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Roundtable on Preseason Heat Safety in Secondary School Athletics: Prehospital Care of Patients With Exertional Heat Stroke

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Objective: First, we will update recommendations for the prehospital management and care of patients with exertional heat stroke (EHS) in the secondary school setting. Second, we provide action items to aid clinicians in developing best-practice documents and policies for EHS. Third, we supply practical strategies clinicians can use to implement best practice for EHS in the secondary school setting.

Data Sources: An interdisciplinary working group of scientists, physicians, and athletic trainers evaluated the current literature regarding the prehospital care of EHS patients in secondary schools and developed this narrative review. When published research was nonexistent, expert opinion and experience guided the development of recommendations for implementing life-saving strategies. The group evaluated and further refined the action-oriented recommendations using the Delphi method.

Conclusions: Exertional heat stroke continues to be a leading cause of sudden death in young athletes and the physically active. This may be partly due to the numerous barriers and misconceptions about the best practice for diagnosing and treating patients with EHS. Exertional heat stroke is survivable if it is recognized early and appropriate measures are taken before patients are transported to hospitals for advanced medical care. Specifically, best practice for EHS evaluation and treatment includes early recognition of athletes with potential EHS, a rectal temperature measurement to confirm EHS, and cold-water immersion before transport to a hospital. With planning, communication, and persistence, clinicians can adopt these best-practice recommendations to aid in the recognition and treatment of patients with EHS in the secondary school setting.

Key Words: best practice, cold-water immersion, hyperthermia, rectal temperature, high school

Exertional heat stroke (EHS) is a life-threatening injury recognized by elevations in body core temperature (>40.5°C [105°F]) and central nervous system (CNS) dysfunction (eg, seizures, disorientation). The morbidity and mortality of an EHS event is directly related to the length of time the body core temperature exceeds 40.5°C (105°F). Accordingly, the cornerstone of initial EHS management is to lower rectal temperature (T_{REC}) to <38.9°C (<102°F) as soon as possible and preferably within 30 minutes of collapse.[1] Importantly, adoption and implementation of EHS-prevention strategies, such as heat acclimatization and modifying work-to-rest ratios based on wet bulb globe temperature, have shown promise for lowering the incidence of heat-related injuries.[2–4]

The cause of EHS and best practices for diagnosing and treating EHS have been known for decades,[1,5,6] with prehospital standards of care updated as recently as 2018.[7] The standard of care for patients with EHS remains rapid recognition of CNS dysfunction, a T_{REC} > 40.5°C (105°F), and whole-body cold-water immersion (CWI) before transport to advanced medical care.[1] Despite improvements in medicine and our knowledge about EHS, it remains 1 of the 3 leading causes of death in young athletes.[8,9]

Of utmost importance to the survivability of patients with EHS is the care they receive before being transported to the hospital. Unfortunately, barriers to the implementation of EHS best-practice recommendations, specifically the use of T_{REC} and "cool first, transport second," continue in the secondary school setting.[10–12] For this reason, a team of scientists, physicians, and clinically practicing athletic trainers (ATs) convened in June 2019 in Orlando, Florida, to discuss preseason heat safety in secondary school athletics. This meeting was sponsored by the National Athletic Trainers' Association, Korey Stringer Institute, and American College of Sports Medicine.

In total, 33 participants were involved in the roundtable meeting. Participants were purposefully selected to provide a multidisciplinary representation of individuals who (1) had expertise in the proper management and care of patients with exertional heat illness; (2) were clinicians actively providing clinical care to secondary school student-athletes; and (3) had expertise in the realms of biometeorology, thermal physiology, and epidemiology. Attendees were clinically practicing secondary school ATs (n = 7); sports medicine physicians (n = 5); an emergency room physician (n = 1); or scientists with expertise in the management and care of EHS (n = 12), biometeorology (n = 2), thermal physiology (n = 5), and epidemiology (n = 1).

A working group of 13 participants (4 clinically practicing secondary school athletic trainers, 3 sports medicine physicians, 1 emergency room physician, and 5 scientists with expertise in the management and care of patients with EHS) drafted this document regarding the prehospital care of EHS in secondary school settings. This document aims to accomplish 3 purposes: (1) address several misconceptions about the prehospital care of EHS in secondary school patients, (2) discuss the evidence for best-practice recommendations for EHS diagnosis and treatment, and (3) provide actionable, practical implementation strategies to assist secondary school clinicians in implementing best-practice recommendations for EHS in their clinical practice.

METHODS

To provide an unbiased aggregation of expert opinion among stakeholders, we used the Delphi method,[13] which consisted of a 2-phase process (ie, exploration and evaluation) to arrive at a consensus on the action-oriented recommendations and implementation strategies developed by the working group. The exploration and evaluation phases are described in the following paragraphs.

For the exploration phase, the working group conducted a narrative literature review on the prehospital care of patients with EHS with key topics pertaining to (1) the recognition and diagnosis of EHS and (2) the proper treatment of EHS. From this review, the working group identified 18 specific misconceptions related to the diagnosis and treatment of EHS, which were then used to develop the action-oriented recommendations.

During the evaluation phase, the working group drafted action-oriented items (Table 1) and implementation strategies (Table 2) pertaining to the 18 misconceptions. After the recommendations were reviewed by the working group, they were compiled into an anonymous survey (Qualtrics) and sent to roundtable meeting participants for appraisal and scoring. Roundtable members scored each recommendation based on validity, feasibility, and clarity (Table 3) and were given an opportunity to provide written commentary to supplement their numeric score.

Scoring of each recommendation was based on a 9-point rating scale; higher scores indicated the item was more valid, feasible, or clear. Scores were averaged for each of the 3 dimensions. Items that received scores $\geq$7 on all dimensions were retained in the final document, whereas items that scored $\leq$3 on any dimension were discarded. Items scoring between 4 and 7 were revised by the working group. After modification, all items were reevaluated by all participants via a second anonymous survey using the same scoring criteria. Reanalysis revealed that all items met our inclusion criteria (ie, $\geq$7) for this manuscript.

RECTAL TEMPERATURE MISCONCEPTIONS

Misconception #1

Rectal temperature is just 1 of many valid body core temperature options clinicians can use to diagnose and monitor patients with EHS.

Facts and Evidence. Accurate measures of body core temperature are essential in the diagnosis and care of patients with EHS.[1,7,14] Temperatures measured at numerous surface body sites, including temporal, tympanic, aural, oral, skin, and axillary temperatures, dangerously underestimate body core temperature in exercising individuals by >3°F to >5°F.[15,16] In fact, recent data[17] on 25 patients with EHS indicated that tympanic temperature was 4.5° ± 1.7°F lower (101.8°F versus 106.3°F) than T_{REC}. Moreover, because these sites do not consistently underpredict body core temperature, correction values cannot be reliably used to estimate true body core temperature.

Esophageal, rectal, and ingestible temperature assessment are valid measures of body core temperature.[18,19] However, esophageal temperature, while accurate, is not practical in the field because it is difficult to obtain and patients with EHS may have altered consciousness, vomit, be combative, or experience convulsions. Similarly, ingestible thermistors can be expensive, require ingestion of the pills 6 to 8 hours before the start of exercise, and may pass through the patient's digestive tract during activity.[20] In contrast, T_{REC} is easy to perform, safe, valid, minimally invasive, and within the scope of practice of ATs and other medical professionals. For these reasons and those listed earlier, T_{REC} remains the only accurate, viable, and cost-effective method for the assessment of EHS in the field.[21]

Misconception #2

Measurement of T_{REC} is not allowed in clinical settings because it is an invasive procedure and an unnecessary violation of a patient's privacy.

Facts and Evidence. Many ATs do not follow best-practice recommendations for the diagnosis of EHS via T_{REC}.[11,12,22,23] The most commonly cited barriers, particularly in the secondary school setting, are fear of liability (especially when the patient is a minor), lack of training or education, and a belief that obtaining T_{REC} is an unnecessary, invasive procedure that violates the patient's privacy.[24] To be clear, T_{REC} is a minimally invasive

Table 1. Action Item Checklist for Best Practice Regarding Prehospital Care of Patients With Exertional Heatstroke in Secondary School Settings

Action Item	Completed?
Rectal temperature	
(1) Discuss T_{REC} with supervising physician and EMS medical directors.	
(2) Incorporate T_{REC} into both sports medicine and EMS standing orders and EHS policies and procedures.	
(3) In the policies and procedures document, explicitly state the following:	
(a) Vital signs followed by T_{REC} assessment and CNS assessment will be used to diagnose EHS.	
(b) EMS will be called immediately after an EHS diagnosis.	
(c) The T_{REC} should be assessed before initiating CWI.	
(d) The T_{REC} should be monitored during CWI, and patients with confirmed EHS will not be removed from CWI until their T_{REC} is 38.9°C (102°F).	
(4) Ensure that all athletic trainers on staff are knowledgeable regarding how to obtain a T_{REC}.	
(5) Purchase rectal thermometer(s), thermistor(s), and sterilants (if using reusable thermistors).	
(6) Ensure that rectal thermometer(s) is (are) available and in proper working order (ie, calibration assessed annually and recalibrated as necessary).	
(7) Prepare documentation or a presentation on exertional heat illnesses that includes the role and importance of T_{REC} in EHS emergencies to educate parents or caregivers, administrators, and athletic department personnel.	
Cold-water immersion	
(8) Have at least 1 type of CWI equipment (eg, tub, trough, pool, tarp) that can hold large volumes of water to accommodate patients of different sizes, with different equipment considerations, and in different locations.	
(9) Ensure that CWI equipment is available, ready (ie, filled with cold water), and in proper working order when the potential for EHS exists.	
(10) In the EHS policies and procedures, explicitly state the following:	
(a) Which CWI equipment will be used in each location, taking into account topography, availability, and access to ice and water.	
(b) Cooling will occur onsite before transporting the patient to the hospital (ie, cool first, transport second).	
(c) Stop CWI only when T_{REC} <38.9°C (102°F). No other signs or symptoms or standardized treatment times will be used as a basis to cease treatment.	
(d) Intravenous fluid replacement, if necessary, should not interrupt or delay CWI.	
(e) The conditions under which athletic equipment will or will not be removed before CWI (eg, removal tools are present).	
(f) Rewarming procedures and techniques should occur if patient's T_{REC} falls <37°C (98.6°F).	
(11) Educate physicians, athletic trainers, and EMS in common misperceptions about CWI (eg, vasoconstriction-induced increases in T_{REC}).	
(12) Educate clinicians to anticipate that T_{REC} reductions may take 5 to 10 min to occur after the onset of CWI.	
(13) Educate EMS regarding expectations that their initial evaluation and treatment should not interrupt cooling efforts or CWI.	
(14) Use appropriate methods for cleaning and maintaining CWI equipment after use.	
Miscellaneous: EAP, education, and communication	
(15) Share EAP and EHS policies and procedures with other members of the sports medicine team (eg, physicians, EMTs) and rehearse EAP annually.	
(16) Provide educational materials to coaches or staff so they can recognize warning signs of EHS.	
(17) Encourage coaches or staff to be trained in basic life support (ie, CPR, AED).	
(18) Ensure coaches, administrators, and EMS know their role in an EHS emergency (eg, spectator or parent control, calling 911).	
(19) Develop and implement regionally specific heat-safety guidelines in all EHI policy and procedure documentation.	
(20) Identify appropriate receiving hospitals for athletes diagnosed with EHS.	
(21) Designate a school representative to follow up with EMS and receiving facility after an EHS transport to determine case resolution and opportunities for improvement.	
(22) Educate coaches, parents, administrators, and other health care providers on differences between dehydration and heat illness.	
Exertional heat-stroke advocacy	
(23) Advocate for policy changes mandating T_{REC} and CWI for EHS patients.	
(24) Educate policy makers, administrators, and health care providers about the value of having qualified medical personnel (eg, athletic trainers) present at all practices and competitions.	

Abbreviations: AED, automated external defibrillator; CNS, central nervous system; CPR, cardiopulmonary resuscitation; CWI, cold-water immersion; EHI, exertional heat illness; EAP, emergency action plan; EHS, exertional heat stroke; EMS, emergency medical services; EMT, emergency medical technician; T_{REC}, rectal temperature.

procedure, taught in all accredited athletic training education programs, and within the scope of practice of ATs.[25] Although some institutions have attempted to reduce liability from T_{REC} assessment by using authorization forms, the lack of a signed permission form should not stop ATs from following EHS best practice. In fact, ATs are obligated to act in the best interest of the patient, irrespective of school officials' indications otherwise.

To date, we are unaware of any successful litigation against a medical professional for following best practice in the case of a patient with suspected EHS. On the contrary, several medical professionals have been involved in legal

Table 2. Practical Strategies for Implementing Best Practice for the Prehospital Care of Patients With Exertional Heatstroke in Secondary School Settings

Cost

(1) Determine which cooling method for CWI would be most feasible considering budgetary and location constraints. Cooling equipment should be located as close to the field of play as possible to minimize treatment delays. If CWI equipment is filled and kept outdoors, it should be in shaded areas (eg, under bleachers, trees, tents, tarps) to maximize cooling potential. If the competition area is too remote for a stationary tub, clinicians should use portable methods of CWI (eg, TACO, inflatable pools).
(2) To fund the purchase of equipment (eg, rectal thermometers, CWI tubs), consider adding the cost of these items to annual budgets. Obtaining quotes from a company's sales staff often results in significant savings. If purchasing flexible thermistors, remember to purchase a sterilant (eg, 3% glutaraldehyde solution) or single-use thermistors to ensure cleanliness before use.
(3) Consider working with booster clubs or parent-teacher organizations to purchase rectal thermometers and cooling equipment. Alternatively, small grants may be available through foundations with missions to prevent EHS deaths (eg, Jordan McNair Foundation, Zach Martin Memorial Foundation).
(4) Create an "equipment wish list" for parents, administrators, alumni, and businesses seeking ways to give back to their community.

Skill performance

(1) If clinical staff are uncomfortable or lack competency in performing T_{REC} or CWI, seek training or education (eg, conferences, universities, hospitals). If conferences do not afford opportunities to learn or practice these skills, consider reaching out to a college or university with a CAATE-accredited athletic training program. These institutions may have the equipment and personnel available to teach some or all these skills because T_{REC} assessment must be taught as part of accreditation standards in athletic training.
(2) Mark 15 cm (6 in) from the tip of flexible thermistors (eg, tape, markers) to ensure thermistors are inserted to the most valid rectal depth past the anal sphincter.
(3) If using inflexible thermometers, purchase at least 2 thermometers, and clearly identify which thermometer is "rectal" and which is used for other body temperature sites. If only 1 thermometer is available, use thermometer covers when taking measurements, and ensure the thermometer tip is cleaned and sterilized between uses.

Communication

(1) Address heat-illness education in preseason meetings with coaches, staff, parents, medical professionals, and administrators. Copies of the National Athletic Trainers' Association "Beat the Heat" handout (https://www.nata.org/sites/default/files/hydration_heat_illness_handout.pdf) can be displayed in the athletic training facility and locker rooms and provided to help educate on recognition and best practices regarding EHS and other heat-related illness. Alternatively, consider creating a custom handout that educates individuals on EHS, the potential side effects of CWI, how EHS differs from other heat illnesses or dehydration, and a hypothetical timeline of events from the time of collapse to the transport of the athlete to a hospital.
(2) Athletic training staff and any school-associated physicians should present a unified voice regarding the necessity of T_{REC} for the diagnosis of EHS and CWI in the care of athletes with EHS.
(3) Coaches or staff and athletes should be instructed to report concerns about heat illness to the medical staff immediately. With larger teams, a "buddy system" among teammates can be implemented when training occurs in conditions of higher risk for heat illness. Athletes should be advised to alert an adult if a teammate "isn't acting right" while exercising in the heat.
(4) Practice EAP and EHS policies and procedures (ie, assessment of body temperature via T_{REC} and CWI) with other health care providers and administrators. This will help to dispel potential conflicts that may arise during an emergency on the field and ensure prompt patient care. Distribute copies of EAP and EHS policies and procedures to coaches or staff before the start of practices and clearly outline their role during heat emergencies.

Implementation

(1) Advocate for policy changes at the local, state, and regional levels mandating CWI and the use of T_{REC} for athletes experiencing EHS.
(2) Advocate for hiring of qualified medical personnel (eg, athletic trainers) in schools. Ensure that these professionals are present at all practices and competitions, especially when environmental conditions are risky. Provide evidence to decision makers and hiring authorities regarding the cost benefits of hiring athletic trainers; many administrators cite cost as a significant barrier to hiring athletic trainers.
(3) Ensure that equipment is ready before the start of the event in which EHS is possible. Water tubs should be filled before athletic participation and large quantities of ice made available (if possible) to use for CWI. Water-bath temperature should be as cold as possible (preferably 1.7°C–15°C [35°F–59°F]) to facilitate rapid cooling. Keeping water tubs in the shade or under cover can lessen the amount of ice needed to keep baths at acceptable temperatures.

Abbreviations: CAATE, Commission on Accreditation of Athletic Training Education; CWI, cold-water immersion; EAP, emergency action plan; EHS, exertional heatstroke; TACO, tarp-assisted cooling with oscillation; T_{REC}, rectal temperature.

proceedings because they did not follow EHS best-practice recommendations (ie, failed to obtain a T_{REC}, cool the patient onsite, or both). Patient privacy, while important, should never dictate best care, especially when T_{REC} can be performed quickly and privately. Privacy fears may be assuaged by having another person present to assist with draping the patient and act as a witness during this process (Figure).[26] Some obstacles to obtaining a T_{REC} originate with school administrations. In many cases, school administrators are not health care providers and should not be making determinations about patient care or EHS best practice.[27]

Misconception #3

Assessing T_{REC} is dangerous and can cause pain and injury to patients.

Facts and Evidence. This misconception likely originated in the days when glass thermometers were available for measuring body core temperature. With the advent of digital electronic thermometers, rectal perforation or other injury from rectal thermometry is extremely rare ($<1:2\,000\,000$).[28] Literature on this topic is scant, dated, and mostly from cases involving neonates and infants in hospital settings.[28,29] In 1 review, 20 cases of rectal

Table 3. Operational Definitions of Validity, Feasibility, and Clarity Used in the Delphi Method for Action Items and Recommendations

Validity	Recommendation was based on current data, theory, literature, or other type of scientific evidence.
Feasibility	Recommendation was realistic in what individuals or campuses could be expected to implement, keeping in mind the widely varying resources and competing demands that individuals and institutions may face.
Clarity	Recommendation was clear and easily understood.

perforation were reported in infants over 30 years in the United Kingdom. Moreover, no published case reports were found of rectal perforations by rectal thermometers in adults, nor were there reports of flexible thermistors causing secondary injury to the rectum during EHS assessment.

Inserting a flexible thermistor 15 cm (6 in) past the anal sphincter assures a valid T_{REC} while also helping to prevent the accidental removal of the thermistor during transport or treatment.[30] If using inflexible thermometers, only the tip of the thermometer should be inserted (usually 2.54 cm [1 in]), and it should be removed once a stable reading occurs. In most cases of EHS, lubricating the thermistor or thermometer tip is optional because sweating provides sufficient lubrication of the area.

Misconception #4

Obtaining T_{REC} in the field is too difficult because of patient noncompliance, lack of cooperation with fellow medical professionals, parental concerns, or all of these.

Facts and Evidence. Clinicians need to immediately implement measures to support any athlete manifesting CNS-related symptoms during or after exertion. This includes providing emergency cardiac care and activation of emergency medical services (EMS) as needed. When EHS is part of the differential diagnosis, rapid T_{REC} monitoring is essential and allows clinicians to prioritize immediate cooling as a lifesaving treatment modality.[15]

Assessing T_{REC} is minimally invasive and easy to perform (Figure). To measure T_{REC}, move the patient to a temperature-controlled, private room or a shaded or cool area out of the heat, if possible. An unresponsive patient should be positioned on one side. Then flex the knees and hips, as in a sitting position. Lower the pants, shorts, or uniform while draping the patient with a towel or sheet to assure privacy. When continuous temperature monitoring is available, a flexible thermistor can be inserted 15 cm (6 in) into the rectum for a continuous digital reading in seconds.[30] Many EHS patients have a depressed level of consciousness, so it is common for them to be unaware their temperature is being taken rectally or that a thermistor

A.
B.
C.
D.
E.
F.

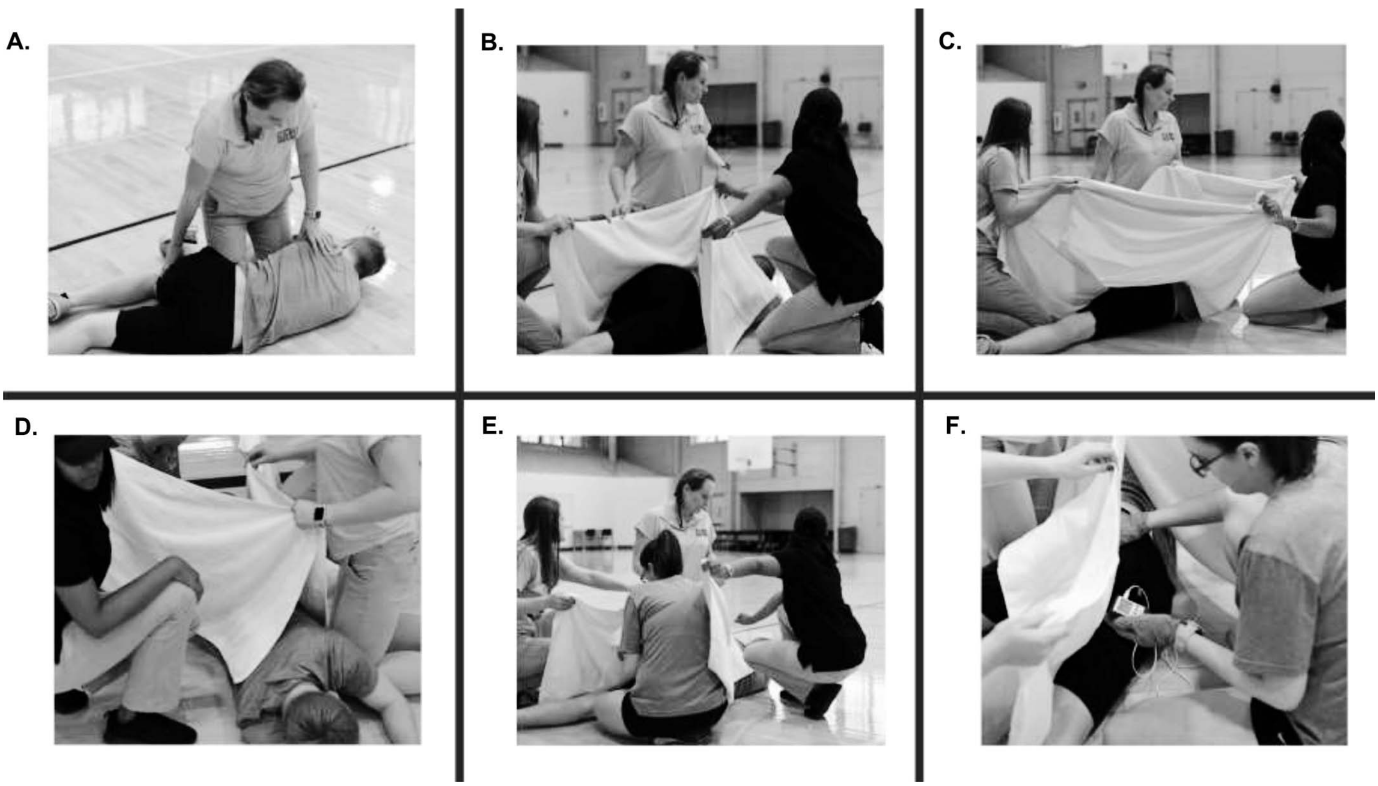

Figure. Procedures to properly assess rectal temperature (T_{REC}). A, Patient is positioned on his or her side with 1 or both legs flexed. Bystanders or assistants should drape the patient with either B, towels or C, a sheet for privacy if T_{REC} must be taken in view of spectators. E, The onsite medical provider dons personal protective equipment (ie, gloves) and positions himself or herself behind the patient, lowers the patient's clothing to expose the buttocks, and inserts a flexible thermistor 15 cm (6 in) past the anal sphincter. Note: If using an inflexible thermometer, insert the thermometer only as deep as the manufacturer instructs. F, If using a flexible thermistor, leave the thermistor inserted in the rectum, return the patient's clothing to its original position, and transport the patient to the nearest cold-water immersion modality. If using an inflexible thermometer, remove the thermometer from the patient's rectum after obtaining a stable T_{REC} and return the patient's clothing to its original position. Then transfer the patient to the nearest cooling modality. From Adams WM, Stearns RL, Casa DJ. Exertional Heat Stroke. In: Adams WM, Jardine JF, eds. *Exertional Heat Illness: A Clinical and Evidence-Based Guide. Springer*. Cham, Switzerland. 2019. Used with permission.[26]

remains in their rectum during CWI. Moreover, the clinician can assume implied patient consent given the life-threatening nature of EHS and the patient's altered mental status.

If the patient is combative, attempt to restrain him or her as gently as possible. This may require the cooperation of several other volunteers or the use of equipment (eg, straps) to control the patient so the clinician can safely assess T_{REC}. Clinicians must be prepared for and expect that some patients with EHS will act belligerently and violently because they are experiencing CNS dysfunction. Consequently, it is vital that clinicians treating an EHS patient take precautions to protect themselves when measuring T_{REC} and during CWI.

It is also essential to plan for possible miscommunication between medical professionals regarding the best care or potential spectator or parental interference when treating patients, especially minors, with EHS. Exertional heatstroke policy and procedure documents should address keeping spectators out of the way so they do not impede life-saving measures. For example, nonemergency personnel (eg, coaches, administrators) can help maintain a barrier between the clinician and spectators to help ensure that any spectators who may become belligerent do not interfere with the proper care of the patient with EHS.

To prevent miscommunications between medical teams, the sports medicine team must communicate, coordinate, and practice these life-saving responses before an event in which EHS is possible (eg, off season). When a mass participation competition is scheduled during high-risk conditions (eg, summer cross-country meet), it is beneficial for the medical providers onsite (eg, ATs) and on call (eg, EMS) to establish consensus policy and procedures for the prehospital care of EHS patients. If other medical providers are uncooperative at the time of an emergency, the clinician must remain calm and treat the patient using the best practices described in this document. This may include clearly communicating to the other medical providers what is being done and why and when the patient can be transferred for further care. Once the emergency has been rectified, the clinician should document everything that transpired and attempt to follow up with the other medical providers to prevent future miscommunications.

Misconception #5

Rather than T_{REC}, clinicians can use their clinical experience, EHS signs or symptoms, or both to diagnose patients with EHS.

Facts and Evidence. For several reasons, T_{REC} should be assessed any time an athlete displays CNS dysfunction during or after exercise in warm or hot environments. First, CNS symptoms present in widely varying ways: syncope and overt changes in levels of consciousness, behavioral changes (eg, agitation, aggression, confusion), changes in physical performance (eg, staggering or loss of balance), or all of these.[1] Symptom recognition can be difficult, as some of the behavioral and performance changes may be quite subtle. Consequently, the similar symptoms represent broad diagnostic possibilities for an athlete with CNS-related dysfunction (eg, cardiac or metabolic condition, toxicologic injury, hyponatremia, sickle cell collapse). Second, EHS may elicit other conditions. For example, cardiac arrhythmias and decreased blood pressure may occur with the physiological stress that occurs with EHS and, therefore, their presence should not preclude appropriate temperature assessment.[31] Additional evaluations, such as electrocardiogram monitoring and assessment of serum glucose and sodium levels (if available), will often be performed immediately by EMS if indicated and do not interfere with CWI. Overall, T_{REC} is the most quantifiable metric for determining the presence of dangerous, life-threatening hyperthermia.

Misconception #6

Rectal thermometers and immersion tubs are too expensive to allow implementation of these best practices in the secondary school setting.

Facts and Evidence. Equipment costs are often a major factor in determining whether clinicians have the tools they need to diagnose and treat EHS patients, especially in the secondary school setting.[11] Cost need not be a limiting factor in the ability to provide appropriate EHS care. Ideally, clinicians would use a thermometer with several feet or meters of flexible thermistor to measure T_{REC}. The major benefits of these thermistors are that they have soft tips, so there is minimal concern about injuring the patient; they allow for continuous monitoring of T_{REC}; and monitoring of patient progress can occur from a safer distance if the patient is belligerent. These devices often cost between \$200 and \$400. Alternatively, rigid thermometers are cheaper (approximately \$10) but cannot be inserted deeper than a few inches or centimeters without potentially causing a secondary injury to the patient, do not allow for continuous monitoring of the patient's T_{REC}, and require removing the patient from cooling to obtain a measurement. For these reasons, we believe the cost of the more expensive thermistors is justified and that they are needed to provide the best patient care.

Several cooling options, with varying costs, also exist for performing CWI. Large (567–1135 L [150–300 gallon]) cooling tubs, animal feeding troughs, or even children's pools allow for CWI and cost between \$10 and \$400. Alternatively, tarp-assisted cooling with oscillation (TACO) can be performed with inexpensive tarps (<\$20). When tubs are not practical, TACO is an efficient and portable CWI method.[32] Cumulatively, rectal thermometers and cooling measures are life-saving pieces of equipment for patients with EHS and cost less than \$250 to \$1000. Other life-saving devices (eg, automated external defibrillators) often cost >\$1000 and require routine maintenance and monitoring. Overall, clinicians have numerous options available; therefore, cost should not prohibit them from providing appropriate care to EHS patients.

Misconception #7

If a clinician suspects a patient has EHS, it is acceptable to initiate CWI without obtaining T_{REC}.

Facts and Evidence. Measuring T_{REC} is a necessary first step before initiating CWI for 4 reasons. First, T_{REC} confirms the diagnosis of EHS. This is paramount because EHS shares many signs and symptoms with other life-threatening conditions (eg, hyponatremia, diabetic emergency). However, unlike other life-threatening conditions, patients with EHS will have $T_{REC} > 40.5°C$ (105°F) concomitantly with signs or symptoms of CNS dysfunction. Second, continuous T_{REC} assessment indicates when a patient's body core temperature has returned to a safe level (38.9°C [102°F]) and CWI can be ended. Third, having a confirmed EHS diagnosis allows clinicians to develop appropriate return-to-play criteria and pursue other advanced confirmatory tests (eg, blood tests for liver and kidney function) before allowing a person back to full sport participation. Finally, some medical professionals may strongly advocate for the immediate transport of a patient with EHS to the hospital. If clinicians can show medical personnel the patient's T_{REC} is dangerously elevated, they may be more easily convinced to wait until body core temperature has been safely lowered before transport to the hospital.

Misconception #8

Exertional heat stroke only occurs in hot and humid locations, so rectal thermometers and immersion tubs are unnecessary in colder areas of the country or during colder times of the year.

Facts and Evidence. The incidence of EHS increases as temperature and humidity increase.[33,34] Additionally, most heat-related deaths occurred during weather that was unusually hot and humid based on local standards.[9] Yet athletes in cooler areas may be more susceptible to sudden heat waves due to a lack of acclimatization to unusually intense conditions.[35] Preferably, clinicians will use region-specific activity-modification guidelines.[36] Grundstein et al[35] developed regional-specific heat-safety guidelines based on local climate patterns in an attempt to standardize heat acclimatization across the country. In fact, recognizing that EHS can occur in milder weather conditions and adopting policies to protect athletes based on the conditions to which they acclimatize can result in decreased EHS rates.[3] Thus, clinicians should ensure that plans are in place to treat patients with EHS even when temperatures or locales are cooler.

Misconception #9

People without medical training (eg, coaches, administrators) should perform T_{REC} assessment when a qualified medical care provider is not present and EHS is suspected.

Facts and Evidence. When athletes experience acute heat illnesses, ATs are the medical professional most commonly onsite.[37] Unfortunately, only 37% of United States secondary schools have full-time access to ATs.[38] It is concerning that many of these schools lacked athletic training services during preseason practice or conditioning sessions[38] because this is when exertional heat illness (EHI) occurred most frequently.[39] We strongly advise that only qualified medical professionals (eg, ATs) perform T_{REC} in emergency situations as EHS signs and symptoms may mimic those of other life-threatening conditions. However, in schools without a medical staff available during these sessions, coaches and conditioning staff must be aware of the EHI policies and procedure documents and emergency action plans (EAPs). These individuals must also be familiar with the mechanisms for preventing EHS as well as the possible signs and symptoms of EHS to allow for its early recognition, especially in the absence of T_{REC} for confirmation. In addition, these personnel should receive explicit instructions on their role in initiating appropriate cooling measures (eg, ice towels, water dousing) and the need to obtain emergent medical care.

COLD-WATER IMMERSION MISCONCEPTIONS

Misconception #10

Cold-water immersion is just one of many acceptable ways to cool a patient with EHS.

Facts and Evidence. Cold-water immersion up to the neck is the most effective cooling modality for patients with EHS and consistently produces the fastest cooling rates.[40] Although results vary, CWI cooling rates are approximately 0.28°C/min (0.38°F/min) or about 1.4°C every 5 minutes (or 1.1°F every 3 minutes) when considering the entire immersion period from postcollapse to 38.9°C (102°F). When properly administered, this technique has resulted in 100% survival rates.[21]

Cold-water immersion is often not available at all sites or may not be feasible secondary to a remote location, space requirements, or cost. Other methods currently used to facilitate cooling include cold-water dousing,[41] temperate-water immersion,[42] and TACO.[32] Although some of these methods have been studied and 100% survival rates in patients with EHS were reported, the cooling rates were slower than those achieved with CWI (Table 2).[40]

Misconception #11

If EMS is onsite when a patient collapses, the patient should be taken to a local hospital immediately once EHS is confirmed.

Facts and Evidence. The mantra "cool first, transport second" is helpful for reminding clinicians that the EHS patient should be cooled onsite before being transported to the emergency room because this line of action saves lives.[21] Indeed, cooling before transport can mitigate the organ damage caused by the cytotoxic effects and inflammatory response when the body becomes severely hyperthermic.[43] Unfortunately, fatal cases of EHS have been attributed to inaccurate diagnosis, lack of triage, inaccurate temperature device, lack of cooling or inefficient cooling, and immediate transport without first performing CWI.[44,45] Notably, ambulances cannot accommodate CWI, and few hospitals have large volumes of cold water available to immediately perform CWI. Consequently, slower methods of cooling must be used in transit, and hospitals must use less effective cooling modalities (eg, cooling blankets), which prolong T_{REC} elevation. Overall, it is critical to lower T_{REC} to $<$38.9°C (102°F) within 30 minutes.[1] After cooling, the patient should be transported to a local hospital for advanced medical care.

Misconception #12

Once a patient with EHS undergoes CWI, T_{REC} will decrease immediately.

Facts and Evidence. Cold-water immersion is the criterion-standard treatment for patients with EHS due to its excellent cooling rates between 0.20°C/min and 0.30°C/min.[40] However, the decline in T_{REC} is not linear over time, and in some patients, T_{REC} may increase or remain constant for several minutes after the start of CWI. Moreover, the clinician may actually observe the patient cool more quickly as T_{REC} approaches 38.9°C (102°F), especially if the patient is immersed in a very cold water bath (2°C–8°C, 36°F–46°F).[46]

Cooling rates depend on a number of factors, including the initial body core temperature, water temperature, degree of peripheral vasoconstriction, frequency with which the water bath is stirred, presence or absence of shivering, and rate of vasoconstriction.[46] Accordingly, the early slow rate of T_{REC} decline may be due to initial displacement of warm blood from the periphery to the core upon skin and limb muscle vasoconstriction induced by CWI. The second degree of cooling occurs more quickly, as body tissue temperatures equilibrate and convective and conductive heat transfer occurs. These differences can also be attributed to a greater lag time associated with tissue heat transfer observed between the start of immersion and initiation of T_{REC} cooling, resulting in the slower temporal response of T_{REC} in the early stages of cooling. In fact, this aforementioned lag time may explain the initially observed paradoxical increase in T_{REC} as CWI is initiated. Understanding when and how quickly EHS patients cool is critical so that the clinician can anticipate when to remove the patient from CWI in order to minimize the afterdrop in T_{REC}.

Misconception #13

Intravenous fluids should be administered to patients with EHS before or during CWI.

Facts and Evidence. The effects of hyperthermia and fluid loss during exercise in the heat are interrelated. Skin and muscle essentially "compete" for cardiac output with physical exertion in hot environments.[47] In quantitative terms, body core temperature increases up to 0.15°C to 0.22°C (0.27°F–0.40°F) for every 1% of body weight fluid loss during exercise in the heat, as compared with exercise in a hydrated state.[48]

Hydration and vascular access are of secondary concern behind lowering T_{REC} when treating EHS. Most athletes with EHS do not require intravenous fluids in the prehospital setting.[49] Aggressive full-body cooling with CWI or TACO not only reduces body core temperature but also helps to restore mean arterial pressures. Consequently, central perfusion is improved.[32] Although vital signs should be monitored throughout cooling, the clinical measures used to determine hydration status in a prehospital setting (ie, heart rate, blood pressure, capillary refill) are often of little clinical utility because they are affected by EHS and CWI.

From a practical standpoint, placement of an intravenous line in a prehospital setting requires equipment and personnel that may not be onsite during most athletic activities at secondary schools. Emergency medical services will often pursue vascular access and may consider intravenous hydration in patients diagnosed with EHI depending on the clinical presentation. When intravenous hydration is indicated, cold normal saline has been shown to decrease core temperature by 0.04°C/min to 0.08°C/min.[50] This has the potential to augment CWI or other cooling methods but is insufficient as a sole modality in EHS treatment.[40]

Misconception #14

Rather than T_{REC}, clinicians can use predetermined CWI times or shivering to know when to safely remove a patient from CWI.

Facts and Evidence. Clinicians should use T_{REC} rather than predetermined CWI immersion times because cooling rates are influenced by numerous factors, including sex, anthropomorphic values (eg, lean body mass:body surface area ratio), water-bath temperature, T_{REC} at the start of treatment, amount of clothing worn during CWI, and the degree of convective cooling that occurs during treatment.[46,51,52] Thus, standardized treatment times are likely to either overcool or undercool patients.

Shivering is also not a quantifiable metric for determining when to remove patients from CWI. Proulx et al[46] observed that some participants shivered after 6 to 7 minutes of CWI despite their T_{REC} being above 39°C. Others reported shivering within the first 5 minutes of CWI, or worse, a lack of shivering in hyperthermic participants[53] or patients treated for EHS.[54] Because shivering is triggered more by reductions in skin temperature than reductions in body core temperature,[55] shivering should not be used to make clinical decisions about body core temperature or when to remove patients from CWI.

Misconception #15

Clinicians must remove athletic equipment before starting CWI or patients will not cool quickly.

Facts and Evidence. Ideally, patients with EHS would undergo CWI so their T_{REC} cooling rate exceeds 0.15°C/min.[40] If trained medical professionals are present and no complications exist, athletic equipment can be removed safely and efficiently in under 5 minutes.[56] Unfortunately, several barriers often exist to removing athletic equipment before initiating CWI (eg, belligerent athlete, lack of knowledgeable personnel to remove equipment). Miller et al[53,57] demonstrated that cooling rates of hyperthermic men wearing full American football uniforms were excellent (ie, 0.20°C/min–0.28°C/min) and comparable with those of EHS patients undergoing CWI.[21] Because the EHS diagnosis is often delayed and medical professionals may not be present at the onset of collapse,[37] immersing fully equipped patients can simplify the protocol and ensure quick treatment. Therefore, equipment should be removed before CWI under the following conditions: (1) removal tools (eg, scissors) are immediately available, (2) the equipment can be easily removed, or (3) the equipment interferes with the ability to fully immerse the athlete. If none of these conditions exist, clinicians can work to remove equipment during CWI given that equipment has a negligible effect on body core temperature cooling.

Misconceptions #16

Cold-water immersion is a dangerous treatment for patients with EHS because it can induce cardiac arrest or subsequent hypothermia.

Facts and Evidence. Some authors cited peripheral vasoconstriction as a reason not to perform CWI because it causes the shunting of warm blood away from the periphery and may increase body core temperature.[58] Normothemic individuals may show a brief, slight increase in body temperature in cold water, but CWI in hyperthermic people typically induces a rapid cooling response, though a short lag in cooling is possible.[46,58] Cold-water immersion-induced hypothermic afterdrop can occur if the athlete is cooled excessively, but afterdrop is minimized by removing a patient when T_{REC} reaches 38.9°C (102°F).[1] Warming blankets, exposure to the sun, or other warming techniques should be included in an EHS policy and procedure document to manage athletes who develop hypothermic afterdrop after CWI. Although EHS patients should be monitored consistently after CWI, drying and rewarming procedures should be initiated if T_{REC} falls below 37°C (98.6°F) and rapidly approaches 36°C (96.8°F).

Perhaps the most valid concern about providing CWI for an athlete who has collapsed is difficulty using an AED. Cardiac events can occur in athletes with EHS but are unlikely when the condition is recognized early and promptly treated with CWI. The literature[58] strongly supported the idea that the risk of not cooling EHS patients aggressively with CWI vastly outweighs the possible risk of a cardiac event.

Misconception #17

Clinicians do not need to activate EMS or send a patient to the hospital if EHS is verified (ie, $T_{REC} > 40.5$°C [105°F] and CNS dysfunction is present) and the patient's T_{REC} is lowered to <38.9°C (102°F) within 30 minutes of collapse.

Facts and Evidence. We recommend transporting patients to hospitals and not delaying the call for advanced medical support after successful reduction in T_{REC} for 3 reasons. First, although EHS morbidity and mortality are markedly reduced with the rapid initiation of CWI cooling,[21] the amount of time spent with core temperature elevations >40.5°C (105°F) may be difficult to determine. Therefore, the risk of additional complications (eg, seizures, tachypnea, hypotension, rhabdomyolysis) may be uncertain. Second, the risk of complications after EHS depends upon the athlete's individual predisposition and underlying medical conditions. The preparticipation physical evaluation, including a thorough history, may indicate an athlete's susceptibility to heat illness.[1] Unfortunately, in emergent situations, accurate medical information is often not immediately available to assess this risk. Finally, current recommendations are for athletes to undergo routine blood analysis (eg, creatine kinase, creatinine) and be monitored by a physician for at least 1 hour after cooling before discharge is considered.[1] Moreover, reevaluation of biomarkers is essential because some markers can remain elevated for up to 16 days after EHS.[59] The overwhelming majority of secondary schools lack the expertise and resources to provide this level of care. Contacting EMS concurrently with initiation of cooling measures is essential and will allow for cooling to begin before EMS arrival. Proximity and expertise in EHS management should be taken into consideration when determining the most appropriate receiving facility.

Misconception #18

Cold-water immersion equipment must be cleaned or disinfected after every patient who is treated for EHS.

Facts and Evidence. Cold-water immersion equipment (eg, tubs) is an important part of EHS treatment strategies and must be available and ready for use. In some settings, cooling tubs may be used for multiple purposes. A tub that is designated for emergency use should be filled on days with an elevated risk for EHS and cleaned before its potential use. The Centers for Disease Control and Prevention[60] recommended cleaning and disinfecting a whirlpool after each use because patients may release bodily fluids (eg, vomit, urine, feces) during treatment. If bodily fluids are excreted, the cooling tub must be cleaned before treating subsequent patients with EHS.

At mass scale events (eg, high school cross-country meets, marathons) in which there is a possibility of treating multiple patients with EHS over a short time period, it may not be possible to clean and disinfect each tub after each person is treated. Immediate cleaning in these instances becomes a secondary priority to lowering T_{REC}. Thus, a clinician must be prepared to prioritize based on the level of severity and whether a tub warrants multiple uses before cleaning. Few schools will likely host this type of event, so sufficient time should be available to clean and disinfect a cold tub after emergency use in secondary school settings.

CONCLUSIONS

Exertional heat stroke is a life-threatening but survivable injury if appropriate measures and actions are taken.[21] Specifically, EHS must be confirmed using T_{REC}, followed by CWI within 30 minutes of the patient's collapse. All interscholastic athletic programs must have a comprehensive and detailed EHI policy and procedure document that includes protocols specifically for EHS and other heat-related conditions. These documents and EAPs need to be readily available for appropriate staff, and it is important that the sports medicine staff educate, review, and rehearse the EAP as it relates to heat injury.[61] With proper planning and communication between the medical team and administrators, the potential for a negative outcome after EHS can be mitigated.

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