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Proper Recognition and Management of Exertional Heat Stroke in a High School Cross-Country Runner: A Validation Clinical Case Report

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A 14-year-old female high school cross- country runner (height = 154 cm, mass = 48.1 kg) with no history of exertional heat stroke (EHS) collapsed at the end of a race. An athletic trainer assessed the patient, who presented with difficulty breathing and then other signs of EHS (eg, confusion and agitation). The patient was taken to the medical area and draped with a towel, and a rectal temperature (T_{re}) of 106.9°F (41.6°C) was obtained. The emergency action plan was activated, and emergency medical services was called. The patient was submerged in a cold-water immersion tub until emergency medical services arrived (~15 minutes; T_{re} = 100.1°F; cooling rate: 0.41°F·min^{-1}[0.25°C·min^{-1}]). At the hospital, the patient received intravenous fluids, and urine and blood tests were normal. She was not admitted and returned to running without sequelae. Following best practices, secondary school athletic trainers can prevent deaths from EHS by properly recognizing the condition and providing rapid cooling before transport.

Key Words: cold-water immersion, cool first and transport second

Key Points

- With proper recognition of exertional heat stroke (EHS) and aggressive cooling onsite, athletic trainers in the secondary school setting can successfully manage patients with EHS.
- Athletic trainers should have a written emergency action plan that is complemented by a written EHS policy that allows for the use of rectal thermometry to diagnose EHS and cooling first and transporting second.

Exertional heat stroke (EHS) is one of the leading causes of sudden death among athletes.[1] The condition is defined as a neuropsychiatric impairment with a high core temperature, usually >40.5°C (105°F), that can result in permanent disability or death if not properly treated.[2–7] Survival relies on the proper recognition of EHS by obtaining a core body temperature, assessing for central nervous system (CNS) dysfunction, and promptly administering aggressive cooling onsite.[1,3,8,9] When EHS is recognized and treated within 30 minutes of collapse, death is preventable.[2,3,10–12] Therefore, athletic trainers (ATs) and other sports medicine clinicians should apply the best evidence of prevention, early recognition, and onsite rapid cooling in all settings. Recommendations for the prehospital care of patients with EHS include rectal thermometry for diagnosis and cold-water immersion (CWI) for onsite treatment; however, this care is not always implemented, particularly in the secondary school setting.[1,3]

The secondary school athletic population leads the United States in athletic-related deaths.[2,13,14] Most EHS deaths in adolescents occur during participation in football, wrestling, or cross-country or track.[15] The beginning of the fall sport season is when athletes are often at greater risk due to not being acclimatized to the heat.[15] Thus, it is imperative that secondary school ATs have the correct training, equipment, and policies in place to implement best practices for the prevention, recognition, and treatment of EHS. Numerous researchers[16–18] have shown inconsistencies between evidence-based recommendations for the prehospital care of patients with EHS and how ATs in the secondary school settings manage the condition.

In a survey of secondary school ATs, only 2 out of 225 (0.9%) ATs who treated EHS assessed the patient's rectal temperature, compared with 77 (34.2%) who measured body temperature orally, which is an inaccurate measure.[15] The common causes of death from EHS are an inaccurate temperature assessment (eg, oral, tympanic), misdiagnosis, delayed treatment, inefficient cooling, and immediate transport to the emergency department.[10] Investigators who examined the attitude and perceptions of ATs regarding EHS intervention found that only 13% of ATs used rectal thermometry and 41% used CWI.[5] The ATs noted a lack of equipment or budget, concerns about a lack of consent or liability (especially with minors), a lack of training or concerns about privacy, and the compliance of the athlete as reasons regarding why rectal temperature was not assessed.[5]

Despite these results, some ATs have revised their emergency action plans (EAPs) and written heat polices

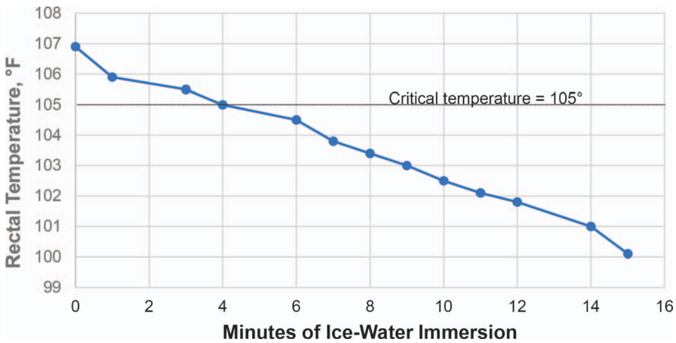

Figure 1. Rectal temperature of exertional heat stroke patient during cold-water immersion.

and implemented best practices for the recognition and treatment of EHS; however, many of these cases are anecdotal.[18] Some researchers[8,9] have published reports of patients with EHS who survived without complications due to proper recognition and aggressive cooling onsite, such as at the Falmouth Road Race. Using an appropriate EHS protocol consisting of rectal temperature assessment and CWI treatment in the medical tent, they have shown success in treating hundreds of EHS patients without fatalities.[8]

Therefore, the purpose of this case report was to present the proper recognition and treatment of EHS in a 14-year-old high school cross-country runner. To our knowledge, no cases have been published about the proper implementation of evidence-based recommendations in the prehospital management of EHS in the secondary school setting. This level 1 validation clinical case report demonstrates how clinicians can successfully implement the current EHS recognition and management recommendations in the secondary school setting.

CASE PRESENTATION

Patient

This case occurred in 2018 at a high school cross-country meet in early October. The high school is in the southeast United States, which is region 3 according to the Grundstein et al[19] heat safety regions. An AT was present for this race and had set up a medical area with a treatment table, heat stress tracker (model 5400; Kestrel Instruments), cold tub, and coolers with ice and water. At 4:00 PM (the start of the race), the wet-bulb globe temperature (WBGT) was recorded as 86.5°F (30.0°C). Two athletic training students were present with the AT on race day. At 4:30 PM, a 14-year-old female high school cross-country runner (height = 154 cm, mass = 48.1 kg) with no pertinent medical history of EHS collapsed at the end of the race. The AT was summoned to the finish line, where she found the patient being held up by her mother. Upon initial evaluation, the patient was conscious and hyperventilating. The AT then began assisting the patient with breathing techniques. Moments afterward, the patient presented with CNS dysfunction and signs and symptoms of EHS, which included disorientation, confusion, behavioral changes, slurred speech, muscle fatigue, rapid breathing, flushed skin, and agitation. The patient's mother reported that the patient had experienced a cold and upper respiratory illness earlier in the week. The parent reported she had not taken any medications at the time of the event.

Table. Laboratory Results Approximately 30 Minutes After the Patient's Exertional Heat Stroke

Measure	Patient's Level	Normal Adolescent Level
Glucose, mg/dL	106	70–110
Chloride, mmol/L	108	95–105
Estimated creatinine clearance (drug dosing), mL/min	66	100–130
Creatine kinase, IU/L	189	12.5–80

Intervention

The patient started to stumble when walking, so the AT assisted her to the medical area and informed the parent that a rectal temperature was necessary to determine whether the patient was experiencing EHS. The parent quickly consented to having the AT obtain a core temperature via rectal thermometry. The AT positioned the patient in a prone position and draped her with a towel for privacy. A rectal thermistor (model KD-2300; DataTherm II) was inserted 10 cm into the rectum by the AT. A core temperature of 106.9°F (42.6°C) was recorded; the AT initiated the EAP, and emergency medical services (EMS) was called. The patient was submerged into a 150-gallon (568-L) CWI tub (Rubbermaid) by the AT. An athletic training student helped to record the patient's core temperature every minute during cooling (Figure 1) while stirring the water in the tub. During this time, the AT explained to the parent the EHS policies and procedures, which consisted of obtaining a core temperature via rectal thermometry, submerging the patient in a CWI tub, and understanding that the patient's core temperature must be at least 102°F (39°C) before removing her from the tub. After approximately 15 minutes, the patient was removed from the CWI tub with a temperature of 100.1°F (37.8°C) when EMS arrived. The clinician had made the decision to keep the patient in the tub even after her temperature reached 102° F due to concerns over persistent clinical signs of CNS dysfunction. The patient was transported via ambulance to a nearby hospital, where she received intravenous fluids and underwent blood and urine tests (Table). Although some of the measures appeared to be slightly outside the normal values for adolescent females, the patient was reported to be stable and was not admitted to the hospital. She was cleared by the emergency room physician and discharged the same day.

Comparative Outcomes

The highest risk of exertional heat illness (EHI) is during the summer months and the beginning of the fall season, specifically in August.[2,15] During the summer, athletes are often not yet acclimatized to physical exertion in the heat. The environmental conditions are also often more severe in the summer and preseason months, increasing the risk of EHI.[20] In this case, the patient was 2 months into the cross-country season, and the WBGT was unseasonably high for the month of October. As previously noted, the patient's mother reported that she had experienced a cold and upper respiratory illness earlier in the week and had not taken any medication. This combination of intrinsic and extrinsic risk factors is believed to have contributed to the runner's EHS. These risk factors are common in EHS, as other case studies[21] have shown that patients with EHS usually have multiple intrinsic and extrinsic risk factors. However, this case is unique in that extreme conditions and the risk of EHS often occur in the first 1 to 2 days of preseason practices and are not often reported a few months into a cross-country season. Also, this case occurred during a competition rather than a practice or conditioning session. Ninety percent of EHS-related deaths occur during practices and not competitions.[2]

Pre-event Preparation

The AT was employed by a clinical outreach program that established EHS policies and procedures for the high school and supplied training for ATs. Before each new school year, the ATs went through a series of meetings and educational requirements before returning to their designated school. During this time, the athletic director signed an EHS treatment acknowledgment form, providing the AT with written documentation that the administration was aware that in cases of suspected EHS, an athlete's temperature may need to be taken via rectal thermometer (Figure 2).

DISCUSSION

The purpose of this case report was to present the case of EHS in a 14-year-old high school cross-country runner. Despite the evidence and current position and consensus statements demonstrating best practices for EHS, many ATs are not following evidence-based recommendations to properly recognize and treat EHS. Several deaths from EHS of athletes at various levels of competition would have been avoidable if the proper recognition and early, aggressive treatment were applied onsite.[4,21,22] Cases have also been documented in which the proper recognition and treatment of patients with EHS resulted in a favorable outcome. DeMartini at el[8] examined 274 runners who sustained EHS at the Falmouth Road Race. By using proper recognition and immediate CWI treatment, the survival rate was 100%, and 95% of the patients were not transported to a hospital.[8] Our case of a high school cross-country runner demonstrates how these evidence-based recommendations can be implemented in clinical practice in the secondary school setting.

This case showed that an AT should always be prepared to handle an EHS emergency. In this patient, several intrinsic and extrinsic risk factors were documented that are often present with EHS[3]; however, the timing of this incident was unique. The fact that this case occurred in early October rather than during the preseason summer months highlights the importance of being prepared, regardless of the season or sport. In heat safety region 3,[19] it is important for clinicians to understand that a sudden rise in WBGT can increase the risk of EHS if the environmental conditions have previously been mild. The main intrinsic risk factor in this case was that the patient had experienced an upper respiratory infection in the preceding days. The activity was a regional cross-country race that likely increased the participants' running intensity. Lastly, ATs in the secondary school setting often host events for athletes from other schools; during these events, the AT often lacks information about the athletic participants' medical histories and cannot change the race start time. This case also showed that although not every case of EHS is preventable, if ATs are prepared to handle an EHS emergency, they can help to avoid a potentially catastrophic event.

Schellhase et al[5] noted that some of the reasons ATs do not use rectal thermometry are a lack of comfort, lack of education, concern for liability, and lack of resources. In the present case, the AT was well prepared to manage an EHS event. The AT's clinical outreach program ensured that the staff completed EHS training before every preseason. During this training, the ATs simulated using rectal thermometers on manikins and cooling modalities such as a CWI tub or tarp-assisted cooling with oscillation. This training process demonstrates the importance of reeducating ATs and increasing their confidence with EHS best practices, as well as creating a realistic EAP for each venue or school. In addition to the training, the AT in the present case had a written EHS policy in place that had been approved by the school's administration and supervising physician. The AT had practiced the policy before this incident, and the 2 athletic training students had been taught these skills earlier. Preparation for properly managing a case of EHS should include thorough training, a written EHS policy that is approved by the supervising physician, and ensuring that the AT is practicing within the state practice act.

To implement these policies, it is important to gain support from all stakeholders (eg, coaches and administrators). Researchers[5] have observed that some ATs were concerned with using rectal thermometry without the support of their administrators. In a recent study,[23] investigators showed that secondary school coaches were unaware of potential causes and symptoms of EHS, despite also reporting a positive perceived level of confidence in managing EHS. In a previous investigation,[5] only half of ATs were using CWI as a treatment for EHS. In the current case, the AT had already discussed these policies with the athletic director and coaches during preseason meetings, and the athletic director had signed a form (Figure 2) acknowledging that he was aware of the urgent need for education on proper assessment and early, aggressive treatment for EHS using rectal thermometry and CWI. If this knowledge is practiced, applied, and rehearsed, then a positive outcome can be achieved, with athletes surviving EHS. Researchers[5,24] showed that some ATs (clinicians and educators) have not completed formal education in these skills; however, it is imperative for ATs to seek continuing education opportunities to stay informed about these evidence-based, life-saving skills.

Cool First, Transport Second

Once EHS is identified, it is essential to reduce the patient's core body temperature using a cooling modality, such as CWI, before transporting the patient to the hospital.[3,4,10,12] Although it is important to contact EMS when EHS is first identified, the patient's core body temperature must reach at least 102°F (39°C) before transport to the hospital, thereby following the mantra of "cool first, transport second."[3,4,13] Measurement of the

[INSERT SCHOOL OR EMPLOYER NAME]
HEAT STROKE TREATMENT ACKNOWLEDGMENT FORM

The National Athletic Trainers' Association has published position statements on *Preventing Sudden Death in Sports* and *Exertional Heat Illnesses.* These are research-based, peer-reviewed documents that specify model practices for treating conditions in athletes such as exertional heat stroke.

These position statements call for taking a rectal temperature of those suspected of having exertional heat stroke. "The only accurate measurements of core body temperature are via rectal thermometry or ingestible thermistors. Other devices, such as oral, axillary, aural canal and temporal artery thermometers, are inaccurate methods of assessing body temperature in an exercising person."

"The evidence strongly indicates that in patients with suspected exertional heat stroke, prompt determination of rectal temperature, followed by aggressive, whole-body, cold-water immersion maximizes the chances for survival. **Thus, practitioners employed in settings where the idea of obtaining rectal temperature is a concern should consult with their administrators in advance.**"

This form facilitates that opportunity for consultation.

Acknowledgment

I am the duly appointed representative of the [SCHOOL OR EMPLOYER NAME]. This is to inform you that, in the case of a suspected heat stroke, our operational protocol and the standing orders from our medical director, direct us to determine core temperature via rectal thermometer. If exertional heat stroke is confirmed, our protocol is to activate the Emergency Action Plan, call EMS, and then initiate cold-water immersion. **Remember: Cool First, Transport Second!**

When rectal temperature is not utilized, I understand the position statement makes the following recommendation: "because immediate treatment is critical in exertional heat stroke, it is important to *not* waste time by substituting an invalid method of temperature assessment. Instead, the practitioner should rely on other key diagnostic indicators (e.g., CNS dysfunction, circumstances of the collapse). **If exertional heat stroke is suspected, cold-water immersion should be initiated at once."**

______________________________ ______________________________

Administrator Date Head Athletic Trainer Date

Modified from the 2012 National Athletic Trainers' Association Authorization Form

Figure 2. Sample Heat-Stroke Treatment Authorization Form.

rectal temperature is critical for cool first, transport second to be effective, as this important vital sign would prevent the patient from being transported too soon, which is one of the most common causes of death from EHS.[10] The appropriate cooling rate for CWI should be approximately 0.2°C/min (0.37°F/min) or about 1°C every 5 minutes (or 1°F every 3 minutes) when an AT is considering the entire CWI period from an athlete's collapse to transport.[1,3] In the present case, CWI was extremely effective in reducing the patient's core temperature, as the cooling rate was approximately 0.41°F/min (0.25°C/min).[8,25] This patient displayed a higher-than-average cooling rate with CWI, which could have been due to a combination of factors, such as the patient's small size, sufficient available ice and water, and continuous stirring of the water during cooling. The overall goal for immediate cooling is to reduce the body's core temperature to below the critical threshold of 105°F (40.5°C) within 30 minutes of collapse and preferably to 102°F (39°C) before transport. This temperature helps to prevent cell damage and the long-term complications that can occur when the core body temperature remains dangerously elevated for an extended time.[25] In this case, the AT and the policy stated that the patient would be cooled until the patient's core temperature reached at least 102°F (39°C) before EMS transport. Fortunately, by the time EMS arrived, the patient's temperature was below 102°F, and therefore, it was safe to remove her from the tub. If EMS had arrived earlier, the AT's measurement of the patient's temperature would have supported the explanation to the EMS crew of why she would need to continue to be cooled before transport. It is recommended that ATs speak with their local EMS personnel about their EHS policies and procedures to establish effective communication, just as ATs do regarding a suspected spinal injury. In this case, the AT also followed her written EHI protocol, which included setting up a CWI tub in advance. This equipment allowed the patient to be cooled onsite before transport. In this case report, we demonstrated the importance of having written policies and procedures, the necessary equipment onsite, and an EAP.

Secondary High School Health and Safety Policies

Recently, researchers[16–18,24,26,27] have examined policies and perceptions related to the prehospital care of patients with EHS in the secondary school setting. An analysis[24] of high school athletic association barriers and progress toward implementing health and safety polices in secondary school athletics indicated that executive members of the athletics department had a lack of understanding about mandating a health and safety policy at the state level or only making it a recommendation to secondary high schools.[24] Perceived barriers can also strongly affect whether ATs follow best practice.[17,18,28] Although barriers exist for mandating health and safety policies and procedures, ATs can still implement their own policies and procedures at the high schools with the support of their supervising physician, administrators, and organization. Perceived benefits and self-efficacy have also been shown to affect whether ATs implement best practices about the recognition and treatment of EHS.[17]

The health belief model was recently used to assess secondary school ATs' perceptions and identified that ATs were more likely to implement rectal thermometry for the diagnosis of EHS if they felt there was a perceived benefit to doing so.[17] With the present case, we established the importance of implementing an EHS policy based on best practices; this policy resulted in the patient's survival from EHS and 1 less EHS fatality in the secondary school setting. It is imperative that such a policy is written, reviewed by all stakeholders (eg, supervising physician, administrators, and coaches), and rehearsed by all those who may be present if EHS occurs.

CLINICAL BOTTOM LINE

Exertional heat stroke is a medical emergency, and if not recognized and treated properly, it can lead to death.[1,3,4,8,10] When treating patients, ATs and other health care professionals need to use the best, evidence-based practice methods of rectal thermometry and CWI. The purpose of our case report was to present the implementation of proper recognition and treatment of EHS in a 14-year-old high school cross-country runner. We highlighted the importance of using best practices, having an EAP, and establishing written EHS policies and procedures. We also emphasized the need to confirm the EHS diagnosis via a rectal temperature of >40.5°C (105°F) and CNS dysfunction and to administer cooling first and transporting second. As evidenced by this case, these procedures can be successfully implemented in the secondary school setting. The patient was not admitted to the hospital and had a safe return to sport participation because of these collaborative efforts.

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