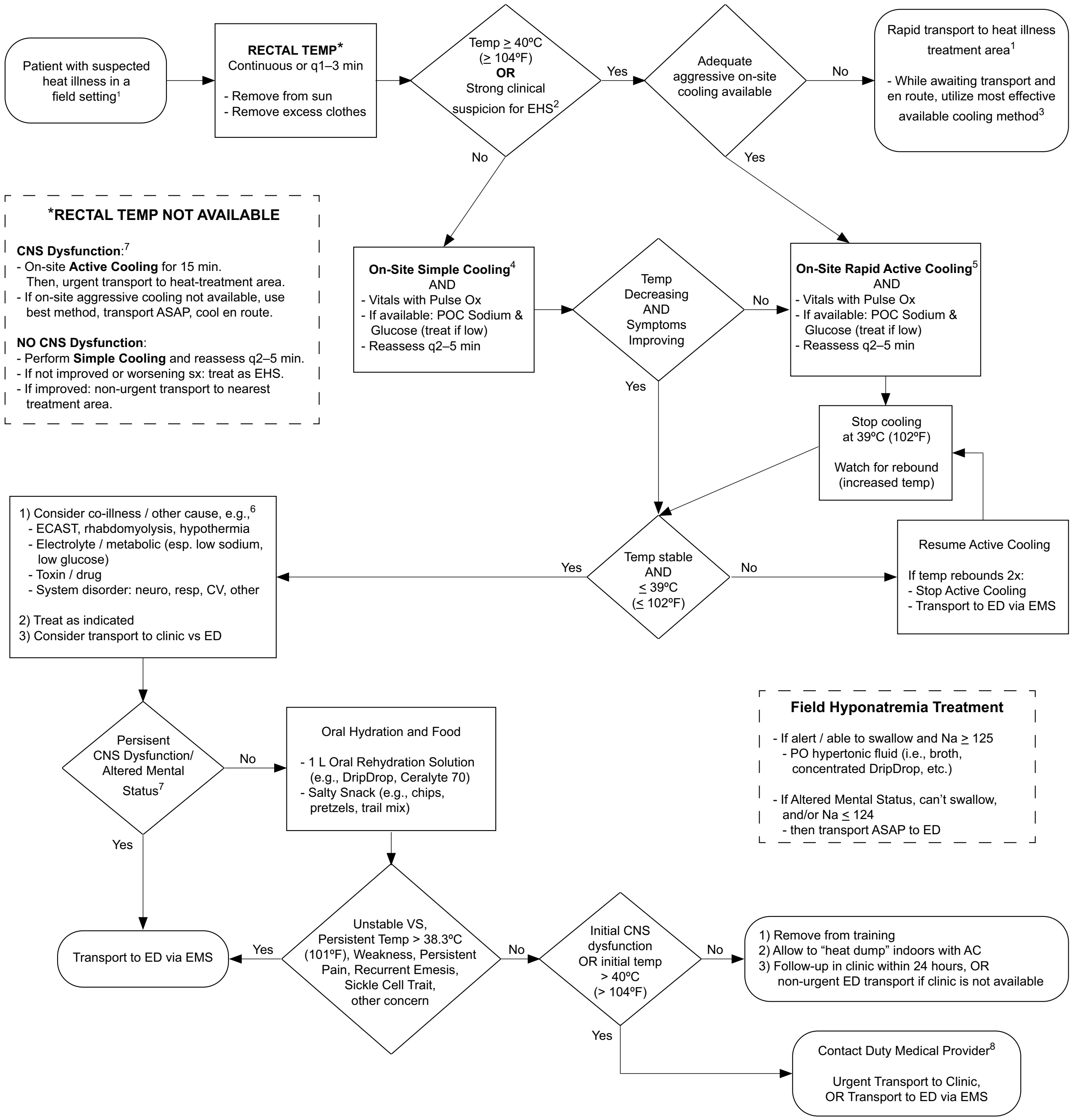


Figure 5.1. Master Algorithm



NOTES:

[1] If at all possible, **Cool first, transport second**. If feasible, a plan should be in place to cool heat injuries on site with cooling initiated within 10 minutes of injury.

[2] Reasons for active cooling at lower temp include: CNS dysfunction with ≥ 40ºC (≥ 104ºF) on an earlier temp, concern about accuracy of temperature, significant EHS symptoms.

[3] Any cooling is better than no cooling. Utilize best available cooling method while awaiting transport and en route to a treatment area with appropriate cooling methods. Examples include: dousing with water, dunking in a river or pond, spraying with a garden hose, applying portable ice packs, fans, sitting in an air-conditioned area.

[4] **Simple Cooling**: Ice packs to head / sides of neck / axilla / groin, ice towels to body, forearm immersion if available, fan if available. Stop simple cooling at 39ºC (102ºF).

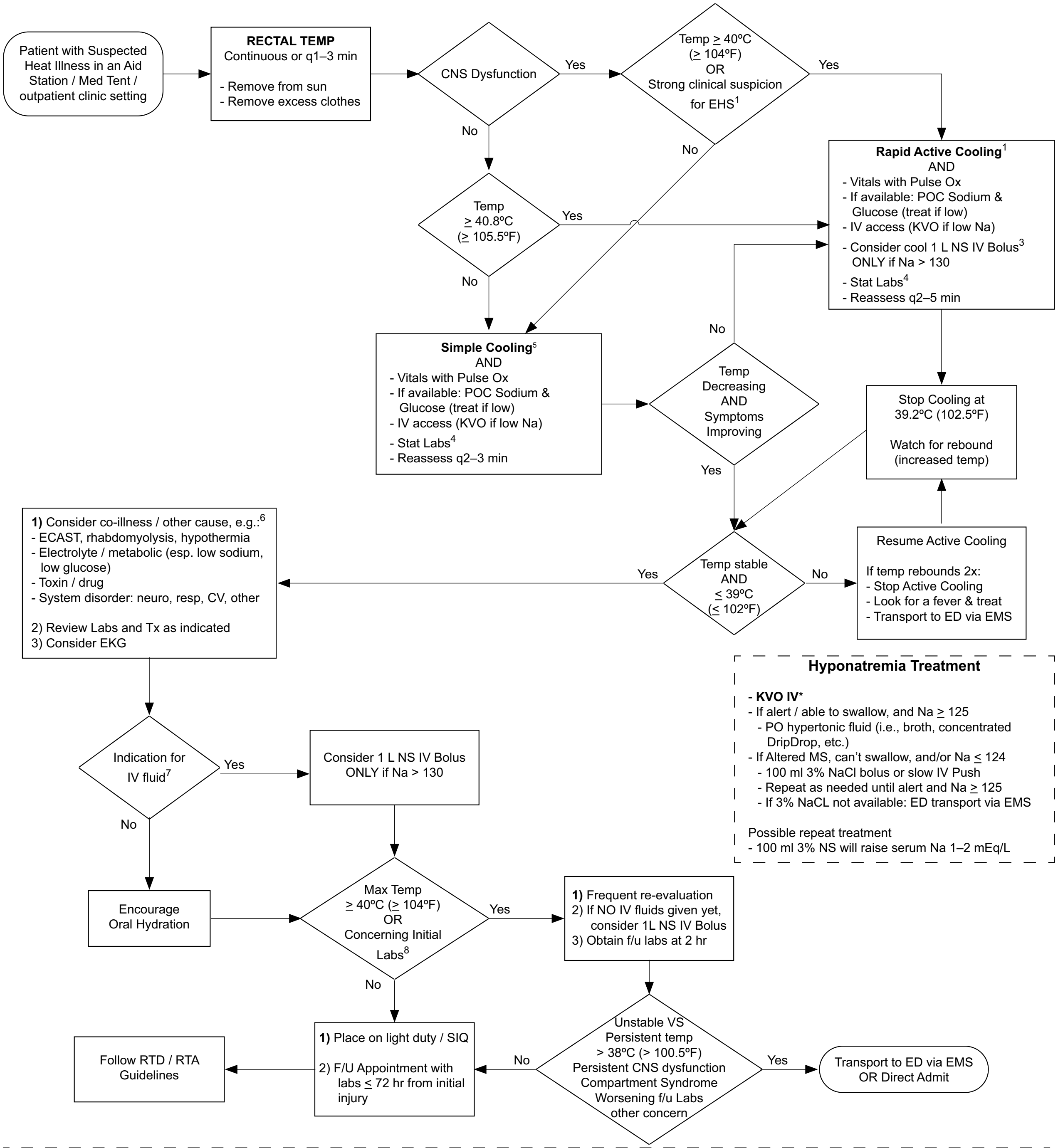
[5] **Active Cooling best practice**: (A) Ice-Water Immersion or (B) Quantico Method (ice-water dousing AND ice massage to legs AND ice packs to head / neck / axilla / groin).
- Alternate active cooling in order of effectiveness: (i) Tarp-Assisted Cooling (TACO) with > 20 gal water & 10 gal ice; (ii) TACO with < 20 gal water & < 10 gal ice; (iii) ice sheets with ice packs to head / neck / axilla / groin. Important: Ice sheets must be rotated when they feel warm (every 30 sec to 3 min) or core temp may increase.
- May add fans to any method to aid cooling (if available).
- **Stop active cooling at 39ºC (102ºF)** – keep on heat deck / in treatment area – watch for rebound and cool again if needed. (If rebound 2x, check and treat for fever.)

[6] Treat according to applicable protocol / CPG (i.e., ECAST, rhabdomyolysis, etc.).

[7] CNS dysfunction = wide range of possible signs / symptoms, including: disorientation, irrational / abnormal behavior, irritability, emotional instability, confusion, seizures, abnormal speech, blurry vision, hearing change, bladder / bowel loss, numbness / tingling, stumbling / clumsy movement.

[8] If available, transport decision is directed by Duty Medical Provider. If Provider is not immediately accessible, or clinic is not available, then transport to ED via EMS.

Figure 5.2. Field Algorithm



NOTES:

[1] Reasons for active cooling at lower temp include: CNS dysfunction with ≥ 40ºC (≥ 104ºF) on an earlier temp, concern about accuracy of temperature, and significant EHS symptoms.

[2] **Active Cooling best practice**: (A) Ice Water Immersion or (B) Quantico Method (ice-water dousing AND ice massage to legs AND ice packs to head / neck / axilla / groin).
- Alternate active cooling in order of effectiveness: (i) Tarp-Assisted Cooling (TACO) with > 20 gal water & 10 gal ice; (ii) TACO with < 20 gal water & < 10 gal ice; (iii) ice sheets with ice packs to head / neck / axilla / groin. Important: Ice sheets must be rotated when they feel warm (every 30 sec to 3 min) or core temp may increase.
- May add fans to any method to aid cooling (if available).
- **Stop active cooling at 39.2ºC (102.5ºF)** – keep on heat deck / in treatment area until 39ºC (102ºF) – watch for rebound and cool again if needed. (If rebound 2x, check and treat for fever.)

Note: Any method of cooling is better than no method of cooling. In the event no preferred or alternate method of cooling is available, use best available method (e.g., dousing with water, dunking in a river or pond, spraying with a garden hose, applying portable ice packs, fans) until a more effective method can be used.

[3] Cool IV fluids may be added to any cooling method. Indications include: dehydration, initial temp > 41ºC (> 106ºF), cooling time > 30 min, other concerning situation. DO NOT give IV fluid if Na < 130.

[4] Heat Illness Labs: CMP, CK, Uric Acid, PO4, CBC, LDH, UA + Micro; screen for sickle cell if not done previously. If indicated, add EtOH, UDS.

[5] **Simple Cooling**: Ice packs to head / sides of neck / axilla / groin, ice towels to body, forearm immersion if available, fan if available. Stop simple cooling at 39ºC (102ºF).

[6] Treat according to applicable protocol / CPG (i.e., ECAST, rhabdomyolysis, etc.)

[7] IV Fluid Indications: dehydration, ≥ 20 min to initiate cooling, cooling time > 30 min, other concerning situation. DO NOT give IV fluid if Na < 130.

[8] Concerning INITIAL Labs warrant f/u labs at 2 hr post injury: ALT > 150, Uric Acid > 7, Bicarb < 19, Phos > 4, Cr > 1.4, Ca < 7.5, CK > 2500, Myoglobinuria.

Figure 5.3. Heat-Treatment Area Algorithm

SECTION 6: EMERGENCY CARE

Emergency Department Preparation

Treating exertional heat stroke (EHS) in the emergency department (ED) begins well before the patient's arrival. Developing an EHS protocol, having established communication lines with prehospital and inpatient services, obtaining the necessary equipment for monitoring and cooling, and training ED staff are key components in the efficient management of EHS.[1, 2] In addition, continuous readiness is important, as there can be EHS even in cool weather conditions. Analyzing the risk of heat illness is unique to the units supported by each individual military treatment facility. It is also important to be familiar with prehospital and clinic protocols.

Advanced coordination with prehospital and inpatient medical personnel is important to integrate their practice patterns and establish communication channels. While cooling for EHS ideally should begin prehospital, this may not always be feasible due to logistical and/or training challenges.[3-6] Thus, it is important to know the local practice standards to coordinate medical resources and understand the care the patient will receive at each step. In collaboration with both prehospital and inpatient personnel, coordination of medical resources should focus on rapid diagnosis of EHS, mobilizing those resources for expedited and aggressive on-site cooling, continuous monitoring during cooling and transport, and seamless transfer of care.

Early Recognition/Early Cooling

Treatment principles in the ED center around stabilizing the patient with rapid recognition of EHS and rapid, aggressive, evidence-based cooling methods (e.g., cold water immersion, internal cooling [see below]), with a goal of reaching a core temperature < 39.2°C (102.5°F) within 30 minutes from onset of symptoms. Much like early CPR and defibrillation for a cardiac arrest, early and rapid cooling is the cornerstone in EHS treatment. After addressing Circulation, Airway, and Breathing (CAB), cooling should be initiated as soon as possible, ideally concurrently with management of cardiac arrest, and with as few interruptions as possible. In addition, treatment should be standardized according to established EHS algorithms (see Figure 6.1).

As detailed in Section 5, specific cooling-method strategies balance efficacy with logistical feasibility. The goal is to maximize efficient core temperature cooling and monitoring by making available the proper medical resources and personnel.

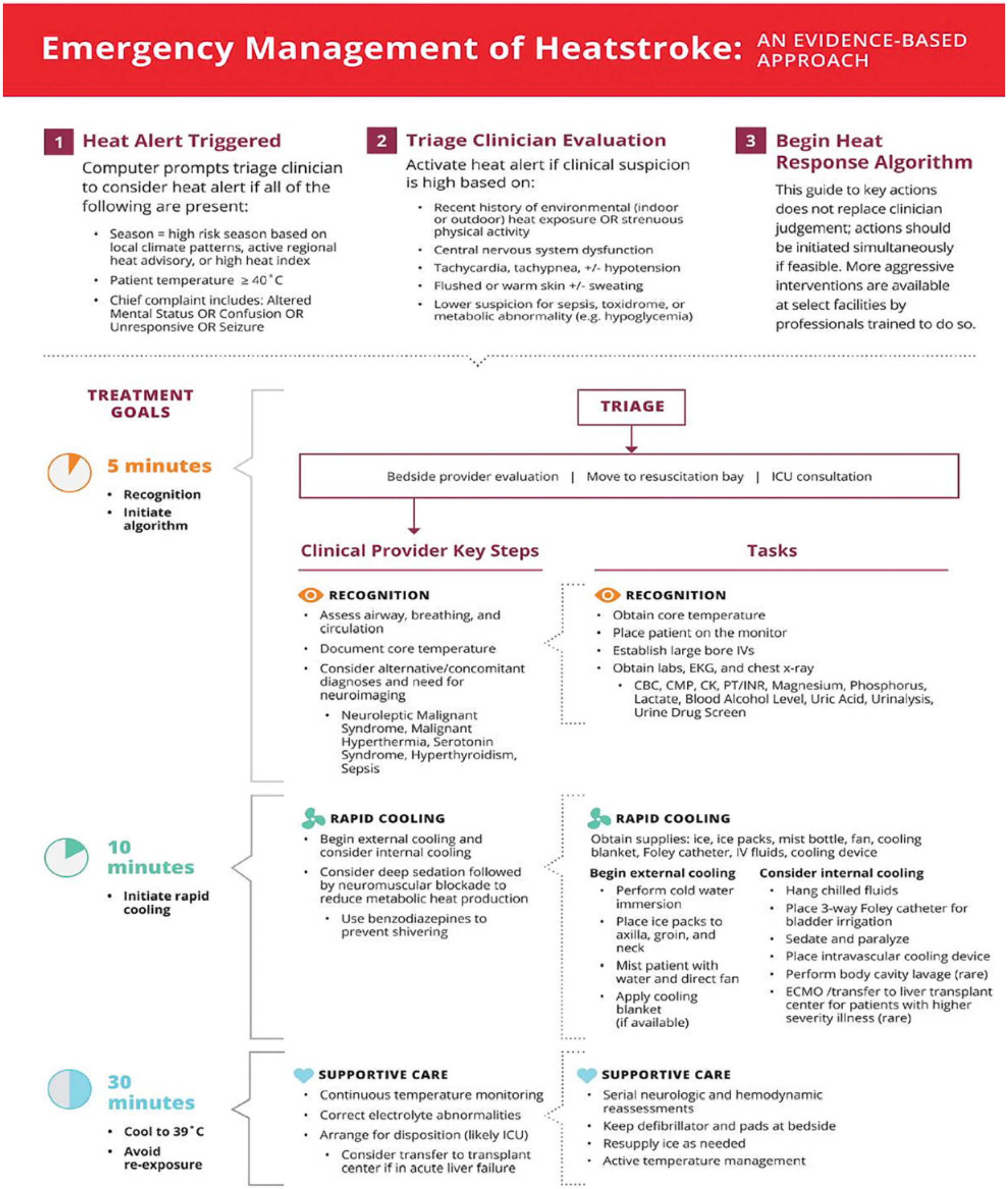


Figure 6.1. Exertional Heat Illness Management in the Emergency Department

(Reproduced with permission[7])

Preparation/Equipment

A designated heat-treatment area and requisite equipment in an ED may be prudent during a period deemed to present a significant risk of encountering EHS patients. The heat-treatment area should include designated personnel roles and responsibilities as well as equipment lists (comparable to Code Blue teams). EHS patient response rehearsals should be a part of preparation.

Example Cooling Equipment List[8]

» Vital Signs Monitor
» Cardiac Monitoring
» Glucometer and Lancets

» Continuous Indwelling Rectal Core Thermometer
- Alternate Continuous Thermometers: urinary or esophageal
- If no continuous thermometers: designated digital rectal thermometer

» External Cooling Supplies
- Immersion Tub: Ex: 100–150-gallon tub
- Ice (100–200 pounds)
- Water – (Rapid access to 40–60 gallons of water, in addition to a cold-water faucet with robust flow)
- Bed Sheets – for wrapping and securing the patient

» Alternative External Cooling Supplies*
- Large Fans
- Large 12' x 16' Tarp with Access to Ice and Water (20 gallons [76 liters] each)
- Cooler with Wet Sheets (4–8) and Towels (2–4) in ice water
- *These alternative methods are more convenient to use but have slower cooling rates than cold water immersion.

» Internal Cooling Supplies
- Peritoneal Lavage Kits
- Intravenous Catheter Kits with Extension Tubing
- Chilled Isotonic Solution (~4°C [39°F])
- Triple Lumen Bladder Catheter
- Thoracostomy Kits
- Nasogastric Tubes
- Drainage bucket

» Suction Catheter and Setup

EHS Evaluation in the ED

When evaluating an ED patient with confirmed or suspected EHS, the priority is CAB. A standard "safety net" is used, consisting of large-bore intravenous and/or intraosseous access, vital signs monitoring, and oxygen as indicated. Personnel should remove all patient clothing to allow heat dissipation, while giving the medical personnel access to evaluate for concomitant conditions, such as any associated trauma. Peripheral intravenous and/or intraosseous access should be established with a large bore for labs and administration of fluids and/or medications. Vital signs monitoring with cardiac telemetry monitoring should be established. In an altered mental status patient, sodium and glucose levels should be immediately checked (whether point-of-care testing or standard BMP) to rule out hypoglycemia or hyponatremia. Oxygen should be administered for signs of respiratory distress, hypoxia, or anticipation of intubation. Consideration should also be given to check for sickle cell trait status, as this can greatly complicate EHS and alter the treatment regimen.

Approaching the critical EHS patient with a mentality of "resuscitate before you intubate" can avoid circulatory collapse during a rapid sequence intubation. In EHS, circulatory collapse can occur due to profound peripheral vasodilation and relative hypovolemia. Assessing a patient's circulatory status involves evaluating for signs of poor perfusion by subjective (e.g., pale skin, altered mental status) to objective (e.g., > 2 seconds capillary refill, tachycardia, hypotension) measurements. Other means may include ultrasound evaluation (inferior vena cava, cardiac, lungs, etc.), passive leg test, urine output, end-expiratory occlusion test. Circulatory insufficiency should be addressed through expedited cooling and judicious fluid administration.

After circulation evaluation, assess the airway for patency, the patient's ability to maintain their airway, and expected clinical course. Any evidence of stridor or signs of upper airway obstruction, apnea, and/or seizure or Glasgow Coma Scale (GCS) ≤ 8 with vomiting should prompt placement of an advanced airway. In addition, persistent hypoxic or hypercapnic respiratory failure despite more conservative measures such as suctioning, oral/nasal airway devices, and positive pressure oxygenation and ventilation may prompt advanced airway placement. Auscultation may reveal crackles and/or decreased lung sounds of pulmonary edema. Seizures and/or cerebral edema, while uncommon, can be sequelae of EHS. Treatment of seizures must prioritize continued rapid cooling using the most effective means possible, while benzodiazepines may be used concomitantly. (But see concerns in the Medications in EHS section below.) A patient who begins seizing while in a cold water immersion tub may require removal from the tub to protect the airway or due to space constraints, but aggressive cooling using alternate means must be continued if the patient remains hyperthermic (> 39.2°C [> 102.5°F]). A focused neurological assessment of GCS, pupillary examination, and gross limb motor function may reveal deficits, indicating possible cerebral or cerebellar pathology and should prompt neuroimaging. Cerebral edema and/or cerebellar atrophy may also manifest up to several days after the EHS.[9]

Finally, considering the differential diagnosis for a patient with neurological signs and hyperthermia is paramount. (See also Table 5.1. Differential Diagnosis of Exertional Collapse.) While EHS may be a leading diagnosis, there are many conditions that have overlapping presentations, as listed in Table 6.1 below.

Table 6.1. Conditions with Overlapping Presentations

Hypoglycemia	Status Epilepticus
Exercise-associated Hyponatremia	Pulmonary Embolism
Exertional Collapse Associated with Sickle Cell Trait (ECAST)	Infectious Etiologies (e.g., Encephalitis, Meningitis, Malaria, Sepsis, Brain Abscess)
Ischemic or Hemorrhagic Stroke	Sympathomimetic Toxicity
Anticholinergic Toxicity	Salicylate Toxicity
Serotonin Syndrome	Alcohol or Benzodiazepine Withdrawal
Neuroleptic Malignant Syndrome	Malignant Hyperthermia
Other encephalopathy (e.g., Hypertensive, Uremic, Hepatic, Hypoxic, Carbon Monoxide)	Endocrinological (e.g., Thyroid Storm, Pheochromocytoma)
Hematologic/Oncological (e.g., Thrombotic thrombocytopenic purpura, Tumor Lysis Syndrome)	

Core Temperature Monitoring

Core temperatures (e.g., rectal, urinary, and/or esophageal) should be obtained for monitoring in EHS.[10] Axillary, aural, oral, and temporal thermometers cannot be used reliably to determine a core temperature, as they vary by 1–2°C (1.8–3.6°F) from true core-temperature values.[10-12] An efficient core-temperature monitoring method during CWI is a rectal thermistor, inserted 15 cm (6 in) into the rectum.[13] Alternatives are a urinary catheter with temperature probe or an esophageal temperature probe in the distal ⅓ esophagus, if the patient has an advanced airway in place. If unable to obtain continuous core temperature measurements, then it is reasonable to cool the patient with digital rectal temperature checks every 10 minutes.[14, 15]

Cooling Goals in the ED

Cooling should begin immediately once the diagnosis of EHS is established, preferably at the scene of collapse and continuing during en-route care (please refer to Section 5, Prehospital Care). However, if an ED can expect to receive heat casualties, preparations need to be made to provide cooling in the ED. Delays in starting cooling are associated with significant morbidity and mortality.[14, 16-19] Cooling rates greater than > 0.15°C/min or 1°C every 5 minutes (1°F every 3 minutes) increase odds of survival and prevent complications.[14, 20] Active cooling should stop at 39–39.2°C (102.0–102.5°F) to avoid excessive overshoot hypothermia.[7] For these reasons, if aggressive cooling can be initiated prehospital, it is generally favorable to do so until the patient reaches 39°C (102.0°F) first, and then transport to the ED, which avoids delays and interruptions in cooling.[3, 18, 21] However, considerations such as transport proximity to improved cooling resources, availability of aggressive cooling modalities en route, and other interventional needs such as advanced airway management must be considered with prehospital cooling decisions. As noted above, CAB takes precedence over cooling.

Cooling Methods in the ED

CWI in 2–10°C (37–50°F) water is the most effective means of cooling.[15, 18, 22-27] However, CWI has some disadvantages: difficulty monitoring the patient, difficulty performing other interventions, and requiring equipment often not readily available in an ED (e.g., immersion tub). When EHS is the exclusive diagnosis, CWI is the preferred method of cooling. In the event of a coexisting condition—such as trauma or seizures—and/or significant comorbidities that could decompensate (e.g., coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease), an alternate method (or combination of methods) should be chosen (Tables 6.2 and 6.3) that allows the team to provide stabilizing care, monitoring, and evaluation in conjunction with cooling.

Internal cooling methods may be considered if external methods are not rapidly lowering core temperature. Cold saline at 4°C (39°F) is a relatively safe means of internal cooling, but there should be consideration for concomitant conditions that may be exacerbated with excessive crystalloid administration (e.g., exercise-associated hyponatremia, congestive heart failure with pulmonary edema). Typically, dehydration requiring large-volume resuscitation is not a factor in heat stroke, and resuscitation should thus be limited to 1 liter of balanced solution per hour unless the patient becomes hypotensive.[28] Endovascular cooling is an effective means of cooling, but it requires experienced and trained personnel to place and monitor endovascular devices. It should only be considered if rapid cooling is not achieved in the first hour by other external means.[21, 29] Extracorporeal Membrane Oxygenation (ECMO) can be considered if there is circulatory collapse.[30, 31] Body cavity lavage varies in its invasiveness from iced bladder and gastric lavage to peritoneal lavage. Evidence of its efficacy is limited to small trials[32, 33] and is not recommended as a first line for internal cooling. See Intensive Care Unit (ICU) section for further discussion on internal cooling methods.

Tables 6.2 and 6.3

Table 6.2. External Cooling Methods

Good	Better	Best
Whole-Body Ice Packing and/or Strategic Ice Packing	Tarp-Assisted Cooling with Oscillation and/or Ice Sheets and/or Evaporative/Convective Cooling	Cold Water Immersion (including Quantico Method)

External Cooling	Procedure
Cold Water Immersion (CWI)[10, 14, 34]	• Most *rapid* cooling technique • May be logistically challenging and requires constant supervision • Difficult to monitor patient • Preparation and maintenance of cold water immersion. Half fill the tub or wading pool with water and ice. The stock tank can be filled with ice and cold water before (or have tub half filled with water and 3–5 coolers of ice next to tub; this prevents having to keep tub cold through the day). Ice should cover the surface of the water at all times. Water temperature should be between 2–20°C (37–68°F). 1. Cover as much of the body as possible with ice water while cooling. 2. During cooling, water should be continuously circulated to increase the water-to-skin temperature gradient. Have an assistant swirl the water during cooling. 3. A continuous rectal thermistor should be placed prior to initiation of CWI, or a rectal thermometer may be used intermittently every 5–10 minutes as clinically indicated.
Tarp-Assisted Cooling with Oscillation (TACO) Method[35-38]	1. A 12 x 16-foot tarp is held by 3 personnel—1 at the patient's head and 1 on each side of the patient—to hold the tarp up to allow the patient to be in semi-reclining position. 2. 20 gallons of water and 10 gallons of ice are poured into the tarp to immerse the participant's torso and legs in cold water. 3. The personnel located on either side of the participant continuously agitate the tarp to circulate the water.
Ice Sheets[39]	1. Prepare cooler of large sheets and/or towels in ice water. 2. Cover all but face in soaked sheets. 3. Replace sheets and towels every 3–5 minutes. 4. May be performed in conjunction with strategic ice packing and fanning. Note: See Appendix 3, Table A3.2 for additional information.
Evaporative/Convective Cooling[7, 18, 19, 40]	1. Undress the patient completely. 2. Position a large fan at foot of the bed, as close as possible to the patient. 3. Sponge or spray tepid water at 15°C (59°F).
Whole-Body Ice Packing[40]	1. Undress the patient completely. 2. Cover the extremities and torso with crushed ice. 3. A fan may be used to assist with cooling.
Strategic Ice Packing[40]	1. Prepare large plastic bags of crushed ice or a mixture of water and ice. 2. Apply bags to asillae, femoral triangles, the lateral neck, and groin. 3. Rotate bags of ice every 3–5 minutes.

Table 6.3. Internal Cooling Methods

Internal Cooling	Procedure
Cold Intravenous Fluids	1. Establish large-bore intravenous access or central access. 2. Instill 1 L/hour of 4°C (39°F) balanced solution.[28] 3. Dehydration is not typically an issue in EHS, so be judicious with fluids.
Body Cavity Lavage (i.e., gastric, bladder, peritoneal)	Gastric Lavage[41] 1. Place a nasogastric or orogastric tube. 2. Instill 10 mL/kg of iced, sterile saline into the stomach. 3. Allow fluid to rest for 30–60 seconds. 4. Suction and repeat, as necessary. Bladder Lavage[40] 1. Place a triple-lumen urinary catheter. 2. Instill and withdraw 300 mL of iced, sterile saline every 10 minutes. Peritoneal Lavage[40] 1. Place a standard peritoneal lavage catheter. 2. Instill and withdraw 1 L of iced, sterile saline every 10 minutes.
Endovascular Cooling Catheter and/or Extracorporeal Membrane Oxygenation (ECMO)	Institution-dependent

Medications in EHS

The treatment standard for EHS is rapid whole-body cooling, with the intent to reduce the core temperature to < 39–39.2°C (< 102.0–102.5°F) within 30 minutes from onset of symptoms. There are no medications that have been proven to improve cooling times in EHS. Specifically, avoid dantrolene and antipyretics (acetaminophen, and non-steroidal anti-inflammatory drugs) in EHS as they have not been proven to improve outcomes, nor assist in decreasing hyperthermia.[19, 28] Additionally, antipyretics may even be harmful given the potential for concomitant acute kidney injury, gastrointestinal, and liver injury.[42, 43]

No evidence supports improved outcomes with any medication used to treat shivering. Specifically, benzodiazepines and meperidine have the possible complications of sedation, muscle flaccidity, and airway compromise, possibly leading to prolonged cooling time (e.g., supporting respirations limits proper cooling). Medications can be used to assist with patient comfort, but should not be given routinely as a preventive measure. Furthermore, whenever medications are given, it is recommended to use the lowest possible dose to achieve the intended effect. Certain medications may be considered for complications and conditions:

Seizures (dosing for adults > 50 kg)

» Midazolam: 10 mg intramuscular or intranasal for one dose
—or—

» Midazolam: 2–5 mg intravenous or intraosseous push. May repeat in 5 minutes if seizures continue.
—or—

» Diazepam: 15 mg intranasal or rectally (gel) for one dose
—or—

» Diazepam: 5–10 mg intravenous or intraosseous push. May repeat in 5 minutes if seizures continue.
—or—

- Lorazepam: 2–4 mg intravenous or intraosseous push. May repeat in 5 minutes if seizures continue.
    - → If giving benzodiazepines, ensure continuous vital signs monitoring, and monitor for signs of respiratory depression and/or circulatory failure.

Circulatory Failure (Hypotension)

- Determine hypovolemic, obstructive, cardiogenic, and/or distributive shock

- Consider up to a 30 mL/kg crystalloid solution intravenous bolus

- If unresponsive to fluid challenge, start norepinephrine intravenous drip at 2–12 mcg/min

Complications of EHS

Exertional heat stroke is frequently accompanied by complications that will necessitate ED management or inpatient care. Known complications include the following:

- Rhabdomyolysis
- Compartment syndrome
- Demand ischemia and/or high-output heart failure
- Status epilepticus and/or cerebral edema
- Pulmonary edema/acute respiratory distress syndrome (ARDS)
- Disseminated intravascular coagulopathy (DIC)
- Acute kidney injury (AKI)
- Ischemic Hepatitis (Shock liver)
- Electrolyte derangements (e.g., hypernatremia, exercise-associated hyponatremia, hypokalemia or complications of hyperkalemia, hyperuricemia, hypocalcemia in the setting of muscle breakdown)
- Associated trauma

SECTION 7: ADVANCED CARE – INTENSIVE CARE UNIT MANAGEMENT

ICU Management of EHS

The majority of EHS cases are managed with rapid cooling by first responders in the field, EMS, or the ED to meet the "golden half hour" goal for core temperature reduction to < 39–39.2°C (102.0–102.5°F) within 30 minutes of collapse. Occasionally, EHS patients will require inpatient observation and supportive care for sequela such as rhabdomyolysis, acute kidney injury, acute hepatic injury, or coagulopathy.

Rarely does EHS require admission to the intensive care unit (ICU) when treated rapidly and appropriately with external cooling techniques such as immediate cold water immersion (CWI). However, in more severe cases of EHS, those with delayed cooling, or those with coexisting conditions, admission to the ICU may be necessary. Figure 7.1 outlines an algorithm for effective EHS ICU management.

Exertional Heat Stroke High Risk Factors for ICU Admission
- Prolonged or resistant elevation in core temperature > 40°C (> 104°F)
- Ongoing intubation for need for Airway Control
- Continued altered mental status
- DIC/Thombocytopenia
- Acute kidney injury/Potential Need for RRT*
- Hemodynamic instability
- Evidence for Shock Liver

ICU Admission

Assess airway, breathing, circulation
Establish large bore IVs
Consider central line, arterial line
Foley to monitor UOP
Advanced airway management as needed
Serial neurologic assessments
Keep AED and pads at bedside

Consider alternative diagnosis
Neurologic malignant syndrome, malignant hyperthermia, serotonin syndrome, hyperthyroidism, sepsis

Perform Rapid Cooling

External Cooling
Cold water immersion
Ice sheets/fans or temperature > 39°C (> 102°F)
Apply cooling blanket

Internal Cooling
Hang chilled fluids
Place 3-way Foley catheter for bladder irrigation
Place intravascular cooling device
Perform body cavity lavage
ECMO*

- Consider deep sedation followed by neuromuscular blockade to reduce metabolic heat production
- Consider benzodiazepines to prevent shivering
- Stop cooling at 39°C (102°F)

Vitals

Obtain continuous core temperature (rectal or esophageal)

Monitor vitals q1–2 hours

Labs

CBC, CMP, LFTs, lactate, PT/NR, CK, serum myoglobin, UA, magnesium, phosphorus, lactate, troponin, urine osm, VBG/ABG, blood alcohol level, uric acid, urine drug screen

Imaging

CXR, EKG, CT head, MRI if altered mental status persists

Fluids

Hypovolemia and serum sodium >134: Give 1–2 L NS bolus and reassess

Hypervolemia, euvolemia, or indeterminate:
Na >134: NS (250–500 mL/hr) to maintain UOP >200 cc/hr
Continue Lasix if fluid overload

Na 133–134: Consider EAH or alternate diagnosis

Na < 132: Refer to Exercise Associated Hyponatremia algorithm

Management by Organ System

Immediate physical cooling to 39°C (102°F) for reversal of inflammatory cascade and metabolic injury, with supportive measures for end organ damage

CNS: altered cognition, with possible seizures, coma, areflexia, miosis, and sustained/permanent cerebellar dysfunction. Frequent neuro checks.

Cardiac: Tachycardia in the setting of distributive shock. Intermittent use of pressor support with volume resuscitation. Non-specific conduction defects may be present and will require monitoring and replacement of electrolytes.

Pulmonary: Alveolar capillary membrane damage with pulmonary edema. Oxygen supplementation with mechanical ventilation if accompanied by severe hypoxia or neurologic injury.

Renal: Pre-renal and direct acute kidney injury resulting in failure and need for intermittent dialysis. Appropriate management of hypoperfusion and rhabdomyolysis may quell the need for renal replacement therapy. Appropriate replacement of electrolytes. Consider CRRT* versus IHD*.

GI: Hepatic injury may include congestion, cholestasis, and necrosis with small bowel injury to include hypoperfusion with splanchnic shunting. Monitoring for liver failure is crucial in the period immediately following injury, as case reports have indicated transplant may be necessary.

Musculoskeletal: Myopathy and rhabdomyolysis may occur.

Hematologic: Monitor for coagulopathy, including disseminated intravascular coagulation. Immediate cooling and supportive care may reverse endothelial injury and ongoing hemorrhage.

Endocrine: Hypoglycemia, along with hyponatremia and hypochloremia may be present upon evaluation and need correction.

Discharge to wards or step-down criteria
- No longer requiring q1–2 hour vitals
- No advanced airway required
- Normothermic and core temperature stable
- CK plateaued + down trending x 24 hrs
- AKI resolving
- LFT downtrend or stable x 24 hrs and no coagulopathy
- Electrolytes stable and improving
- No longer receiving high-volume IVF
- Symptomatically improved

* Abbreviations:
ECMO = Extracorporeal Membrane Oxygenation
RRT = Renal Replacement Therapy
CRRT = Continuous Renal Replacement Therapy
IHD = Intermittent Hemodialysis

Figure 7.1. ICU Management of EHS

Exertional Heat Stroke Risk Factors for ICU Admission

Several risk factors have been identified from experience and the peer-reviewed literature to identify those SM who will necessitate ICU care:

- Prolonged or resistant elevation in core temperature > 40°C (104°F)
- Mechanical ventilation for respiratory distress, hypercapnia, or hypoxia in the setting of multi-organ failure
- Metabolic encephalopathy leading to respiratory distress
- Coagulopathy to include DIC, thrombocytopenia, or thromboembolism
- Renal failure/potential need for emergent hemodialysis or continuous renal replacement therapy
- Hemodynamic instability resulting in circulatory and/or cardiovascular shock
- Evidence of ischemic hepatitis (shock liver)

EHS Management in the ICU

Continued aggressive whole-body cooling for persistent hyperthermia is central to the management of the ICU patient with EHS, in addition to continuous reassessment of circulation, airway, and breathing. Administer oxygen and place an advanced airway as indicated. Ensure placement of large bore peripheral IVs (16 or 18 G) for fluids, medications, and laboratory testing. Consider central line and arterial line placement for advanced monitoring and access for medication and fluid administration. Consider Foley catheter placement to accurately monitor fluid status and urine output. Perform serial neurologic assessments. Maintain defibrillator pads at bedside, if not already placed on the patient. The care team must also maintain a high index of suspicion for co-morbid and alternative diagnoses to include those listed in Table 7.1. (See also Table 5.1 Differential Diagnosis of Exertional Collapse.)

Table 7.1. Co-morbid and Alternative Diagnoses

Hypoglycemia	Intracranial Hemorrhage
Hyponatremia	Serotonin Syndrome
Exertional Collapse Associated with Sickle Cell Trait (ECAST)	Anticholinergic Toxicity
Infectious Etiologies (i.e., Encephalitis, Meningitis, Malaria, Sepsis)	Sympathomimetic Toxicity
Status Epilepticus	Salicylate Toxicity
Pulmonary Embolism	Pheochromocytoma
Thyroid Storm	Malignant Hyperthermia
Alcohol or Benzodiazepine Withdrawal	Neuroleptic Malignant Syndrome

Cooling Methods in the ICU

The primary goal of treatment of EHS is lowering core temperature to < 39–39.2°C (< 102.0–102.5°F) rapidly and supporting organ system function as needed.[1] Full-body immersion in cold water (Table 6.2) at 2–10°C (37–50°F) is the most effective technique for cooling an EHS patient and is identified as best-practice treatment.[2-9] However, this is often not feasible in an inpatient hospital setting due to lack of space or drainage for a cold tub, lack of access to patient for advanced airway and vascular lines, and need for electronic patient monitoring.[10] Cooling techniques in the ICU mimic those utilized in an ED setting (Tables 6.2 and 6.3, and Figure 7.1).

Non-Invasive External Cooling Systems

Non-invasive external cooling systems have been evaluated in individual case reports. One case described successful treatment of severe heat stroke with multi-organ dysfunction and DIC with therapeutic hypothermia by a non-invasive external cooling system.[11] Data also support the efficacy and time to resolution of hyperthermia extrapolated from the cardiac arrest literature to bolster the use of non-invasive techniques.[12] However, cooling should not be delayed while systems such as these are wheeled to the bedside and set up. Application of CWI and/or ice sheets or towels should begin immediately.

Invasive Cooling Methods

Intra/endovascular and other invasive cooling techniques, including body cavity lavage, transpulmonary cooling, and other forms aside from surface cooling (Table 6.3), are reserved for refractory cases and should involve a multidisciplinary approach and consent. Invasive internal cooling methods should be considered in the ICU in patients with persistent hyperthermia and the development of end organ damage. One liter of chilled saline (4°C [39.2°F]) given intravenously over 30 minutes has been shown to reduce core temperature by 1°C (1.8°F).[13] Cold saline can also be used for bladder irrigation. Peritoneal and gastric lavage with ice water have been suggested as a means of cooling for EHS, but there is a lack of literature to support these techniques in real-world cases.[14] An endovascular cooling device has been evaluated in EHS, albeit only in case reports.[10, 15-17]

Intravascular Cooling Devices

Extrapolating data from temperature-targeted management protocols,[12] both times to goal temperature and actual temperature, are not different between intravascular devices and surface-cooling devices. Each institution will have different devices, but in essence the intravascular devices function as a form of convective cooling, while surface devices rely on perfusion and conductive cooling. The risk of placing an intravascular catheter for cooling includes the risks from the procedure itself, a theoretical risk to the myocardium, and increased risk of thrombosis.[18] If the surface-cooling method appears to be ineffective within the first hour of use, only then should an intravascular device be considered.[19]

Recently, an endovascular cooling catheter was successfully used after traditional cooling methods failed to reduce the core temperature of a Ranger military trainee in Georgia.[10] In this case, the patient's core temperature remained above 41.1°C (106°F) for 50 minutes following initial collapse. An endovascular cooling catheter was immediately placed into the inferior vena cava upon arrival to the ED. Cooling was achieved at a rate of 0.08°C/min (0.16°F/min), with core temperature down to 37.6°C (99.6°F) after 42 minutes. The patient survived after an extended stay in the ICU for renal failure, hepatic failure, DIC, and thrombocytopenia, and was able to resume his previous state of exercise after 6 months of rehabilitation and recovery.

Management of Heat Stroke by Medication

No literature supports the use of acetaminophen, non-steroidal anti-inflammatory drugs, or sedatives for EHS. Given the underlying etiology, it should not be expected that centrally acting medications could reverse this process. Dantrolene has failed to show benefit in a randomized clinical trial of dantrolene vs. placebo in 52 Muslim pilgrims with heat stroke. This medication showed no difference in either cooling rates or outcome.[20]

Management by Organ System

CNS: Patients with EHS may have persistent altered mental status despite cooling treatment in the field. They will present with altered cognition, along with possible seizures, coma, areflexia, miosis, and sustained/permanent cerebellar dysfunction. Frequent neurologic checks must be performed to monitor for improvement. Imaging should be considered for neurologic deficits or acute changes. Mechanical ventilation may be required if a patient develops refractory seizures or status epilepticus and requires increasing doses of benzodiazepines or second- and third-line anti-epileptics.[21] Given the prevalence and insidious onset of seizure activity in this cohort, electroencephalogram (EEG) is recommended early if encephalopathy occurs due to EHS.

Cardiovascular: EHS is often associated with hypovolemia due to excess sweating and dehydration. The shift of blood flow to the skin for heat dissemination can reduce perfusion to internal organs and exacerbate end organ damage. Tachycardia and/or arrythmia may be seen in the setting of hypovolemic and distributive shock. Arrhythmia can also be present due to rapid core temperature changes and abnormalities. Non-specific conduction defects may be present and will require monitoring and replacement of electrolytes. EHS patients will require advanced hemodynamic monitoring and judicious volume resuscitation. They may require intermittent use of pressor support, to sustain hemodynamic stability, as severe EHS exhibits a predominantly distributive shock state, which portends a worse outcome.[22] In the setting of distributive shock physiology, troponin may be elevated as a demand ischemia. However, acute myocardial infarction is a potential etiology of elevated troponin even in otherwise healthy patients, and echocardiography should be performed concomitantly if an elevated troponin is identified and cardiac dysfunction is suspected. EHS can provoke myocardial injury that may persist for up to 2 weeks following the episode.[23] Of note, cardiac troponin has also been shown to be elevated following prolonged exertion.[24] Therefore, the specificity of cardiac troponin to EHS-induced cardiac injury is unclear.[25] Regardless, it is reasonable to trend cardiac troponin in the setting of EHS and obtain TTE and cardiac MRI if there is concern for myocardial injury, or if the troponin levels do not stabilize and decline appropriately.

Pulmonary: EHS patients may have alveolar capillary membrane damage with pulmonary edema. Oxygen supplementation with mechanical ventilation may be required if accompanied by severe hypoxia or neurologic injury.

» If the patient is conscious and able to follow at least simple commands, consideration for non-invasive ventilation can be made to provide positive pressure to the airways and help bridge through the initial portion of resuscitation.

» A low threshold should be made to place the patient on mechanical ventilation following endotracheal intubation to support ventilation and oxygenation when the patient is unable to breathe on their own. Every effort should be made to provide lung-protective settings maintaining tidal volumes at 6–8cc/kg, plateau pressures < 30cm H20, and consideration of driving pressures < 14cm H20.

Renal: EHS is associated with pre-renal and direct acute kidney injury, which may result in renal failure and need for intermittent dialysis. Appropriate management of hypoperfusion and rhabdomyolysis may quell the need for renal replacement therapy. Common electrolyte disturbances will include hyperkalemia, hypomagnesemia, hyper- or hyponatremia, and hyperphosphatemia. Phosphate is of particular concern, as persistent elevated phosphate is both indicative of a severe EHS, and has a higher incidence of requiring renal replacement therapy.[26] If the renal injury is substantial, nephrology consultation is indicated, and renal replacement therapy may be required. Continuous renal replacement therapy (CRRT) should be considered in the setting of hemodynamic instability and renal failure with severe electrolyte derangements or metabolic acidosis that fails to respond to judicious IV fluid resuscitation. Intermittent hemodialysis (IHD) is preferred if the patient is hemodynamically stable.

GI: Hepatic injury may include congestion, cholestasis, and necrosis with small bowel injury to include hypoperfusion with splanchnic shunting. Monitoring for liver failure is crucial in the period immediately following injury, as case reports have indicated transplant may be necessary.[27] Liver transplant center referral should be considered if liver function tests do not show signs of improvement with resuscitation, or if Kings College criteria are met for non-paracetamol induced fulminant hepatic failure.[28]

Musculoskeletal: Myopathy and rhabdomyolysis may result in muscle pain, edema, and weakness. If rhabdomyolysis is present, frequent checks for compartment syndrome of the extremities is important. Careful restoration of electrolyte dyscrasias and hypovolemia must be performed under intensive care monitoring.

Hematologic: Coagulopathy may be present, including disseminated intravascular coagulation (DIC). DIC has been described in up to 45% of patients with classic and exertional heat stroke and is a significant factor in mortality rates.[29, 30] Immediate cooling and supportive care may reverse endothelial injury and ongoing hemorrhage.

Endocrine: Hypoglycemia, along with hyponatremia and hypochloremia, may be present upon evaluation and needs correction.

Extracorporeal Support

Organ-failure support devices, including ECMO, renal replacement therapy, and plasma exchange, are advanced forms of therapy to bridge the patient through their disease process to recovery. In the case of EHS, the untoward consequence of prolonged duration of hyperthermia and multi-organ injury may result in myocardial injury, respiratory failure, acute renal failure, liver failure, encephalopathy, cerebral edema, and DIC. Organ-failure support devices may be considered in these cases and are outlined in the sections below.

Extracorporeal Membrane Oxygenation

ECMO requires a team of perfusionists and cannulators who can both place and manage the "circuit." Anticoagulation is also a requirement if a patient is placed on veno-arterial ECMO. The two main considerations for the use of ECMO in heat stroke include refractory cardiogenic shock secondary to myocardial injury from persistent hyperthermia and impending circulatory collapse, or severe and progressive hypoxia or hypercapnia. Early consideration for the use of ECMO should be made to prevent cardiac arrest or to aid in resuscitation during cardiac arrest that is deemed to be due to heat stroke. The inclusion and exclusion criteria should be discussed with the ECMO team. Please refer to the ECMO CPG from the Extracorporeal Life Support Organization.[31]

Renal Replacement Therapy

CRRT, or hemodialysis, requires placement of a temporary dialysis catheter. This modality can help correct many electrolyte abnormalities, including potassium, calcium, bicarbonate, sodium, magnesium, phosphate, and chloride. It is most efficient when performed as intermittent hemodialysis but can be performed continuously and preferably as CRRT if the patient requires vasopressor support. There have been case reports of the use of filtration to remove inflammatory cytokines released during heat stroke, but this should not be considered as a primary treatment.[15]

Criteria for "Step-Down" to Ward Care

- No longer requiring q1–2-hour physical examination or vitals
- No advanced airway required
- Normothermic and core temperature stable
- CK plateaued + downtrending x 24 hours
- AKI resolving, not requiring continuous renal replacement therapy
- LFT downtrend or stable x 24 hours without life-threatening coagulopathy
- Electrolytes stable and improving
- No longer receiving high-volume IVF
- Symptomatically improved

Prognosis

Mortality rates for heat stroke (including classic and exertional heat stroke) approach 60% for those requiring ICU care. Complications such as cognitive and motor dysfunction range from 3.7% to 40.7%.[32-34] Recovery of cognition and neurologic function during cooling indicates a positive prognosis.[32] Poor prognostic indicators include: organ dysfunction beyond 96 hours,[33] advanced age, duration of hyperthermia, and hypotension.[34] Scoring systems such as SOFA (Sequential Organ Failure Assessment) and J-ERATO (Japanese Early Risk Assessment Tool for Detecting Clinical Outcomes in Patients with Heat-related Illness) may be used to identify those with greater risk of mortality.[35, 36]

SECTION 8: ADVANCED CARE – INPATIENT WARD MANAGEMENT

The ED or ICU Consult

The hospitalist of a Ward or step-down unit receiving consultation for admission from the ED or transfer from the ICU for a patient with EHS must ensure the patient is suitable for this level of care. When evaluating a patient in the ED, it is prudent to ensure EHS is the appropriate diagnosis, evaluate for any coexisting condition, and investigate the underlying cause of the EHS. Medical illnesses may precipitate EHS, and these must be evaluated for and managed appropriately.[1]

The great majority of SM presenting with EHS should be admitted and monitored for complications once stabilized in the ED. While some SM with EHS may be recovered post-cooling with no signs of significant end organ dysfunction, the provider should be judicious on discharging to home, and should ensure a clear plan for home observation and follow-up care. Common complications include acute kidney injury (AKI), liver illness, and coagulopathies. Cases that do not meet EHS criteria (e.g., no CNS dysfunction or signs of end organ damage), but rather a less severe EHI, may still warrant admission to monitor for development of AKI and/or ER). Prudent clinical judgment must be used on an individualized basis, depending on comorbid conditions, reliability of follow-up, and severity of the presentation. SM dispositioned with heat exhaustion or EHI with only mild hepatic enzyme or creatinine elevations may be considered for release to quarters for up to 72 hours. Coordinated outpatient follow-up within 24 hours with repeat labs is preferable. See Section 9 for return-to-training (RTT) and return-to-duty (RTD) guidelines.

Recognizing EAH is critical in the care of SM, as EAH may present similarly or coexist with EHI. As the symptoms for both conditions are similar, it is prudent to check both a core (rectal) temperature and a sodium level in patients in the ED or inpatient setting with confusion and/or mental status changes.[2, 3] Sodium levels ≤132 mEg/L along with other characteristic findings are indicative of EAH. Warfighters diagnosed with hyponatremia generally require admission if it is moderate to severe (serum sodium < 125 mEq/L; Table 5.1). Patients with mild hyponatremia may generally return to quarters with fluid consumption education, close outpatient follow-up, and RTT/RTD guidance.

ER is a condition that can manifest either in isolation or concomitantly with EHS as a complication. The Creatine Kinase (CK) level may be minimally elevated at initial presentation with normal exertion, but clinicians should monitor for increasing CK levels during the hospitalization. Levels > 5 times normal in the setting of significant muscular soreness should raise suspicion for ER. CK levels generally peak at 2–3 days after strenuous physical exertion and have a half-life of 1.5 days (DoD Rhabdomyolysis CPG).[4] IV fluids for renoprotection should follow accepted guidelines for rhabdomyolysis. Clinicians must also be aware of ECAST.[5, 6] Refer to the DHA Practice Recommendations: Inpatient Management of Exertional Rhabdomyolysis.[7]

The hyperthermic Warfighter presenting to the ED with persistently elevated core temperature and CNS dysfunction despite cooling efforts in the prehospital setting portends a high risk for complications, and hospital admission is recommended for monitoring. Patients who have been sufficiently stabilized either in the ED or ICU may be appropriate for continued treatment and monitoring in the inpatient Ward. Intravascular cooling may be considered in the ED or ICU for EHS cases where core temperature remains > 40°C (> 104.0°F) despite aggressive external cooling measures. Cooling should stop when the core temperature reaches 39–39.2°C (102.0–102.5°F).

Disposition of the Warfighter from the ED is dependent on overall stability and evaluation for high risk factors. Severe cases of EHS with refractory hyperthermia, severe or persistent CNS or other end organ damage, or those with delayed initiation of cooling may warrant ICU admission over the Ward/step-down unit.

High risk factors that should prompt ICU admission (see Figure 6.1)

- Prolonged or resistant elevation in core temperature > 40°C (> 104.0°F)
- Mechanical ventilation for respiratory distress, hypercapnia, or hypoxia in the setting of multi-organ failure
- Metabolic encephalopathy or prolonged altered mental status (AMS)
- Coagulopathy to include DIC, thrombocytopenia, or thromboembolism
- Renal failure/potential need for emergent hemodialysis or continuous renal replacement therapy (Cr > 2.5 mg/dL)
- Hemodynamic instability resulting in circulatory and/or cardiovascular shock
- Evidence of shock liver (AST or ALT > 1000 U/L)

Although not every patient with metabolic abnormality needs ICU care, presence of severe abnormalities such as prolonged and continued AMS, elevated transaminases > 1000 U/L, creatinine > 2.5 mg/dL, persistent hyperphosphatemia, or other electrolyte disturbance warrants ICU consideration, especially for those with delayed or prolonged cooling.

Transfer from ICU to Ward

A crucial transition of care occurs when the patient is transferred from the ICU to the Ward. Effective handoffs and communication between teams are critical at this stage, to ensure all prior and ongoing problems and complications are appropriately monitored and followed up. As outlined in Section 7 (Advanced Care – Intensive Care Unit Management), recommended criteria for transfer from the ICU to the Ward include the following:

- No longer requiring q1–2-hour physical examination or vitals
- No advanced airway required
- Normothermic and core temperature stable
- CK plateaued + downtrending x 24 hours
- AKI resolving, not requiring continuous renal replacement therapy
- LFT downtrend or stable x 24 hours without life-threatening coagulopathy
- Electrolytes stable and improving
- No longer receiving high-volume IVF
- Symptomatically improved

If stable, the Ward can monitor electrolytes and trend CK, LFTs to plateau and downtrend.

Care of the Warfighter on the Ward

Once the patient is deemed sufficiently stable for admission to the inpatient Ward, the focus is optimizing fluid status and promoting normal organ function. Continued judicious fluid management is key in reducing risk for morbidity associated with EHS, in particular ER, as determined by volume status, lab values (LFTs, Cr, CK, etc.), urine output, and cardiopulmonary function. It is also critical to correct electrolyte/metabolic abnormalities, primarily through hydration and electrolyte repletion. The patient should be monitored for persistent or worsening symptoms and laboratory markers. Another important aspect is to investigate underlying etiologies that may have predisposed the SM to the heat illness.

General recommendations for inpatient Ward management include:

» Telemetry over first 24 hours

» Monitor CK, LDH, CMP, Mg, Phos, serum lactate q4–6 hours over first 24 hours

- If downtrending, decrease to q12 hours

- If hyperkalemia (K+ > 5.0–5.5 mEq/L), obtain ECG
    - i. Consider calcium gluconate (1 amp)
    - ii. D50 and 10U insulin
    - iii. Furosemide (intravenous, cautiously)
    - iv. Inhaled beta-agonist
    - v. If persistent, consult nephrology for potential dialysis

» Evaluate hepatic enzymes and liver function tests; manage transaminitis
- Hepatic enzymes may triple in the initial 24-hour period
- Consider addition of N-Acetylcysteine IV for rapid rise of hepatic enzymes or INR > 1.5[8, 9]
- If continuing to rise, consider consult with hematology/gastroenterology if available or transfer to higher level of care

» PT/PTT/INR to rule out disseminated intravascular coagulation (DIC), monitor for coagulation and/or bleeding diathesis
- If symptomatic, consider fresh frozen plasma (FFP), platelets, cryoprecipitate

» UA w/ urine myoglobin QAM up to 4 days as clinically indicated

» Fluids:
- If hypervolemia or euvolemia, fluids based on sodium level
- Na > 134: NS 250–500 mL/hr to maintain UOP > 200 mL/hr
- Continue aggressive fluids until CK begins to drop
- Consider intravenous furosemide if developing fluid overload

» Na 133–134 (consider EAH or other Dx)

» Na ≤ 132 (consider EAH)

» Hypovolemia and Na ≥ 134: Give 1–2 L NS bonus and reassess

» Routine neurologic exams

» If not improving or begins to worsen, consult specialist(s) as indicated, and consider transfer to a higher level of care

Warfighters recovering from EHI on the inpatient Ward require multidisciplinary care for optimal outcomes. This may include specialists (nephrologist, hepatologist, neurologist, etc.) to assist with appropriate organ dysfunction as outlined above. The clinical pharmacist may assist with identifying medications or supplements that may have predisposed to heat illness. See also Section 7, Medications.

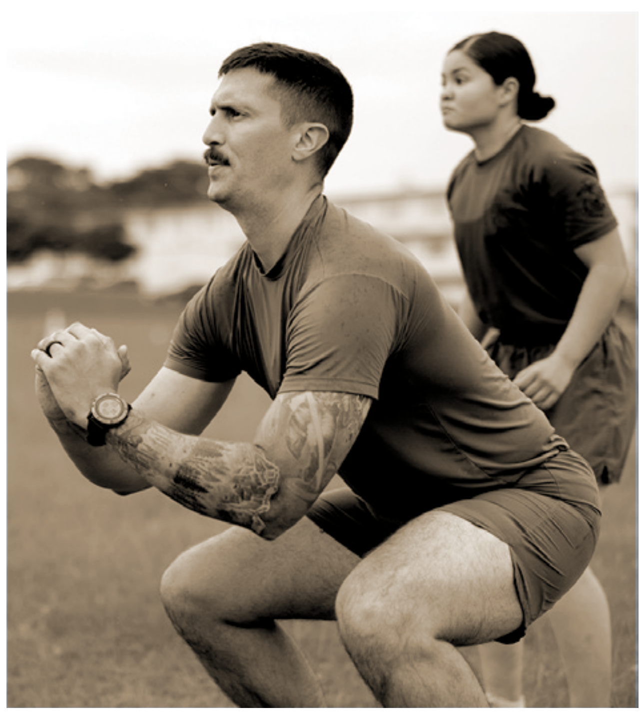
Another important member of the care of the Warfighter is the Preventive Medicine (PM) physician. A recommended practice is that PM receives a daily record of patients seen in the ED and either discharged or admitted for heat illness, and a weekly copy of the EMS Heat Illness Data collection. Other entities that see heat illness that are not routed through the ED must report the case to the PM Chief. Preventive Medicine submits a weekly report by category of EHI to Safety Office Chief to enable a common operating picture of the installation illness milieu. The PM Department will report all confirmed heat injuries via appropriate channels (e.g., for Army, via DRSi to Army Public Health Command within 7 days). Please see Service-specific reporting guidelines.

Discharge and Disposition

Warfighters may be considered for discharge to home from the inpatient Ward when the following criteria are met:

- Normal neurologic exam
- CK plateaued and downtrending for 24 hours
- Resolving AKI
- Hepatic enzymes and LFTs downtrending or stable x 24 hours without coagulopathy
- Normalized electrolytes
- Weaned off IVF
- Symptoms improved
- Profile placed

Accurate diagnosis of the type of heat illness and any comorbid conditions is critical to the safe disposition, profiling, and prevention of further illness for the SM. All medical providers involved in any stage in the care of EHI must become familiar with and be able to differentiate the types of heat illness.[10-13] Service Members admitted to the hospital with EHS or other types of EHI will have a light duty profile as required for recovery documented prior to discharge. See Return to Duty section for details on the duty status for EHI.



SECTION 9: RETURN TO DUTY

EHI Risk and RTD

Current literature provides guidance for the recognition, prevention, and treatment of EHI in the prehospital, emergency department, inpatient hospital, and intensive care settings, but there is no consensus definition for either EHS severity or risk-stratification method for EHS victims. Without specific steps to stratify EHS victims based on their risk of adverse outcomes or a subsequent/recurrent EHS event, appropriate treatment, evaluation, and RTD recommendations are challenging, given its highly individualized nature.[1-4] As a result, decisions for treatment and RTD after EHI are often left to the treating provider, whose medical decision-making is mostly based on anecdotal observations and caution.[3] This CPG, the result of Joint Service medical provider expert consensus, identifies risk-stratification definitions for return to duty after EHI, recognizing limited data, existing clinical practice guidelines, Service-specific recommendations, and existing protocols. This CPG further provides an algorithm for RTD; further research is needed to validate these definitions.

Risk Definitions for RTD after EHI

This CPG identifies definitions for minimal-, low-, moderate-, and high-risk EHI categories.[4-10] These definitions are intended to guide the provider in decision-making for RTD. These definitions are not intended to stratify an EHI victim during ongoing hyperthermia. The goal is to facilitate safe RTD as rapidly as possible, while minimizing the potential for any adverse outcome or recurrent EHI. Minimal- and low-risk patients are those diagnosed with HE or uncomplicated/mild EHI, while EHS casualties may fall into the low-, moderate-, or high-risk categories.

Minimal Risk (must meet ALL the following):

- » Maximum temperature < 39°C (< 102.0°F)
- » No evidence of end organ damage on exam (e.g., neurologic dysfunction)
- » Initial labs on the same date of injury and 48–72 hours post-injury (if obtained) showed no evidence of end organ damage. The lab panel should have included CMP, CK, uric acid, PO4, CBC, LDH, UA + Micro, and sickle cell trait screen if not done previously. Depending on clinical consideration of risk, if labs were not obtained on the date of injury due to other administrative or provider-driven reasons, the patient should not be classified as minimal risk, taking patient safety into utmost consideration.
- » Appropriate, active, and aggressive cooling was not required per the protocol and algorithm (Figures 5.1 and 5.2). If the protocol indicated the need to perform active and aggressive cooling, but it was not performed, then the patient would be excluded from the minimal-risk definition. If cooling was initiated out of an abundance of caution by non-medical personnel, but the patient was later determined not to have needed cooling, they may still meet the criteria for minimal risk.
- » Time from symptom onset to initiation of treatment was less than 10 minutes.
- » Total time from injury to complete resolution of symptoms is less than 50 minutes.
- » No comorbid conditions. Examples include but are not limited to: hyponatremia, sickle cell trait, concurrent infection (e.g., pneumonia, cellulitis), chronic disease (particularly heart, liver, kidney), and chronic metabolic conditions (e.g., diabetes, thyroid).
- » Initial follow-up appointment is within 72 hours after incident, and patient condition has completely resolved and is currently asymptomatic.
- » Follow-up labs are performed within 48–72 hours after incident and are completely normal by 72 hours post-incident.

Low Risk (must meet ALL the following):

- Time from injury to initiation of cooling was less than 10 minutes.
- Total time from injury to stable temperature < 39°C (102°F) was less than 30 minutes (including any rebound hyperthermia).
- Return of normal neurologic status within 45 minutes post injury
- No comorbid conditions. Examples include but are not limited to: hyponatremia, sickle cell trait, concurrent infection (e.g., pneumonia, cellulitis), chronic disease (particularly heart, liver, kidney), chronic metabolic condition (e.g., diabetes, thyroid).
- Access to frequent medical follow-up with labs, at least every 48 hours (Lab panel = CMP, CK, Uric Acid, PO4, CBC, LDH, UA + Micro; sickle cell screen if not done previously)
- All labs have trended down to clinically reasonable levels within 72 hours.
- Improved patient condition at each follow-up appointment, and currently asymptomatic
- Concussion-like heat-related symptoms have resolved within 48 hours (e.g., headache, fatigue, difficulty concentrating/fogginess, slowness, memory issues).

Moderate Risk (does not qualify as minimal, low, or high risk):

- Characteristics are intermediate between low- and high-risk definitions.

High Risk (any of the following):

- Initial core temperature ≥ 42.2°C (108°F)
- Time from injury to initiation of appropriate cooling > 30 minutes
- Total time from injury to stable temperature < 39°C (102°F) was > 60 minutes.
- ICU admission
- Requirement for renal replacement therapy during recovery period
- Return of normal neurologic status > 60 minutes post injury
- Heat illness during low to moderate exertion
- Personal or family history of malignant hyperthermia or family history of unexplained complications or death following general anesthesia
- Personal history of sickle cell disease or trait
- Presence of comorbid conditions such as hyponatremia, concurrent infection, chronic disease (particularly heart, liver, kidney), chronic metabolic condition (e.g., diabetes, thyroid)
- History of heat illness/exertional illness within the last 30 days
- Prior history of acclimatized exertional heat illness
- Family history of malignant hyperthermia (MH)
- Persistent concussion-like heat-related symptoms > 14 days (e.g., headache, fatigue, difficulty concentrating/fogginess, slowness, memory issues)

Table 9.1. Risk Stratification for Return to Duty After EHI

Clinical Criteria/ Variables	Minimal Risk (must meet all criteria below)	Low Risk (must meet all criteria below)	High Risk (if meets any 1 or more criteria)
Max T_{Core}	< 39°C (102.0°F)	See note*	≥ 42.2°C (108.0°F)
Time from symptoms to treatment/cooling	≤ 10 min	≤ 10 min	> 30 min
Initial CNS dysfunction	n/a	Resolved < 45 min	≥ 60 min of initial CNS dysfunction
Total time T_{Core} > 39°C (102.0°F)	n/a	< 30 min	≥ 60 min
Total time from injury to complete resolution of symptoms	< 50 min	< 3 days	Varies with individual case
Initial Labs (if obtained)	No evidence of EHS/no end organ damage	Normal or elevated	Elevated
Active cooling required?	No	+/–	Yes
Comorbid conditions	None	None	Present
Concussion-like symptoms related to heat illness	Resolved < 48 hr	Resolved < 48 hr	> 14 days
Follow-up appointment(s)	Within 72 hr	Minimum every 48 hr	As clinically indicated
Follow-up labs	Normal within 72 hr	Downtrending to clinically reasonable levels within 72 hr	Varies with individual case
Complicating factors (ICU admission, sickle cell trait, prior EHS, Fam Hx of MH)	No	No	Yes

***Note:** No specific core temperature range was assigned to both low and moderate risk due to the variability of core temperature in EHI and the individualization of each heat injury. Both low and moderate risk may exhibit core temperatures between 39°C (102.0°F) and 42.2°C (108.0°F). Other characteristics of moderate risk are intermediate between low and high risk.

Return-To-Duty Algorithm for EHI

Several professional medical societies and organizations have published guidelines for EHI recognition, prevention, and treatment. Return-to-play (RTP) and RTD guidelines, however, have only been published by the American College of Sports Medicine (ACSM) and the National Athletic Trainers Association (NATA). The ACSM and NATA recommendations are congruent with regard to the recognition, prevention, and treatment of EHI, but there are several differences involving RTP/RTD after EHI, echoing similar incongruencies within the various branches of the U.S. Armed Forces.[11] Although the Army and Air Force have similar recommendations for RTD, as seen in AR 40-501[12] and AFI 48-151[13], the Navy RTD guidelines for EHI still differ in a few significant areas, particularly among the Marine Corps.[14, 15] These differences lead to potential confusion surrounding best practices. Thus, updating and standardizing current guidelines across the Department of Defense in accordance with the best available evidence is pivotal to ensuring the safety and mission effectiveness of all SM. Unified RTD guidance across the Services may also reduce duplication of effort and wasting of resources.[11]

Risk stratification (Table 9.1) is a logical method to guide RTD protocols after EHI, and similar constructs have been employed successfully with other exertion-related illnesses such as exertional rhabdomyolysis.[16] Initially, patients suffering from EHI are evaluated, and those with recurrent EHI or deemed high risk according to the criteria above are appropriately referred and evaluated for other rare underlying conditions. Subsequently, those who are classified as minimal risk or low risk are allowed to start the minimal RTD protocol (Table 9.2) or the low-risk RTD protocol (Table 9.3), respectively. In minimal-risk and low-risk cases, no heat tolerance test (HTT) is required. However, prior to initiating the minimal- or the low-risk RTD protocols, follow-up with a medical provider is required to ensure that ALL criteria are met. Patients must be asymptomatic, physical exam must be normal (i.e., no signs or findings of end organ damage), and laboratory values (including a comprehensive metabolic panel, CK, uric acid, phosphate, complete blood count, lactate dehydrogenase, and urinalysis with microscopy) must be trending down to a clinically reasonable level. (Note: Sickle cell trait screening should also be performed, if not done previously.)

If all criteria are met, then a gradual increase in activity is initiated, with each stage in a protocol occurring over a minimum of 24 hours. The patient must be able to tolerate their current stage without recurrence of symptoms in order to progress to the next stage. As with concussion RTD protocols, failure to tolerate the current stage triggers a return to the previous stage. For example, if the patient is asymptomatic in stage 2, they may progress to stage 3. However, if they attempt stage 3, but experience recurrence of symptoms (e.g., headache, nausea, lightheadedness, fatigue), they must return to stage 2. The minimal and low-risk RTD protocols are listed below; the process is illustrated in Figure 9.1.

Minimal RTD/RTP Guidelines (for minimal-risk EHI)[6]

Table 9.2. Minimal-Risk RTD Protocol (for minimal-risk patients)

Stage	Activity	Profile / Duty Status
0	No physical activity for minimum of 1 day. Activities of daily living are okay.	Limited/light duty
1	Light-moderate activity, < 70% age-adjusted max HR, 60 min limit (e.g., jog at ½ speed)	Limited/light duty
2	Moderate activity, < 80% age-adjusted max HR, 60 min limit (e.g., slow run at ¾ speed)	Limited/light duty
3	Full participation, including any fitness test/competition	Full duty

Note: Each stage is a minimum of 24 hours.

Low-Risk RTD/RTP Guidelines (for EHE and low-risk/severity EHS)[2, 4-7, 9, 10, 17]

Table 9.3. Low-Risk RTD Protocol (for low-risk patients)

Stage	Activity	Profile / Duty Status
0	No physical activity for minimum of 2 days. Activities of daily living are okay.	Limited/light duty
1	Exposure to warm environment, light stretching, 60 min limit	Limited/light duty
2	Light aerobic activity, < 50% age-adjusted max HR, 20–60 min (e.g., brisk walk)	Limited/light duty
3	Light-moderate activity, < 70% age-adjusted max HR, 60 min limit (e.g., jog at ½ speed)	Limited/light duty
4	Moderate activity, < 80% age-adjusted max HR, 60 min limit (e.g., slow run at ¾ speed)	Limited/light duty
5	Complete participation in training/practice settings, excluding any type of maximum-effort test or full competition	Limited/light duty
6	Full participation, including any fitness test/competition	Full duty

Note: Each stage is a minimum of 24 hours. The stage length may be longer depending on both operational and clinical needs, with patient safety being the utmost consideration.

Patients who fail to progress appropriately after initiation of the minimal- or low-risk RTD protocols should be placed into the moderate- or high-risk RTD protocol, and a referral to sports medicine or other experienced heat injury specialists should be considered. HTT should also be considered, if available, or if there is operational need-to-know. HTT should ideally be completed no sooner than 6 weeks after the heat injury.[5, 18] In general, SM should be back to or close to their baseline aerobic fitness either clinically or via other objective data points such as VO2max prior to taking an HTT. An abnormal HTT may be repeated in 3 months, and persistently abnormal HTT should trigger appropriate specialty referral (e.g., CHAMP Multidisciplinary Case Review Committee) and evaluation for other rare underlying conditions. If the HTT normalizes at 3 months after initial abnormal HTT, the patient should then begin the moderate- or high-risk RTD protocol to begin the process of exercise and environmental acclimatization.

Strategic differences exist between the low-risk and moderate- or high-risk RTD protocols. Prior to initiation of the moderate- or high-risk RTD protocol, follow-up with a medical provider is required to include a full set of labs (see above and below) within 7 days of injury or discharge from the hospital. Weekly follow-up afterwards should be conducted until the patient is asymptomatic, displaying normal physical exam without signs or findings of end organ damage, and normal lab values consisting of comprehensive metabolic panel, creatine kinase, uric acid, phosphate, complete blood count, lactate dehydrogenase, and urinalysis with microscopy. (Note: Sickle cell trait screening should also be performed, if not done previously.) Any laboratory values outside of the normal range should be monitored at 1- to 2-day intervals looking for a downward trend. Initiation of gradual return to activity should not begin until all labs are within normal limits and the patient is asymptomatic.

Once gradual increase in activity within the moderate- or high-risk RTD protocol is initiated, each stage is individualized and may take up to 2 weeks to complete, but a minimum of 4 days per stage is required so that stage 7 is no sooner than 4 weeks from initiation of return to activity. Of note, this protocol is to be used as a guideline and not to override sound provider judgment, where patient safety is of utmost importance. Typically, in the moderate- or high-risk protocol, a low-risk patient who fails the low-risk RTD protocol calls for 4–7 days per stage, moderate-risk

RTD calls for 7–10 days per stage, and high-risk RTD requires 10–14 days per stage. But the patient should remain asymptomatic; perform further lab testing during return-to-duty activity stages only as clinically indicated. A patient's inability to progress from one stage to the next stage within 2 weeks or to return to vigorous activity while adapting to exercise-related heat stress within 4 to 6 weeks would constitute a progression failure from the moderate- or high-risk RTD protocol. This warrants a referral to a regional expert clinician with experience in heat-related disorders for further evaluation. HTT may also be considered, if available, upon failure of the moderate- or high-risk RTD protocol or if there is operational need-to-know. HTT should occur no sooner than 6 weeks after the heat injury, provided the SM is back to or close to their baseline aerobic fitness. An abnormal HTT may be repeated in 3 months; a repeat abnormal HTT should trigger appropriate referral for further evaluation and consideration for a medical evaluation board referral. A normal repeat HTT after a previous abnormal HTT should provide reassurance that the SM may continue their progressive rehabilitation with reintroduction to thermally challenged environments.

Moderate- or High-Risk RTD/RTP Guidelines (for moderate-risk EHS and high-risk EHS after appropriate workup)[2, 4-10]

Follow-up with a medical provider is required to include a full set of labs (see below) within 7 days of injury or discharge from the hospital. Weekly follow-up should be conducted until the patient is asymptomatic with normal exam and normal lab values. The standard lab panel includes CMP, CK, uric acid, PO4, CBC, LDH, UA + Micro, and sickle cell trait screen if not done previously. Any labs outside the normal range should be monitored at 1–2-day intervals, looking for a downward trend. Initiation of the gradual return to activity should not begin until all labs are within normal limits and the patient is asymptomatic.

Once gradual increase in activity is initiated, each stage is individualized and may take up to 2 weeks to complete, but a minimum of 4 days per stage is required, so that stage 7 is no sooner than 4 weeks from initiation of RTD. Low-risk patients who fail the low-risk RTD protocol require an estimated 4–7 days per stage, moderate-risk require 7–10 days per stage, and high-risk require 10–14 days per stage. These time frames are to be used as an estimate, but not a hard requirement, as patient safety is of utmost importance. But the patient should remain asymptomatic; perform further lab testing during return-to-duty activity stages only as clinically indicated.

A patient's inability to progress from one stage to the next within 2 weeks, or inability to return to vigorous activity while adapting to exercise-heat stress within 4 to 6 weeks would constitute a progression failure and would warrant a referral to a physician with experience in heat-related disorders (e.g., Sports Medicine, CHAMP) for further evaluation. Special duty and activity waivers should be granted on an as-needed case-by-case basis, per medical provider discretion.

Figure 9.1. RTD Algorithm

Table 9.4. Moderate- or High-Risk RTD Protocol (for moderate or high-risk patients)

(See Notes below for estimated days per stage)

Stage	Activity	Profile / Duty Status
0	Individualized length of ADLs for 7–14 days	Limited/light duty or LIMDU
1	Mild activity/stretching in a low-heat stress condition (mild outdoor temperature/air-conditioned area)	Limited/light duty or LIMDU
2	Light aerobic activity, < 50% age-adjusted max HR, 20–60 min (e.g., brisk walk) in a low-heat stress condition	Limited/light duty or LIMDU
3	Light-moderate activity, < 70% age-adjusted max HR, 60 min limit (e.g., jog at ½ speed) in a low-heat stress condition	Limited/light duty or LIMDU
4	Heat acclimatization, < 70% age-adjusted max HR, 60 min limit (e.g., jog at ½ speed) in a warm/hot condition	Limited/light duty or LIMDU
5	Moderate activity, < 80% age-adjusted max HR, 60 min limit (e.g., slow run at ¾ speed) in a warm/hot condition	Limited/light duty or LIMDU
6	Complete practice participation, excluding any type of test/competition in ambient conditions	Limited/light duty or LIMDU
7	Full participation, including any fitness test/competition (minimum 4 weeks prior to this stage)	Full duty

Notes:

Required minimum 4 days per stage, so stage 7 is no sooner than 4 weeks from initiation of return-to-activity.

Each stage is individualized and may take up to 2 weeks to complete.

Low-risk patients who fail low-risk protocol estimate: 4–7 days per stage.

Moderate-risk patients estimate: 7–10 days per stage.

High-risk patients estimate: 10–14 days per stage.

Heat Tolerance Testing

A great portion of the research and development of heat tolerance testing has been done by the Israeli Defense Force (IDF), Uniformed Services University, and others, where it is now regularly used to assist in the diagnosis of heat intolerance and as a tool to guide return to duty in SM.[19] The IDF testing protocol was developed to assess thermoregulation in Israeli military members, aged 17 to 30, at 6 to 8 weeks following an EHI. The test consists of 120 minutes of treadmill walking at 5 km/h at a 2% grade in 40°C (104°F) and 40% relative humidity.[19, 20] Taking patient safety into account, testing is aborted if the rectal temperature reaches 39°C (102°F), the heart rate rises above 180 beats/minute, or if the participant develops symptoms of EHI.[19] Interpretation of results to determine heat tolerance depends on the rectal temperature and the heart rate. Specifically, individuals are classified as…

- **Heat intolerant** if the in-test rectal temperature rises > 38.5°C (101.3°F), the heart rate rises > 150 beats/minute during the test, or if the change in rectal temperature between 60 and 120 minutes is > 0.45°C (0.25°F).[21, 22]
- **Borderline heat intolerant** if the in-test rectal temperature is > 38.2°C (100.8°F), the heart rate is between 120 to 150 beats per minute during the test, or if the change in rectal temperature between 60 and 120 minutes is between 0.25 and 0.45°C (0.14 and 0.25°F).[21, 22]
- **Heat tolerant** if the in-test rectal temperature remains < 38.2°C (100.8°F), in-test heart rate remains < 120 beats/minute, and the change in rectal temperature between 60 and 120 minutes is < 0.25°C (0.14°F).[21, 22]

As stated above in the RTD algorithm (Figure 9.1), HTT is ideally performed no sooner than 6 weeks after EHI, and if abnormal, the test may be repeated in 3 months.[19, 20] In addition, the SM should be back or close to their baseline aerobic capacity clinically or via other means of objective testing such as VO2max. Persistent abnormal HTT should prompt evaluation for metabolic or genetic abnormalities as well as a change in duty status.

Although an abnormal HTT is indicative of either borderline or true heat intolerance, results should be corroborated with a detailed history, physical examination, determination of acclimatization status, and other objective measures of end organ dysfunction and functional capacity. It is unclear whether HTT improves diagnostic and prognostic accuracy over a comprehensive medical evaluation and laboratory testing in tactical athletes with EHI.[11] However, there is evidence correlating heat intolerance (as defined by the HTT) with low cardiorespiratory fitness.[23] There are also some data linking heat tolerance (as defined by the HTT) to significantly reduced risk of recurrent EHI.[21, 22]

There are limitations in using HTT as a standard for RTD. Although the HTT protocol per the IDF is the most widely used and validated method of assessment of thermoregulation, modifications and alternative protocols have been developed for individualized military, athletic, occupational medicine, and research applications.[5] There have been concerns for the validity of HTT pertaining to EHI case specificity, and timing of testing has yet to be established.[5] However, recent studies demonstrate 100% negative predictive value for future EHI over 2 years for SM with recurrent heat injury and negative HTT.[24] HTT has also been shown to be sensitive to acclimatization status.[25] Furthermore, facilities capable of performing the HTT are not readily accessible, requiring the patient to travel to limited specialized testing facilities and carrying considerable costs for the equipment and personnel required to operate and interpret results.[11] The future of monitoring and diagnosis may reside with readily available worn or ingestible mobile thermistor sensors, monitoring thermoregulation during function in the execution of duty requirements in real time, but further studies are needed.[11] Current best practice in the U.S. DoD is to limit HTT to only those individuals who have a demonstrated inability to progress to normal activity after an EHS event.

Service-Specific Return to Duty/Physical Evaluation Board Referral/Advanced Consultation

Return to duty after EHI remains controversial due to the individualized nature of each case and Service-specific requirements. Historically, efforts from the various Service branches to guide RTD remain somewhat discordant. This section (9) is an attempt to standardize components of RTD decision-making, but individual Service-specific protocols should still be respected; regulations and doctrine have been identified throughout this clinical practice guideline. In general, failure to RTD, especially after multiple attempts, should trigger referral to higher level specialty care (e.g., sports medicine, CHAMP WHEC), consideration for a permanent profile, and referral to the Disability Evaluation System (DES).

Finally, the Consortium for Health and Military Performance (CHAMP) Warrior Heat- and Exertion-Related Events Collaborative (WHEC) is a resource to assist providers with the management of Warfighters with exertional illness. WHEC works in collaboration with The Army Heat Center at Fort Moore, GA, and USU's Multidisciplinary Case Review Committee (MDCRC). Since its inception in 2020, WHEC has been dedicated to advancing the science and the Defense Health Agency's Clinical Practice Guidelines for preventing, reducing, risk-stratifying, and managing exertional injuries and heat illness. WHEC also provides information about the surveillance, research, and education on heat-related injuries.

WHEC is available for clinical consultation when challenging cases arise.

SECTION 10: GLOSSARY

Arm Immersion Cooling System (AICS): AICS is a method developed by the U.S. Army to aid in "heat dumping" during rest breaks or at the conclusion of high-intensity events. This is a prevention tool and is not intended for field treatment of a suspected heat casualty. However, in the absence of other, more aggressive cooling modalities, it may be an acceptable alternative.

Cold Water Immersion (CWI): CWI is identified as best practice for cooling of an exertional heat stroke casualty. The casualty is immersed to the clavicles, neck, or half body deep enough to allow for the patient's legs and torso to be fully submersed, if possible, in cold (0–4°C [32–39.2°F]) water. Continuous core (rectal) temperature monitoring is required to monitor progress and avoid overcooling.

Exercise-Associated Muscle Cramps (EAMC): Exercise-associated muscle cramps (EAMC), previously known as "heat cramps," typically present as acute spasm, stiffness, and cramping in the muscle belly. This may be experienced during or after exercise and may occur with or without core temperature elevation. Differential diagnosis includes exertional rhabdomyolysis and exertional collapse associated with sickle cell trait (ECAST). Whole-body muscle cramps may indicate exercise-associated hyponatremia, which warrants further investigation.

Exercise-Associated Collapse (EAC): Exercise-associated collapse (formerly termed "heat syncope", and also known as Exercise-Associated Postural Hypotension [EAPH]) refers to sudden loss of consciousness immediately after cessation of exercise and is typically preceded by dizziness, light-headedness, and/or tunnel vision. This is caused by orthostatic hypotension due to venous pooling in the lower extremities, as muscular contraction is no longer aiding with venous return. This is primarily seen in unconditioned individuals after bouts of unaccustomed exercise in the heat. After checking for a pulse (can be difficult to distinguish immediately from cardiogenic syncope), treatment involves moving the patient to the shade, elevating their feet, monitoring vitals, and appropriate rehydration.

Exercise-Associated Hyponatremia (EAH): EAH is serum sodium < 135 mmol/L due to progressive loss of sodium due to sweating, accompanied by excessive hypoosmolar fluid intake (e.g., plain water) and insufficient electrolyte replacement via food and beverage. EAH is potentially life-threatening and requires emergent transport when CNS dysfunction is present, with appropriate treatment to include hypertonic 3% saline. Adherence to fluid-replacement guidelines mitigates the risk of EAH.

Exertional Collapse Associated with Sickle Cell Trait (ECAST): ECAST is a spectrum of clinical presentations which ranges from ischemic muscle pain to fulminant collapse. Unlike EHS (see below), there are no signs of CNS dysfunction, and it is often referred to as a "conscious collapse." CNS dysfunction may present later during collapse, as progressive hypoxemia effects neurological function.

Exertional Heat Illness (EHI): Exertional heat illness is an umbrella term that encompasses the full spectrum of conditions (exertional heat exhaustion, heat injury, and heat stroke) associated with illness/injury during physical work in the heat and in humid environments. Note that core temperature has been reported as high as 41.5°C (106.7°F) in highly conditioned athletes without any signs or symptoms of heat illness. Therefore, elevated core temperature alone is insufficient to diagnose heat illness.

Exertional Heat Injury (HI): Heat injury is defined as heat exhaustion (see below) with laboratory evidence of end organ damage such as acute kidney injury, liver injury, or exertional rhabdomyolysis. (Note: Rhabdomyolysis requires more than mild CK elevation for diagnosis; it requires concomitant muscle symptoms; see CHAMP Exertional Rhabdomyolysis CPG.[1]) Central nervous system function is, by definition, normal in cases of heat injury. Repeat labs are necessary, as numerous biomarkers of end organ damage can peak 24–72 hours post-injury.

Exertional Heat Stroke (EHS): Exertional heat stroke is defined as severe hyperthermia (core temperature of 40°C [104.0°F] or greater) associated with central nervous system dysfunction that occurs during or after exertion. Common signs and symptoms include agitation, confusion, disorientation, fatigue, poor balance, uncoordinated movement, and loss of consciousness. This may progress to delirium, convulsions, coma, and even death.

Exertional Rhabdomyolysis (ER): Exertional rhabdomyolysis is a clinical diagnosis for severely *symptomatic* myonecrosis that results from prolonged, strenuous exercise or exertion, especially involving eccentric loading. ER typically presents as severe muscle pain and stiffness, often associated with cramping (EAMC), weakness, localized swelling, and in some cases dark-colored urine. In the context of appropriate clinical presentation, diagnosis is confirmed by significantly elevated serum creatine kinase (CK) levels (at least > 5x but often 50–100x the upper limit of normal) or myoglobin in the urine. It is not just a laboratory diagnosis. If ER is suspected, immediate referral to a physician is warranted. For further discussion, please refer to the CHAMP CPG for Exertional Rhabdomyolysis.[1]

Heat Acclimatization: Acclimatization is the process in which an individual adapts physiologically (optimized thermoregulatory mechanisms) during repeated exposure to a hot/humid environment. The process can take up to 14 days. Daily 1–2-hour long light- to moderate-intensity exercise/exertion in the heat is necessary to induce heat acclimatization.

Heat Exhaustion (HE): Heat exhaustion is the body's protective mechanism, shutting down the exertion to allow cooling to occur. Physical signs of heat exhaustion include severe fatigue, profuse sweating, weakness, rapid pulse, dizziness, confusion, nausea, and headache. The body core temperature is generally between 38.3°C (101.0°F) and 40°C (104.0°F). Contributing factors include dehydration, lack of acclimatization, insufficient aerobic fitness for the exertion level, and circulatory strain from competing demands for blood flow to the skin and to active muscles. It is reasonable to assume in the field that individuals with heat exhaustion can progress to heat stroke if the exertion is not terminated and the individual is not treated immediately.

Heat Tolerance: Heat tolerance is objectively determined either via the Heat Tolerance Test (see below) or subjectively assessed by an experienced healthcare provider. An individual who can engage in their normal work and exercise activity in the heat, without any signs or symptoms of exertional heat illness, may be considered heat tolerant in those conditions.

Heat Tolerance Testing (HTT): HTT is a protocol to triage EHS patients as either heat tolerant or heat intolerant. Thus, the HTT aids in the return-to-duty decision-making process. The test is 2 hours long and consists of treadmill walking in a 40°C (104°F), 40% relative humidity (RH) environment.

Ice-Sheet Cooling: An acceptable alternative cooling method is ice sheets. In this method, towels or sheets are kept in an ice slurry or frozen in a cooler. The towels or sheets are taken from the cooler and applied to the patient. Sheets should be balled up and placed in the axilla and groin, with another draped over the entire body, except the head/face. Towels should be placed over/around the head and neck, and on the back, chest, each arm, and each leg. The wet towels/sheets must be exchanged frequently, every 30 seconds to 3 minutes, when the material begins to feel warm. Adding ice packs to this method decreases the cooling time.

Quantico Method/Ice-Water Dousing: This is an effective best-practice alternative to CWI in which the casualty is placed on a field litter, typically over an appropriately sized water tub filled with an ice-water slurry. Ice-cold water is continuously poured over the casualty, accompanied with ice massage to the legs and ice packs to the head, neck, axilla, and groin.

SECTION 11: APPENDICES

Appendix 1. Prevention

Despite a large body of literature documenting risk factors for EHI, prevention remains a challenge in the military Services. Data from The Army Heat Center at Fort Moore, GA, indicates that 89% of all EHI casualties had 2 or more identifiable risk factors, when assessed post-collapse (LTC David DeGroot, pers. comm. Feb. 2024). The “suck it up and drive on” mentality, in which SMs are encouraged to push their physical limits in the face of discomfort, likely contributes to the incidence of EHI.

Physical performance assessment is integrated into military service in numerous ways, including selection for certain schools, awarding of special skill badges and tabs, and promotion considerations. Given these extrinsic motivators, it is unreasonable to expect to fully mitigate all EHI risk factors. However, that does not absolve the unit commander from the responsibility to conduct a risk assessment and to implement controls to the maximum extent possible. Additionally, as there will always be residual risk, ensuring adequate preparedness for the recognition and response to an EHI casualty is of paramount importance. See Section 5 of this document for detailed information.

Risk management is a critical topic in military leadership, and preparing for EHI is no exception. Preparation and planning for the risk of EHI is crucial. Army Techniques Publication 5-19 (ATP 5-19 2021)[1] is the most current doctrine regarding the process of risk management and the associated decisions and mitigations deployed. This document clearly states, “The commander has overall responsibility for RM integration and is the risk acceptance authority” (ATP 5-19 2021) within military operations.

Those with tactical-level authority must be prepared to make appropriate risk-management decisions. This requires education and knowledge of the risks of EHI in specific settings and the effectiveness of various mitigation strategies and treatment resources available. An unnecessary risk is any risk that, if taken, will not contribute meaningfully to mission accomplishment or will needlessly endanger lives or resources. Additionally, leaders should only accept the level of risk where the potential benefit of the mission outweighs the potential consequences. Leadership needs to communicate clearly the level of risk they are willing to take to accomplish the training or mission objective and empower tactical leaders to make appropriate risk-management decisions. This process must continue throughout the time span and must involve constant re-evaluation of the effectiveness of each heat-mitigation strategy employed. During the operational mission, time and environment may not allow adequate preparation to deploy all available risk-mitigation techniques (i.e., ice-water immersion tubs, acclimatization, development of good emergency response plans, etc.). The known, often repeated, objectives in the training environment allow time for deliberate risk management in which adequate time is dedicated to the five-step process of risk management.

Preparticipation Exam/ Periodic Health Assessment

Some guidelines recommend the use of a preparticipation exam to identify those at risk of EHI.[2, 3] It can also be used as an opportunity to promote aerobic conditioning and acclimatization, counsel on hydration and other mitigation strategies, and educate on the signs and symptoms of EHI. Whereas athletic preparticipation exams specifically are not utilized in the military, recruits are required to undergo a comprehensive medical assessment at Military Entrance Processing Stations (MEPS). Additionally, SMs are required to have annual periodic health assessments during which they report any new or ongoing medical conditions, as well as report use of exogenous substances such as tobacco, alcohol, dietary supplements, and energy drinks. This information is available via varying databases based on the branch of Service and can be accessed prior to an exercise if enough time and resources allow.

Emergency Action Plan

The Emergency Action Plan (EAP) is a vital component of planning for an EHI. The EAP should include clear and specific instruction on how resources will be deployed in the event of a medical emergency, including EHS. These resources are critical with regard to secondary heat stroke prevention and field care and are discussed in Section 5.

Education of Instructors/Command

One of the most important responsibilities of a military leader is education of those responsible for and at risk of EHS. This includes training on avoiding or mitigating risk factors, one of the largest of which is excessive motivation, discussed below.

Leaders, both in a command capacity and in a medical advisory role, should be aware of this risk and promote a climate change within their units to reduce such injuries. Leaders should also feel empowered to remove SMs exhibiting risk factors from high-risk activities and cancel high risk activities that propose unnecessary risk due to current adverse weather conditions. They can also create policies and culture that promotes protection of the unit's or teams' most valuable resource: the people.

The availability of healthcare resources can markedly lessen the severity of the outcome after an EHS. The morbidity and mortality of an EHS increases as the time to return to a euthermic condition increases, exceeding 50% mortality beyond 30 minutes of elevated body core temperature.[4] This demands rapid cooling as quickly as possible. The best way to accomplish rapid cooling will be dependent on the resources available in an individual setting, as detailed elsewhere in this document. Fortunately, in many military settings, such as the training environment, similar exercises are repeated regularly in similar weather and with similar resources. This presents an opportunity for commanders to supply experienced medical professionals such as physicians, physician assistants, physical therapists, nurses, field medics, and athletic trainers directly to the training environment. These resources allow for rapid assessment and diagnosis when a casualty occurs. If a frequent exercise occurs at a location that can be provided with ice-water immersion tubs, those should be deployed to facilitate rapid on-site cooling and decrease the severity of potential morbidity and mortality from an EHS. If the exercise is too austere to supply a tub, a tarp can be used to simulate a soft side tub. Other examples include rotating ice-cold towels, temperate water immersion, and air-movement modalities that rely on convection and evaporation. But no matter the environment, planning for a potential EHS and ensuring that the appropriate medical resources are available to respond is critical.

Risk Assessment

Risk Factors

This section first considers modifiable followed by non-modifiable risk factors. While numerous risk factors have been identified, there is a lack of data providing insight regarding the relative importance of each. Within the modifiable and non-modifiable risk factor sections, those that are likely of greater importance (i.e., where effective mitigation will have significant impact) are discussed first, followed by those of lesser importance. Finally, universal mitigation tools, those that can help mitigate all risk factors, are detailed.

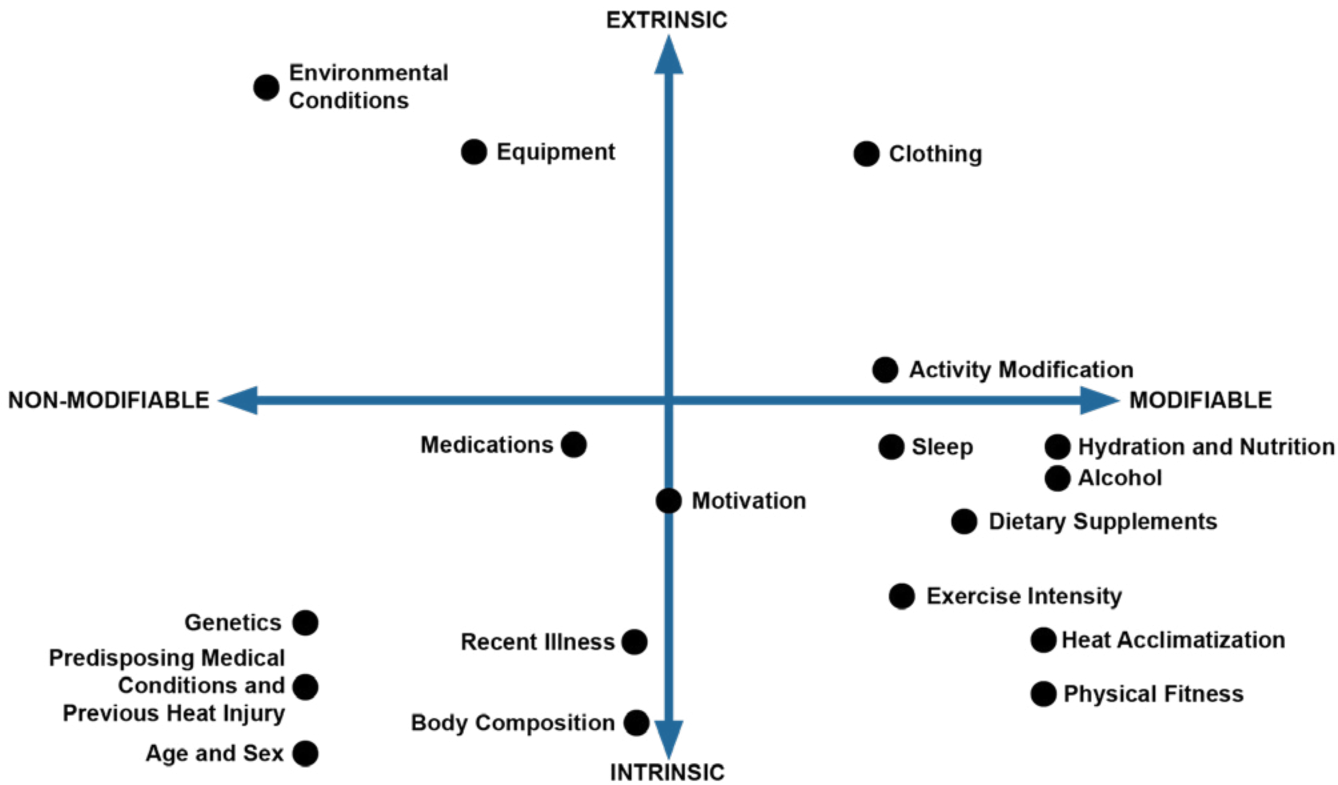


Figure A1.1. Intrinsic/Extrinsic and Modifiable/Non-Modifiable Risk Factors for Heat Injury

Modifiable Risk Factors

Motivation

Six decades ago, it was observed that "the tragedy of heatstroke is that it so frequently strikes highly motivated young individuals, under the discipline of work, military training, and sporting endeavor. Under other circumstances these individuals would have rested when tired, drank when thirsty or remained home when ill."[5] Although numerous environmental, mission-related, and individual risk factors for EHS have been identified, the acknowledged role of motivation has not been sufficiently incorporated into EHS prevention efforts. Data from American college football players shows that the risk of EHS is 2.6 times higher in competition compared to training.[6] Motivation, due to intrinsic and/or extrinsic factors, may lead to over-exertion and a sustained physical effort that exceeds an individual's work capacity.[7, 8] Recent publications highlight the association between excessive motivation and EHI. Proposed mechanisms include excessive internal and external motivation that push athletes and Warfighters to perform beyond their physiologic capacity.[9-16] Recent data from The Army Heat Center indicate that > 90% of all EHS casualties at Fort Moore, GA, occurred during foot march and run events. As these events are often timed and used as a training benchmark, motivation to excel is often very high.

Mitigation: Prior to event start, educating SMs on appropriate pacing strategies during unfavorable environmental conditions is recommended. SMs must understand that performance WILL be impaired in the heat, compared to temperate conditions, and they should not have the expectation to equal or exceed their personnel best. Administrative controls include removing best-performer incentives, using a "pacer" to control the pace, and removing SMs from the event if they are failing to maintain the required minimum pace.

Physical (Aerobic) Fitness and Work Intensity

Although strenuous exercise is an independent risk factor for EHS, it is of most concern in those with low physical (aerobic) fitness, worsening as the acute bout of exercise increasingly exceeds that to which the individual has previously been accustomed/adapted (acute = chronic workload ratio). This is illustrated in the higher risk for exertional heat illness of recruits entering the military with lower physical fitness, as has been measured previously via performance on physical fitness test runs.[17, 18]

This increased risk in unfit individuals is due to the inability of the cardiovascular system to meet the combined demands of high muscle blood flow to support exertion coupled with high skin blood flow for heat dissipation. Additionally, a high level of aerobic fitness conveys partial heat acclimatization. Overall, a well-trained person can acclimatize more quickly once exposed to heat than an untrained person.[19-22]

Work intensity is related to aerobic fitness. For tasks with fixed demands, such as a timed run or foot march, a more aerobically fit Service Member can meet the standard at a lower relative work intensity. The addition of load carriage, which may include body armor, increases the metabolic work, and therefore heat production increases.

Mitigation: Regular physical fitness training and maintenance of a high level of aerobic fitness is protective. On the day of an event, those with lower aerobic fitness should be educated on appropriate pacing strategies; ability groups may be utilized. When feasible, reducing the pace, distance, and/or load carriage requirements can each reduce the work intensity. For timed events with a pass/fail standard, a Service Member with very high aerobic fitness can be coached to reduce their pace yet still meet the standard. Just because a Service Member can run 5 miles in 35 minutes does not mean they should, when heat illness risk is high!

Acclimatization

Acclimatization is the process by which repeated exposure to heat/humidity improves physiologic function, heat tolerance, and exercise performance compared to the unacclimatized condition. These adaptations are specific to the conditions to which the SM is exposed. Adaptations may be maximized by variable intensity exercise/work in hot-humid environments sufficient to increase internal body temperature (about 60–90 minutes) on consecutive days.[23-27]

Most adaptations to acclimatization reduce physiologic strain and occur in the first 1–2 weeks of being exposed to work in heat, with longer regimens appearing to be more effective than shorter ones.[28] The characteristic adaptations due to heat acclimatization are lower resting Tc, lower peak Tc during exercise, lower heart rate, earlier onset of sweating, higher peak sweat rate, and plasma volume expansion.[29] Rapid increases in local WBGT or recent travel from a cooler location should prompt leaders to consider modifications if individuals do not have the opportunity to acclimatize to the new environment.

Heat acclimatization adaptations decay over time (at a variable rate among individuals), so re-acclimatization is necessary if the individual has not been exposed to work in heat after just days or weeks.[20, 30] Higher aerobic fitness may be associated with slower decay, and some may not require re-adaptation to heat after one month without exposure to heat.[27, 31]

Mitigation: Engage in 7–14 days of daily, low- to moderate-intensity exercise in the heat prior to any timed or maximal-effort events. Maintenance of a high level of aerobic fitness confers partial heat acclimatization and should be considered an effective adjunct measure.

Table A1.1

Table A1.1. Strategic Tips for Ensuring Appropriate Heat Acclimatization

Ensure adequate heat stress
Invoke sweating.
Use exercise and rest to modify heat strain.
Try to achieve ≥ 100 minutes of daily heat exposure.
Try to achieve between 4 and 14 days of heat exposures.
Methods
Climate-controlled rooms, hot weather, or over-dress for indoor exercise.
Start slowly.
Acclimatize in heat of day.
Train in the coolest part of the day.
Maintain aerobic fitness and integrate heat acclimatization within training.
Use work/rest cycles and build toward continuous work.
Increase heat and training volume as tolerance permits.
Other
Be especially observant of salt needs during the first week of acclimatization.
Remember that heat acclimatization increases fluid needs.
High fitness facilitates heat acclimatization.
If heat exposure is discontinued, benefits are retained for about one week and lost within one month.

Recent/Concurrent Illness

Recent or current acute infection, usually gastrointestinal or upper respiratory, is a well-recognized risk factor for EHS. Recent infection has been shown to be associated with higher rectal temperatures and heart rates during initial presentation.[32] The exact mechanism for this elevated risk is not entirely understood. Proposed mechanisms include elevated baseline core temperature that lowers the threshold of exertion needed to reach pathologic hyperthermia, and systemic activation or dysregulation of cytokines from the infection and/or the heat stress that can impair thermoregulation, and the body's previously successful adaptation to heat exposure.[33]

Mitigation: Individuals suffering from or recently recovered from an acute illness should be limited in their participation in high-risk activities, including restriction from participation in timed or maximal effort events.

Hydration

An individual's hydration status is important to sustain optimum performance and prevent injury during physical work in the heat. However, the role of hypo/dehydration in the etiology of EHS is less well understood. Dehydration was not found to be a contributing factor in 83% of military EHS cases,[34] while marked dehydration (~ 5% body mass loss) has been reported in endurance runners competing in warm/humid climates without ill effects.[35] Recent data from The Army Heat Center indicate that only 25% of EHS casualties were hypohydrated, which suggests the contribution of other risk factors, despite adequate hydration. A 3–4% body-weight loss can be tolerated by some trained endurance athletes, but in others a 2% body-weight loss due to dehydration can severely impact performance as well as mental function, mood, and energy level. Dehydration is also associated with a greater core temperature during a given workload.[36-38]

TB MED 507[29] provides strategies to optimize hydration in troops. It is important to ensure troops have had adequate hydration over the preceding 24 hours. This includes monitoring of first morning urine color, urine specific gravity, or 24-hour frequency of urination. The fluid-replacement guidelines in Table 1.4 were developed to ensure appropriate hydration while minimizing the risk of exercise-associated hyponatremia. Consumption can also be optimized by cooling water to 10–15°C (50–60°F), flavoring water, providing snack and meal opportunities, and enforcing hydration tracking.

Mitigation: Monitor urine color (Figure A1.2) and frequency of urination as indicators of hydration prior to training. Follow the fluid-replacement guidelines (Table A1.4) to ensure appropriate hydration during and after exertion. Beverages other than water should be available with meals to encourage hydration. Plain water, coffee, tea, soups, fruits, and vegetables provide fluids to support hydration. Food also provides the electrolytes necessary to replace those lost during prolonged sweating.

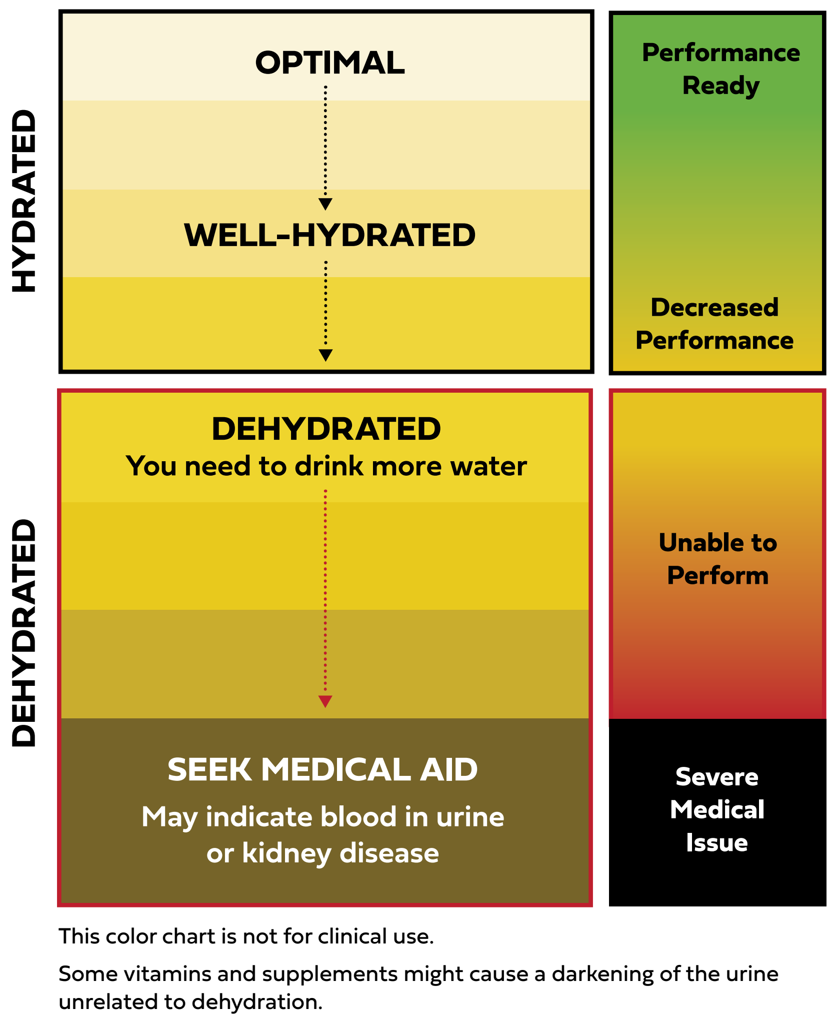


Figure A1.2. Urine Color/Hydration Chart

Source: Human Performance Resources by CHAMP

Body Composition

Military recruits with higher BMI have been noted to be at increased risk of developing exertional heat illness.[17, 18, 39] Fatal heat stroke is 3.5x more common in overweight and obese adults. Increased body mass leads to increased metabolic expenditure, thus creating excess heat. However, due to high skin blood and, therefore, convective heat transfer from the core to the skin, there is limited cause for concern that increased subcutaneous adiposity limits heat dissipation. Excess body fat increases heat production and cardiovascular strain, thus increasing risk of heat injury.[40]

Mitigation: Maintaining a healthy body composition is protective against heat illness. Sustainable, long-term changes begin with health-focused dietary and exercise habits that support overall well-being and fitness. Overweight SM should be educated on proper pacing strategies and early signs and symptoms of heat illness prior to conducting a high-risk event. Despite the risk associated with higher BMI, Service Members should not be encouraged to acutely "cut weight" prior to high-exertion events, as this could cause increased risk of exertional heat injury due to compromised conditioning, hydration, and nutrition status.

Clothing Considerations

Service-specific utility uniforms provide protection against a variety of non-heat-related hazards. The same uniforms will also limit the dissipation of metabolic heat to the environment due to insulation and limited evaporation of sweat. Chemical-biological protective overgarments greatly increase thermal strain, due to the impermeable nature of the uniform. Mitigation recommendations must be considered against other risks, such as sunburn and insect bites. In the operational environmental, most uniform modifications are not feasible due to tactical considerations.

Mitigation: When feasible, uniform modifications such as switching from a helmet to a soft cap (or no headgear at all), removing the uniform blouse, and un-blousing uniform pants/cuffing the bottom of the pants can all aid in heat dissipation.

Medications

Certain medications are another risk factor for EHS, but the association is based primarily on epidemiological studies. Proposed pathways for increased risk of EHS after medication use include increased heat production as a direct effect of the medication (amphetamines and sympathomimetic supplements); dysregulation of the thermoregulatory process (alpha adrenergic medications); impaired sweating (antihistamines and anticholinergics); shifts in electrolytes and water within the body (diuretics); changes in the circulation of blood throughout the body and to the skin (calcium channel blockers); and psychologic effects (psychotropic and neuroleptic medications).[41] Table A1.2 lists medications associated with an increased risk of EHS.

Non-steroidal anti-inflammatory drugs (NSAIDS) deserve special mention, as there are conflicting studies, some that show an association with increased risk of EHS and others that show a potential protective effect.[29] A proposed mechanism for greater risk is increased intestinal damage to intestinal mucosa resulting in increased gut permeability. It is difficult to parse the elevated risk due to concurrent illness from the elevated risk due to medications taken to treat a health condition.

Mitigation: Individuals taking over-the-counter or prescription medications that are known, or are suspected, to increase the risk of EHS should be limited in their participation in high-risk activities, including maximal-effort and timed events.

Table A1.2

Table A1.2. Medications That Can Impair Adequate Thermoregulation

Medication Class	Examples	Used To Treat	Proposed Mechanism
Antihistamines	• Diphenhydramine (Benadryl®) • Loratadine (Claritin®)	Seasonal allergies, insomnia	Impaired sweating (anticholinergic side effect)
Anticholinergics	• Meclizine (Antivert®) • Tolterodine (Detrol®) • Dicyclomine (Bentyl®)	Vertigo, bladder spasm, irritable bowel syndrome	Impaired sweating
Phenothiazines	• Thioridazine • Chlorpromazine • Promethazine (Phenergan®) • Prochlorperazine	Schizophrenia, psychotic disorders, nausea/vomiting	Disrupted hypothalamic function, impaired sweating (anticholinergic side effect)
Mood stabilizer	• Lithium	Bipolar disorder	
Anticonvulsants	• Lamotrigine (Lamictal®) • Topiramate (Topamax®) • Gabapentin (Neurontin®) • Acetazolamide	Epilepsy, migraine headache prophylaxis, altitude sickness, bipolar disorder, neuropathic pain	
Tricyclic antidepressants	• Amitriptyline (Elavil®) • Nortriptyline (Pamelor®)	Depression, neuropathic pain, migraine headache prophylaxis, postconcussion syndrome, insomnia	Increased heat production, possibly altered central thermoregulation
Beta blockers and calcium-channel blockers	• Metoprolol (Lopressor®) • Atenolol, Propranolol	Hypertension, post-MI mortality reduction, tachyarrhythmias	Impaired compensatory increase in cardiac output
Diuretics	• Hydrochlorothiazide (HCTZ) • Furosemide (Lasix®)	Hypertension, heart failure	Dehydration and depletion of electrolytes (e.g., sodium, potassium)
Decongestants	• Pseudoephedrine (Sudafed®) • Ephedrine	Common cold, cough, nasal congestion	Increased heart rate and blood pressure
Stimulants	• Caffeine • Ephedra • Pre-workout stimulants • Methylphenidate (Ritalin®) • Cocaine • Ecstasy • Methamphetamine	Performance enhancement, ADHD, narcolepsy, eating disorders	Increased heart rate and blood pressure, increased activity, impaired sweating
Alcohol	Beer, wine, liquor	Socially or as anxiolytic	Diuresis, impaired vasomotor reflexes
Antidiarrheal	Loperamide (Lomotil®)	Diarrhea, gastroenteritis	Impaired sweating

Nutrition

Nutrition strategies for performance sustainment in the heat is beyond the scope of this document. There are limited data on the role of nutrition in heat-illness prevention. There are pathophysiological features of EHS that may be impacted by nutrition, such as intestinal permeability and microbial translocation, cellular thermotolerance, systemic inflammation and/or immune activation, and central drive.[42] However, there are no data available to translate these as-yet hypothetical effects into mitigation practices.

Prolonged energy deficit is not known to have a direct influence on the risk of EHS.[42, 43] However, energy deficit may indirectly predispose to EHS through negative effects on immune function and, therefore, susceptibility to viral illness or infection. Commonly thought of as an extension of hydration, proper electrolyte intake during exertion can be accomplished solely with adequate nutrition and is known to protect against exertional hyponatremia and may also help mitigate hyperthermia, provide cardiovascular stability, or support organ and tissue perfusion.[44, 45]

Mitigation: appropriate fueling before, during, and after high-intensity training in the heat will support performance sustainment. However, short term (< 1 day) energy deficit is not known to increase EHS risk.

Sleep

Sleep deprivation has been shown to result in higher body core temperature during fixed-intensity exercise in the heat.[46] This may be due to decreased skin blood flow and sweat rate and/or changes in hormonal temperature regulation via cortisol or growth hormone.[19] However, sleep deprivation also results in lower self-selected exercise intensity. The lower metabolic heat production associated with lower exercise intensity likely offsets the impaired thermoregulatory function.

Mitigation: Adequate sleep will support performance sustainment in the heat, but there is no evidence to support short-term (1–2 nights) sleep deprivation as a risk factor for heat illness.

Dietary Supplements

The primary concern with dietary supplements regarding EHI risk is that many contain stimulants. Stimulants have been shown to increase risk for EHI, and this likely occurs via multiple mechanisms.[29] Importantly, stimulants increase the metabolic rate and thereby increase heat production both at rest and with exercise. Furthermore, high doses of stimulants can reduce the body's perception of fatigue, leading the individual to push beyond their body's "warning light" signals to stop exercise.

Supplements of all varieties are concerning from a medical perspective, as well as difficult to study, both due to the lack of reliability regarding what is and what is not included in any individual supplement. Differences between ingredients listed on a supplement's label compared to what is measured in third-party laboratories is a known concern.[47]

Mitigation: Best practice is to avoid dietary supplements altogether. However, if dietary supplements are taken, avoid supplements that do not contain a seal from a third-party clearing house, and avoid supplements that contain proprietary blends and stimulants. Consider consultation with Operation Supplement Safety (OPSS.org).

Caffeine

Caffeine has been heavily studied both as an ergogenic aid to athletes and as a risk factor for EHI. Current research suggests that a small amount of caffeine in tea or coffee (< 200 mg) should not negatively affect hydration status. However, Warfighters frequently drink more caffeine and often do so via energy drinks with additional ingredients that may not be as safe. Additionally, more than 200 mg of caffeine can negatively affect fluid balance and thermoregulatory response in some individuals, which increases the risk of EHI.

Mitigation: Limit caffeine intake to beverages containing < 200 mg, or multiple beverages with lower caffeine levels, in the 12 hours preceding strenuous work in the heat.

Alcohol

Recent alcohol intake may increase the risk of EHI via its diuretic effect on fluid balance. Impaired judgement and decision-making while under the influence may limit SM ability to recognize signs and symptoms of heat illness in themselves.

Mitigation: Alcohol should be avoided within 24 hours of high-risk exercises.

Non-Modifiable Risk Factors

Environmental Conditions

High ambient (dry bulb) temperature, humidity, and solar radiation, as well as a lack of wind, are well-established risk factors for EHI. While these are not modifiable per se, military leaders may have control over the time of day during which a high-risk training event occurs. Additionally, monitoring the weather forecast several days in advance can help inform the application of other heat illness prevention and/or mitigation measures.

Army TB MED 507[29] recommends hourly monitoring of the wet-bulb globe temperature index (WBGT) once ambient temperature reaches 24°C (75°F). WBGT is the weighted average of dry-bulb, wet-bulb, and black-globe temperatures. WBGT should be monitored at the training location, as variability across a given installation may reach 2 heat categories.[48] The use of other environmental indices, including the Heat Index and the Humidex, is not recommended.

Mitigation: High-risk (i.e., timed or maximal-effort) events during warm weather should be scheduled for the coolest part of the day, typically the 3–4 hours before sunrise. When that is impractical, the work/rest table in TB MED 507 (Table A1.4) provide guidance for limiting the risk in body core temperature, accounting for the heat category and intensity of the event.[48]

Sex

Whereas some reviews note males to be at increased risk of EHI,[49] physiologically, females exhibit a lower rate of evaporative heat loss and a higher sweat threshold during exercise in heat, which may predispose them to heat illness through difficulty dissipating heat.[50] Additionally, some retrospective epidemiological reports indicate that men are at increased risk.[51] However, this finding is not consistent.[52] Relative risk of heat stroke attributable to sex is thus likely polyfactorial and related to other risk factors that may be more common in males than females (i.e., higher BMI, profession and sport choices, and cultural pressures of physical work tolerance and expectations, among many others). In support of this hypothesis, recent data indicate that EHS risk is similar for men and women, when matched for BMI.[53]

Age

The active-duty population of the U.S. Armed Forces is predominantly young, with only ~ 8% of the Force over 40 years of age. Additionally, the mandatory retirement age for active-duty military is 62 years of age. In contrast, most studies of thermoregulation and aging, demonstrating age-associated deficits in thermoregulatory function, compare young (18–30 years old) to older (> 65 years old) individuals.[54] Whereas these studies are valuable for understanding normal human aging, they have little relevance to the active-duty population.

Epidemiologic data show the highest incidence of EHI in young individuals (ages 18–29), with incident rates progressively decreasing over age 30.[1] This trend likely reflects occupational exposure rather than any difference in physiology. Furthermore, research has shown that maintaining a high level of aerobic fitness is protective against age-associated decrements in thermoregulatory function.[55]

Medical Conditions

Many medical conditions, as shown in Table A1.3, are associated with an increased risk of EHI. These include conditions that: (1) affect heat transfer from the skin to the environment (hypohydrosis, extensive scarring, and sunburn that impairs sweating[22, 56]); (2) impair circulation necessary to transfer heat from the core to the skin (congestive heart failure or coronary heart disease); (3) affect thermoregulation (fever, hyperthyroidism, pheochromocytoma, etc.); (4) affect hydration status (infectious disease, diabetes mellitus, etc.); and (5) affect behavioral adaptations (psychiatric illness).[57]

Table A1.3

*Table A1.3. Examples of Medical Conditions Associated with EHI**

Type of Condition	Examples
Disorders of skin and sweating	Sunburn, large burn scars, psoriasis, miliaria rubra, cystic fibrosis, ectodermal dysplasia, chronic anhidrosis, therapeutic X-ray radiation, Type 1 diabetes mellitus
Metabolic / thermoregulatory disorders	Insomnia (sleep deprivation), febrile conditions (common cold, streptococcal pharyngitis, mononucleosis, etc.), hyperthyroidism
Cardiovascular disorders	Heart failure, cardiomyopathy, myocarditis, hypertension (especially due to medications used to treat hypertension)
Functional factors	Low physical fitness, lack of acclimatization, fatigue
Multifactorial	Obesity, dehydration, advanced age, previous heat stroke (depends on what factors contributed to previous episode)
Unknown mechanism	Sickle cell trait (conflicting data)

* **Note:** numerous conditions in this table are disqualifying for military service, but they are included here for completeness.

Genetics

Numerous studies have examined the expression of genes in response to heat stress. When exposed to heat stress, heat shock transcription factors (HSF, most notably HSF1 and HSF2) rapidly induce numerous genes to express proteins essential for maintaining body core temperature and homeostasis; this is known as the heat stress response (HSR).[58-66] How genomic variations alter this HSR, and the implications for EHS prevention, are unknown.

Multi-Hit Hypothesis (1–3 days)

The heat stress metric for the day when the EHI occurs is important but may not be the only factor to consider. Many EHI occur in the morning when temperatures are below 21°C (70°F).[17, 18, 67] Data suggest that exposure to a warm environment on the day preceding training can increase the risk of EHI.[67] Specifically, the combined effect of the WBGT on training day and previous day is more important in predicting EHI risk than the training-day WBGT alone. Although not carefully studied, it is likely that cumulative heat loads over a period of several days likely increase the risk of EHI. Stated otherwise, exposure to a WBGT of 26.7+°C (80+°F) on the day preceding training can predispose to EHI, which suggests a lasting effect of heat exposure.[17]

Previous Heat Illness

The evidence supporting prior heat illness as a risk factor for future heat illness is generally inconclusive.[68] A minority of EHS casualties may be heat intolerant, and heat tolerance testing using established protocols may be warranted in the return-to-duty decision-making process.

Mitigation: For most EHS casualties who have a normal recovery and return to duty, no additional precautions are warranted.

Universal Mitigation Strategies

The strategies in this section are applicable to all SMs and can help mitigate each of the previously identified risk factors.

Work/Rest Cycles

The concept of work/rest cycles has been considered for many years in the military and by occupational safety specialists to mitigate heat stress and strain.[69] Guidelines for recovery from the stresses of physical work in the heat, including work/rest cycles and sleep, must be incorporated into the heat illness risk-mitigation plan.

Specific instructions exist for the appropriate duration of work relative to the requisite rest period; they are typically determined based on temperature, humidity, and clothing/PPE. In general, the instructions are to shorten/adjust work periods and increase rest periods in accordance with guidelines. Importantly, new and unacclimatized athletes and/or workers should be assigned to lighter work with longer rest periods and close monitoring until they are fully acclimatized.[70-72] Table A1.4 presents the current hydration/fluid replacement and work/rest cycle recommendations used throughout the military.

Table A1.4. Fluid-Replacement and Work/Rest Cycle Guidelines for Training in Warm and Hot Environments[29]

		Easy Work (250 W)		Moderate Work (425 W)		Heavy Work (600 W)		Very Heavy Work (800 W)	
Heat Category	WBGT Index (°F)	Work/Rest	Water Intake (qt/hr)	Work/Rest	Water Intake (qt/hr)	Work/Rest	Water Intake (qt/hr)	Work/Rest	Water Intake (qt/hr)
1	**78–81.9**	**NL***	**½**	**NL**	**¾**	**50/10**	**¾**	**25/35**	**1**
2 (Green)	**82–84.9**	**NL**	**½**	**NL**	**¾**	**40/20**	**1**	**20/40**	**1**
3 (Yellow)	**85–87.9**	**NL**	**¾**	**NL**	**¾**	**35/25**	**1**	**20/40**	**1**
4 (Red)	**88–89.9**	**NL**	**¾**	**50/10**	**¾**	**25/35**	**1**	**15/45**	**1**
5 (Black)	**> 90**	**NL**	**1**	**35/25**	**1**	**20/40**	**1**	**10/50**	**1**

*NL = No limit to work time per hour (up to 4 hr). Rest = Minimal activity and in shade, if possible.
Hourly fluid intake should not exceed 1.5 qt, and daily fluid intake should not exceed 12 qt.

Easy Work 250 W ~ 3.5 kcal/min	**Moderate Work** 425 W ~ 6 kcal/min	**Heavy Work** 600W ~ 8.4 kcal/min	**Very Heavy Work** 800 W ~ 11.2 kcal/min
Maintaining weapon; drills and ceremonies; walking a dog; yoga; raking; washing clothes; golfing	Patrolling with 25 lb. load; stair climbers; rowing 5 km/hr; cutting wood; biking 15 km/hr; hiking; low and high crawl; tennis	Walking and climbing briskly up hills; patrolling with 45 lb. load; 4-person litter carry; jogging 9 km/hr; cycling 25 km/hr; cross-country skiing 7 km/hr	Obstacle course; 2-person litter carry (150 lb.); basketball game; jogging 11 km/hr; judo; skipping rope 100 steps/min; swimming 3.5 km/hr

Active Cooling

In hot and humid conditions, both dry heat and evaporative heat transfer mechanisms are limited. Therefore, active cooling measures can be implemented to support heat dissipation. During rest periods, heat loss can be improved through reducing clothing, seeking shade, and taking advantage of a variety of body-cooling methods. These methods include Arm Immersion Cooling Systems (AICS),[73] fans, misters, ice, access to air conditioning, and field showers.[29] During training, units should strive to have a variety of body-cooling options available for troops, to the extent practical. While in-garrison, recovering nightly in an air-conditioned or adequately cooled sleeping environment can be helpful.

An effective method of body cooling for prevention of EHI is arm immersion (AICS). Compared to passive recovery, hand and forearm immersion has been shown to decrease core temperature, increase time spent working, and increase total work performed during a subsequent work bout.[74, 75] Extremity immersion is effective because the heat transfer coefficient of water is greater than air, the extremities have a large surface area to mass ratio, and blood flow within the cutaneous vasculature is elevated when the core temperature is elevated.[73] The AICS technique has been demonstrated to lower body temperature and reduce the risk of EHI.[73] But the patient should remain asymptomatic; further lab testing during return-to-activity stages should be performed only as clinically indicated. AICS is available commercially, and numerous organizations have successfully implemented alternative solutions, such as a 50-gallon drum cut in half lengthwise. Regardless of the size factor of the water trough, the principle of use is the same.[76]

Table A1.5. Required Cooling Time Based on Water Temperature
(adapted from TRADOC 350-29, 2023177)

Temperature (degrees C)	Temperature (degrees F)	Cooling time (minutes)
> 27°C	> 80°F	Replace water
22–27°C	71–80°F	12–15 minutes
13–21°C	55–70°F	8–12 minutes
7–12°C	45–54°F	5–8 minutes
2–7°C	35–44°F	3–5 minutes

Buddy System

A key heat-mitigation measure is the buddy system, specifically the assignment of low-risk personnel to high-risk personnel.[76] Buddy checks should be performed frequently to assess both the hydration status and well-being of troops. Troops should be educated on the importance of monitoring their buddies both during annual heat training and as a reminder prior to any training or operation where heat is a concern.[29] It is important to note that use of the buddy system alone is not sufficient, and this must be augmented by checks and supervision from unit leadership to ensure effective compliance.

Non-invasive Physiological Monitoring

Many cooling technologies have recently been introduced to the market. These include a wide range of devices, ranging from wearable cooling devices to monitoring devices. As these products are rapidly entering the market, it is likely that many of these are made publicly available before their effectiveness has been scientifically proven and before any validity or reliability testing is made available.[77] This does cause concern that these products could produce either a false sense of security in the face of potential exertional heat illness or a false sense of danger.[78] The increased research on physiological monitoring systems can be used to provide physiological feedback, which would allow for both risk reduction and performance enhancement through use of complex sensors and algorithms. These tools have the potential to help mitigate the risk of exertional heat illness and provide leaders with enhanced monitoring, but the specific application and safeguards have not yet been developed. Because this is relatively new technology, the potential for its use in military environments is not yet well defined.[79]

Educational Resources

For educational resources and toolkit, visit the Warrior Heat- and Exertion-Related Events Collaborative online (on the Human Performance Resources by CHAMP website).

DELIBERATE RISK ASSESSMENT WORKSHEET

1. MISSION/TASK DESCRIPTION AND EXECUTION DATE(S)	2. DATE PREPARED

3. PREPARED BY

a. NAME *(Last, First, Middle Initial)*	b. RANK/GRADE	c. DUTY TITLE/POSITION

d. UNIT	e. WORK EMAIL	f. TELEPHONE *(DSN, Commercial (Include Area Code))*

g. UIC/CIN *(as required)*	h. TRAINING SUPPORT/LESSON PLAN OR OPORD *(as required)*	i. SIGNATURE OF PREPARER

Five steps of Risk Management: (1) Identify the hazards (2) Assess the hazards (3) Develop controls & makes decisions (4) Implement controls (5) Supervise and evaluate *(Step numbers not equal to numbered items on form)*

	4. SUBTASK/SUBSTEP OF MISSION/TASK	5. HAZARD	6. INITIAL RISK LEVEL	7. CONTROL	8. HOW TO IMPLEMENT/ WHO WILL IMPLEMENT	9. RESIDUAL RISK LEVEL
+ -					How: Who:	

10. OVERALL RESIDUAL RISK LEVEL *(All controls implemented):*

☐ EXTREMELY HIGH ☐ HIGH ☐ MEDIUM ☐ LOW

11. OVERALL SUPERVISION PLAN AND RECOMMENDED COURSE OF ACTION

12. APPROVAL OR DISAPPROVAL OF MISSION OR TASK ☐ APPROVE ☐ DISAPPROVE

a. NAME *(Last, First, Middle Initial)*	b. RANK/GRADE	c. DUTY TITLE/POSITION	d. SIGNATURE OF APPROVAL AUTHORITY

e. ADDITIONAL GUIDANCE:

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Figure A2.1. Deliberate Risk Assessment Worksheet DD 2977

RISK ASSESSMENT MATRIX		Probability *(Expected frequency)*				
		Frequent: Continuous, regular, or inevitable occurrences	**Likely:** Several or numerous occurrences	**Occasional:** Sporadic or intermittent occurrences	**Seldom:** Infrequent occurrences	**Unlikely:** Possible occurrences but improbable
Severity *(expected consequence)*		A	B	C	D	E
Catastrophic: *Mission failure, unit readiness eliminated; death, unacceptable loss or damage*	I	EH	EH	H	H	M
Critical: *Significantly degraded unit readiness or mission capability; severe injury, illness, loss or damage*	II	EH	H	H	M	L
Moderate: *Somewhat degraded unit readiness or mission capability; minor injury, illness, loss, or damage*	III	H	M	M	L	L
Negligible: *Little or no impact to unit readiness or mission capability; minimal injury, loss, or damage*	IV	M	L	L	L	L

LEGEND: EH - Extremely High Risk H - High Risk M - Medium Risk L - Low Risk

13. RISK ASSESSMENT REVIEW *(Required when assessment applies to ongoing operations or activities)*

a. DATE	b. LAST NAME	c. RANK/GRADE	d. DUTY TITLE/POSITION	e. SIGNATURE OF REVIEWER

14. FEEDBACK AND LESSONS LEARNED

15. ADDITIONAL COMMENTS OR REMARKS

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Instructions for Completing DD Form 2977, "Deliberate Risk Assessment Worksheet"

1. Mission/Task Description and Execution Date(s): Briefly describe the overall Mission or Task and execution date(s) for which the deliberate risk assessment is being conducted.

2. Date Prepared: Enter date form was prepared.

3. Prepared By: Information provided by the individual conducting the deliberate risk assessment for the operation or training.
Legend: UIC = Unit Identification Code; **CIN** = Course ID Number; **OPORD** = operation order; **DSN** = defense switched network; **COMM** = commercial

4. Subtask/SubStep of Mission/Task: Briefly describe all subtasks or substeps that warrant risk management.

5. Hazard: Specify hazards related to the subtask in block 4.

6. Initial Risk Level: Determine initial risk level. Using the risk assessment matrix (preceding block 13), determine level of risk for each hazard specified. Use probability and severity to determine risk level; enter risk level into column.

7. Control: Enter risk mitigation resources/controls identified to abate or reduce risk relevant to the hazard identified in block 5.

8. How to Implement / Who Will Implement: Briefly describe the means of employment for each control (i.e., OPORD, briefing, rehearsal) and the name of the individual, unit or office that has primary responsibility for control implementation.

9. Residual Risk Level: After controls are implemented, determine resulting probability, severity, and residual risk level.

10. Overall Risk After Controls are Implemented: Assign an overall residual risk level. This is equal to or greater than the highest residual risk level (from block 9).

11. Supervision Plan and Recommended Course of Action: Completed by preparer. Identify specific tasks and levels of responsibility for supervisory personnel and provide the decision authority with a recommend course of action for approval or disapproval based upon the overall risk assessment.

12. Approval/Disapproval of Mission/Task: Risk approval authority approves or disapproves the mission or task based on the overall risk assessment, including controls, residual risk level, and supervision plan.

13. Risk Assessment Review: Should be conducted on a regular basis. Reviewers should have sufficient oversight of the mission or activity and controls to provide valid input on changes or adjustments needed. If the residual risk rises above the level already approved, operations should cease until the appropriate approval authority is contacted and approves continued operations.

14. Feedback and Lessons Learned: Provide specific input on the effectiveness of risk controls and their contribution to mission success or failure. Include recommendations for new or revised controls, practicable solutions, or alternate actions. Submit and brief valid lessons learned as necessary to persons affected.

15. Additional Comments or Remarks: Preparer or approval authority provides any additional comments, remarks, or information to support the integration of risk management.

Additional Guidance: Blocks 4-9 may be reproduced as necessary for processing of all subtasks/substeps of the mission/task. The addition and subtraction buttons are designed to enable users to accomplish this task.

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Example Heat Illness Risk Management Matrix				
Risk Factors	**Risk Level**			
	0 points/circle Low Risk	**1 point/circle Medium Risk**	**2 points/circle High Risk**	**3 points/circle Extreme Risk**
Risk Management Worksheet	All controls implemented			Not all controls implemented
WBGT Add 5ºF backpack or body armor	< Cat 1	Cat 1	Cat 2–3	Cat 4–5
Back-to-back Cat 5 days	0	1	2–3	> 4
Heat illnesses in past 2 days	0	Heat cramps (EAMC)	Heat exhaustion	Heat stroke/ death
Workload in past 2 days (see TR 350-29 workload classification chart)	Easy	Easy or moderate	Moderate or hard	Hard
Projected workload	Easy	Easy or moderate	Moderate or hard	Hard
Heat acclimatization days	> 13	7–13	3–6	< 3
Leader/NCO presence	Full time	Substantial	Minimal	None
Cadre duty experience (tested at training site)	18 months	7–18 months	1–6 months	< 1 month
Communication system (tested at training site)	Radio and landline phones	Landline phone only	Radio only	None
Previous 24 hours sleep	> 7 hours	5–7 hours	2–4 hours	< 2 hours
Food/salty snacks every 4 hours	< 4 hours	4–6 hours	6–7 hours	> 7 hours
On-site 91W/CLS and ice sheets (min. 8 single bedsheets/ company in cooler)	Both ice sheets & Medic, EMT, or CLS	Only ice sheets	Medic, EMT, or CLS	None
Add Circled Blocks with points/circle				
Total score: 0–7 = Low Risk; 7–15 = Medium Risk; 16–24 = High Risk; 25–39 = Extreme Risk > 11 total score should have on-site Medic, EMT, or CLS and organic evacuation transportation				

Figure A2.2. Deliberate Heat Illness Risk Assessment Example

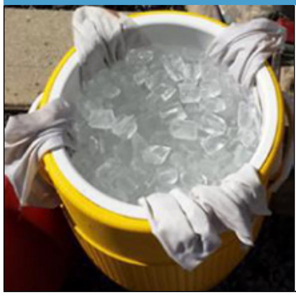
Appendix 3: External Cooling Techniques

Table A3.1. Cold Water Immersion (CWI) Setup and Procedure[80, 81]

1. Prepare for cold water immersion	• On the field or in a temporary medical tent, half fill the tub or wading pool with water and ice. ◦ (Before an emergency, check the water source to see how quickly it fills the immersion tub.) • The stock tank (100–150-gallon capacity) can be filled with ice and cold water before an event (or have the tub half filled with water and 3–4 coolers of ice next to tub; this prevents having to keep the tub cold through day). • Ice should always cover the surface of the water.
2. Just before immersing EHS patient, take vital signs.	• Assess core body temperature with a rectal thermistor. • Check airway, breathing, pulse, and blood pressure. • Assess the level of central nervous system dysfunction.
3. Immerse body to neck or half body.	• Circulate or stir the water to increase heat transfer. • Add ice during cooling, and support head above water level. • Continuous supervision.
4. Total body coverage.	• Cover as much of the body as possible with ice water while cooling. ◦ If full body coverage is not possible due to the container, cover the torso as much as possible. • To keep the Service Member's head and neck above water, an assistant may hold the casualty under the axillae with a towel or sheet wrapped across the chest and under the arms.
5. Circulate water.	• During cooling, water should be continuously circulated to increase the water-to-skin temperature gradient. ◦ Have an assistant swirl the water during cooling.
6. Continue medical assessment.	• Vital signs should be monitored every 2–5 minutes.
7. Fluid administration.	• If a qualified medical professional is available, an IV fluid line can be placed for hydration and support of cardiovascular function.
8. Cooling duration.	• Continue cooling until the patient's rectal temperature lowers to 39–39.2°C (102.0–102.5°F).* • Remove the patient from the immersion tub only after rectal temperature reaches 39°C (102°F). ◦ Using a bed sheet around the patient's chest can aid in transfer. • *If rectal temperature cannot be measured and cold water immersion is indicated, cool for 10–15 minutes, and then transport to a medical facility.

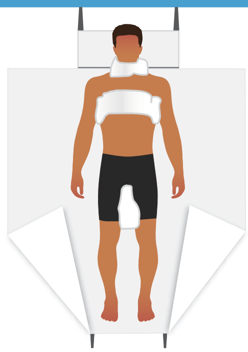
Table A3.2. Ice-Sheet Setup and Procedure

Step 1: Preparation



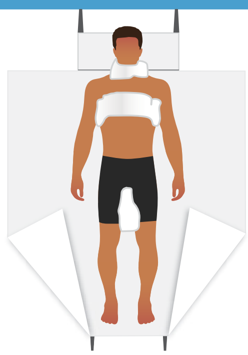
- Fill ice chest with 1/3 cool water and 2/3 ice
- Place ordinary bed sheets in ice water (5 per anticipated heat casualty)
- Pre-soak sheets or immerse while Service Member's clothing is being removed

Step 2: Application



- Lay first sheet down on litter or stretcher
- Place casualty on top of first sheet
- Place wadded or rolled ice sheets in the casualty's groin and armpits and around neck
- Place an additional ice sheet over the top of the torso and/or legs

Step 3: Re-application



- *"When in doubt, change it out"*
    - Failure to exchange ice sheets/towels results in trapping heat and will worsen the injury.
    - Re-wet or replace ice sheets/towels when the material begins to feel warm; could be as soon as 30 seconds, but no longer than every 3 minutes.

Note: When possible, cool in shade/under cover and use fanning to complement ice-sheet body cooling; overcooling with ice sheets is very unlikely. Do not disrupt cooling with ice sheets until reaching definitive care.

SECTION 12: REFERENCES

SECTION 3 REFERENCES

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