Exertional Heat Stroke in Secondary School Athletics

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Abstract:

Exertional heat stroke (EHS) remains one of the leading causes of sudden death in sport despite clear evidence showing 100% survivability with the proper standards of care in place and utilized. Of particular concern are student athletes competing at the secondary school level, where the extent of appropriate health care services remains suboptimal compared with organized athletics at the collegiate level and higher. While rapid recognition and rapid treatment of EHS ensures survival, the adoption and implementation of these lifesaving steps within secondary school athletics warrant further discussion within the sports medicine community. Establishing proper policies regarding the prevention and care of EHS coupled with utilizing an interdisciplinary care approach is essential for 1) minimizing risk and 2) guaranteeing optimal outcomes for the patient.

Keywords: exertional heat stroke | high schoolers | treatment | heat illness

Article:

The unfortunate deaths of athletes from exertional heat stroke (EHS) on an annual basis are a constant reminder of the dangers of this medical emergency. Defined as extreme hyperthermia (internal temperature, >40.0–40.5°C [104–105°F]) with associated neuropsychiatric impairment, EHS is a medical emergency that can be fatal if not appropriately managed ([1–4]). The recent death of Jordan McNair, an American football player at the University of Maryland as a result of the EHS he suffered during a summer conditioning session in May 2018 has renewed the scrutiny of the care that we as health care professionals provide to the patients we are charged with overseeing ([5]). While this example highlights the case of a collegiate football player that did not receive the proper care he deserved, student athletes competing at the secondary school setting are not immune from the risks of EHS. The purpose of this commentary is to discuss EHS in the context of secondary school athletics and highlight ways in which health care providers can optimize survival from this medical emergency.

Incidence of EHS within Secondary School Athletics

Exertional heat illness (EHI) is observed in a number of both boys' and girls' sports at the secondary school level; however, American football has the highest incidence of EHI-related injuries when compared with all other sports (Fig.) ([6,7]). Furthermore, rates of EHI in American football are highest during preseason with data showing that the incidence rate was 9.8 times higher in preseason (1.45 per 10,000 athlete exposure [AE]) than during the regular season (0.15 per 10,000 AE) ([8]). Reasons likely responsible for the increased risk of EHI in American football, and specifically during preseason are 1) the protective equipment required to be worn for the sport, which increases thermoregulatory strain ([9]) and 2) the start of preseason beginning during the month of August, which is typically the warmest month of the year in the northern hemisphere ([10]).

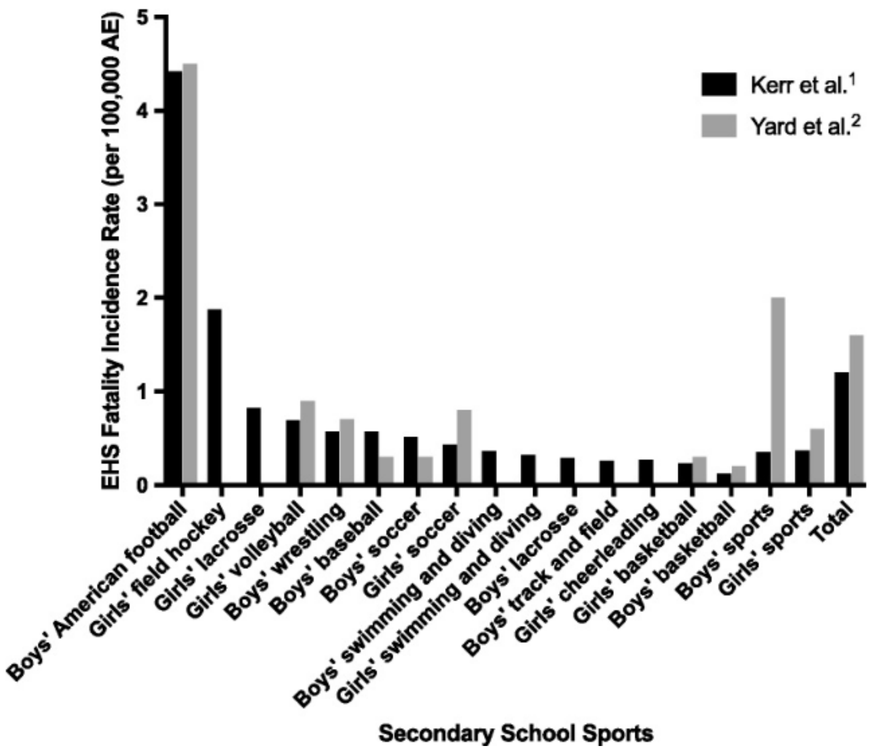

Figure. EHS fatality incidence rates in secondary school sports. Adapted from Kerr et al. ([1]) and Yard et al. ([2]).

Specific to EHS, between the years of 1995 and 2017, there were 63 EHS-related deaths in American football within the United States; 47 of the deaths occurred at the secondary school level alone ([11]). Ninety percent of EHS-related deaths occurred during practice ([11]) and were more likely to occur when environmental conditions were hotter than average for that particular geographical location ([12]). Furthermore, athlete-specific characteristics show that lineman and those with a greater body mass index were more likely to succumb to EHS than their other teammates ([13]). It must be acknowledged, however, that data specific to EHS at the secondary school level may be underestimated due to a lack of a standardized injury surveillance tracking and reporting system coupled with the disproportionate focus on tragedy in mainstream media.

With the risk of EHS being ever present in secondary school athletics, a focused approach on the prevention and appropriate care in the advent of EHS occurring should be prioritized.

Prevention Strategies for Reducing EHS Risk

Without question, having the ability to prevent a medical emergency from occurring during sport is the first step for ensuring athlete survival. For EHS, which is caused by a multitude of both extrinsic (*e.g.*, environmental conditions, clothing/protective equipment, pressure from coaches to perform) and intrinsic (*e.g.,* lack of heat acclimatization, low physical fitness status, hydration status, illness, lack of sleep) risk factors ([1–3]), prevention of the condition is not 100% certain. In addition, individuals succumbing to EHS often present with varying numbers and combinations of known risk factors ([14]), further complicating the development of safe and effective approaches for preventing this condition that account for all risk factors. While not 100% preventable, various considerations and steps can be made to drastically reduce the risk of EHS. Implementation of heat acclimatization and environmental-based work-to-rest ratio guidelines are examples of strategies that can successfully attenuate EHS risk ([1,2,4,15,16]) and will be discussed further below.

Physiologically, the human body is adaptable to the environments in which it is exposed. Heat acclimatization lends a series of cardiovascular, thermoregulatory, and perceptual adaptations that improves one's thermal tolerance and ability to perform physical activity under thermal stress ([17–20]). Heat acclimatization recommendations specific for secondary school athletics ([15]) began to be mandated at the state level starting in 2011 and have been successful in reducing the risk of EHS. Specifically, in states where the secondary school athletics association has mandated that its member schools follow current best practices for heat acclimatization ([15]), there has been a 55% reduction in the incidence of heat-related illness ([21]) and the number of EHS-related deaths in secondary school athletics have been reduced ([22]).

Similar to heat acclimatization, environment-based guidelines to modify work-to-rest ratios during sport and physical activity are essential for abetting the health and safety of secondary school student athletes. As environmental conditions increase, the body's ability to dissipate metabolically produced body heat is reduced, especially when relative humidity increases ([23,24]), resulting in an increased risk of EHS ([10,12,25,26]). Wet bulb globe temperature (WBGT), an index factoring in ambient temperature, relative humidity, radiant load from the sun and wind speed has been extensively used in both the athletics and military settings to dictate activity modifications that have been shown to reduce the occurrence of EHS in these populations ([25–30]). These activity modifications should include increasing the number and length of rest/hydration breaks, extent of protective equipment to be worn, overall length of activity, and thresholds for rescheduling/canceling activity.

In addition, the aforementioned environment-based activity modifications should be established using regional environmental conditions as these are more appropriate given the climatic variability observed over various geographical locations ([1,12,31]). For example, a secondary school student athlete participating in a sport, such as American football, would experience vastly different environmental conditions if they were living in Northwest Washington as compared to Florida. Having a standardized set of activity modifications would not be appropriate in this case given the discrepancies in the environmental conditions individuals residing in these locations are exposed to. However, establishing activity modifications based on environmental conditions specific to a certain geographical region would allow for environmental-based activity modification thresholds that are specific to the relative heat stress one may be exposed to.

Management and Care of EHS

While strategies, such as heat acclimatization and environment-based activity modification guidelines, are effective in reducing the risk of EHS, establishing an evidence-based approach to the management and care of EHS ensures survival from the condition ([1,2,4,16,32]). Evidence shows that when the patient is appropriately triaged and the proper steps are followed for the management and care of EHS, 100% survivability is ensured ([14,33]).

Establishing policies and procedures inclusive of best practices for the immediate recognition, assessment, treatment, and care of EHS optimizes patient outcomes ([1,2,32]). Given that neuropsychiatric impairment, one of two key diagnostic criteria for EHS, is shared with other potentially life-threatening medical conditions (*e.g.,* exertional hyponatremia, head injury, diabetic emergency, etc.), evaluating the patient's mental status in conjunction with an assessment of internal body temperature is vital for proper diagnosis and subsequent treatment. The confirmation of an internal body temperature in the presence of altered mental status allows for the clinician to quickly determine and narrow down the list of differential diagnoses to begin the proper treatment.

Current best practices ([1,2,4]) dictate that rectal temperature be used for obtaining internal body temperature as this method is the only accurate assessment of internal body temperature in exercising persons ([34–38]). Despite the fact that rectal temperature is regarded as the gold standard for temperature assessment in exercising individuals suspected of EHI, data suggests that this is not often utilized at the secondary school level. Specifically, in 225 cases of EHS that were treated at the secondary level, only 2 (0.9%) athletic trainers assessed their patient's rectal temperature compared with the 77 (34.2%) that measured oral temperature ([39]). This is concerning given the extensive research on the topic and the number of position ([1–4]) and interassociation consensus ([16,32,40]) statements that have been published over the past 17 years clearly stating that rectal temperature should be the only method of temperature assessment performed when EHS is suspected.

When EHS is suspected (*i.e.,* when there is no medical provider onsite at the time of collapse and a coach suspects EHS has occurred), or confirmed in the event of a rectal temperature being taken onsite by an appropriate health care provider at the time of collapse, immediate and aggressive whole-body cooling is warranted. The goal is to reduce internal body temperature below 40.0°C within 30 min of collapse ([33,41–46]). Using the mantra "cool first, transport second," or "when in doubt, cool" (*i.e.*, when a nonmedical person suspects EHS and is awaiting the arrival of advanced care), it is vital that the EHS patient is cooled onsite before being transported to the nearest medical facility for follow-up care. Given water's greater capacity for heat transfer over that of air, whole-body, cold water immersion is the gold standard and optimal method of treatment of EHS with average cooling rates approximating $0.22°C \cdot min^{-1}$ ([41,47]). In instances where the utilization of cold water immersion is not feasible (*e.g.*, remote athletics or military settings, inability to transport a tub large enough for all athletes, etc.), utilizing a tarp or other impermeable sheet that can be filled with ice and water for body cooling ([48,49]) is the next best alternative as this cooling method affords optimal cooling rates (>0.155°C·min^{-1}) for treating EHS ([47]). Other alternatives for body cooling, such as using an ice sheet ([50,51]) or covering the body with wet towels ([52–54]), present with mixed results when examining the efficacy of these modalities following exertional hyperthermia and may be acceptable if the aforementioned methods are not accessible. Clinicians must carefully consider the use of these latter alternative methods when deciding on their use for EHS treatment to ensure acceptable (0.078–0.154°C·min^{-1}) cooling rates for whole-body cooling in EHS patients ([47]).

When establishing policies and procedures for the onsite treatment of EHS, appropriate plans for follow-up care must be considered. An interdisciplinary approach with coordination between the onsite athletic trainer, responding emergency medical services personnel and the receiving medical facility allows for a seamless transition of care to optimize patient outcomes. Following successful treatment of EHS, a guided and medically supervised approach through the recovery process is needed to ensure that the student athlete is safe to return to a level of full and unrestricted activity. Particular focus on identifying the factors causing the EHS episode and then monitoring the student athlete as they gradually progress back into physical activity and exposure to heat stress is essential for minimizing future risk of EHS ([55–57]).

Future Directions for Enhancing Patient Care for EHS

Despite the overwhelming evidence showing reduced risk and guaranteed survival from EHS with the proper policies and procedures in place, society is still plagued with EHS-related deaths in the athletics setting. Continued efforts focused on the prevention and care of EHS within secondary school athletics is needed to guarantee that the health and safety of the participating student athletes is upheld.

The development and implementation of health and safety policies specific to the prevention and care of EHS is an essential component for ensuring student athlete safety; however, recent evidence shows that the presence of the aforementioned policies is inadequate at the state level ([58,59]). This is problematic given that approximately one third of secondary schools in the United States are without appropriate medical services ([60,61]) and coaches lack the knowledge to properly manage EHS ([62]). By requiring all secondary schools to adopt best practice heat acclimatization and environment-based work-to-rest ratios, state high school athletics associations can provide oversight over the adoption of best practices for their member schools.

Regardless of the presence of policies at the state level for the prevention and care of EHS, athletic trainers and other health care professionals providing medical services at the secondary school level must guarantee that best practices are in place at the school in which they are employed. With published ([39]) and anecdotal evidence showing that athletic trainers are not likely to use best practices for the assessment and treatment of EHS, we as health care providers must hold one another to a higher standard for the care provided to our patients. Additionally, in situations where barriers for the implementation of best practices exist (*e.g.*, administrator refuses to permit the implementation of best practices), continued efforts for overcoming these barriers are needed. Involving members of the community (*e.g.*, other health care providers, parent groups, risk management groups) may be effective strategies for overcoming noted barriers on this particular topic.

Health care providers, and others involved with athletics at the secondary school level, must continue to advocate for the employment of appropriate medical services in all secondary schools hosting an athletics program and for the implementation of current best practices for not only preventing and managing EHS, but for all causes of sudden death in sport. Without appropriate medical services, health care professionals that are trained in preventing and managing the leading causes of death in sport and physical activity, and without the implementation of policies utilizing current best practices, we will continue to see premature deaths in our young student athletes.

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