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Exertional Heat Illness: Overlooked Risk Factors

1. Introduction

The year of 2023 was the hottest on record, which brings with it increased risks of heat exposure for people around the world (NOAA; Périard et al., "Exercise under heat stress" 2*)*. Climate change is raising the temperature of the Earth, but awareness of the dangers of heat exposure is not rising with it ("How to prevent"; Krohn et al. 1). Furthermore, prolonged heat exposure can often lead to the development of a heat illness, especially in concurrence with vigorous exercise (Périard et al., "Exertional heat stroke" 1). There are many different factors that play into an individual's susceptibility to heat illnesses, but one that is not often discussed is para-athlete status. Individuals with paralytic impairments may have decreased ability to thermoregulate (Alkemade et al. 1), which thereby increases the risk of heat illness in this demographic. However, among all types of athletes, heat illness is a topic that is often allowed to go by the wayside. Exertional heat illness is a serious concern for athletes (especially para-athletes), and they should be more educated on causes, risk factors, and prevention strategies in order to actively prevent such an affliction.

2. Earliest Findings

30 years ago, heat illness was even more of an obscure issue. The heat-related death rate peaked in 1999 at a staggering 587 deaths ("Climate Change Indicators"; "National Environmental"), which prompted efforts to reduce athletes' risk of developing exertional heat

stroke (EHS) throughout the 2000's. The following decade is when many studies began to be published on the causes and treatment of heat illnesses. For example, a study published by the American Journal of Sports Medicine in 2007 suggests that "[exertional] heat illness is generally the result of increased heat production and impaired dissipation of heat," and that "[it] should be treated aggressively to avoid life-threatening complications". At that time, EHS was the third leading cause of death in athletes behind cardiac disorders and head/neck trauma. These studies also gathered information on the myriad of causes that exist for the development of heat illness. Over a dozen types of medications were found to increase risk, as well as medical conditions such as sickle cell anemia, dehydration, sleep deprivation, sunburn, and obesity (Howe & Boden). These inherent qualities were beneficial to identifying high-risk individuals and subsequently providing them with better protection against EHS.

However, paralysis is a medical condition that has largely flown under the radar of exertional heat illness (EHI) studies, only recently gaining attention ahead of the 2020 Olympic games in Tokyo. Studies emerged as early as the 1990's on thermoregulation in paralyzed individuals, independent of the studies on EHI. They found that "individuals with quadriplegia [(paralysis of all four limbs)] had the poorest tolerance to heat" (Yamasaki et al. 1). Nonetheless, paralysis was never directly linked to greater risk of EHI until 2019, when "the [wet bulb globe temperature (WBGT)] 2 weeks prior to the [2020 Olympic] games at the hottest moment of the day (13:00 h) [was] 26.4±2.9°C and 28.6±2.8°C during the games." This would have been the hottest Olympics on record, and the Paralympics would be doomed to the same fate. The same study states that at merely "18.4–22.2°C" there is an increased "risk of exertional heat stroke and heat illness," and recommends that "high risk individuals should be monitored or not compete." 22°C is already a risky temperature for athletes to compete, let alone at temperatures higher than

28°C. Acknowledging the risk factor for paralyzed athletes, the researchers note that the heat would “impose considerable heat strain” on the Paralympic athletes since they “often have a reduced ability to thermoregulate.” (Gerrett et al. 1-3).

3. Environmental Causes

While medications and medical conditions are noted as “internal factors” in the onset of heat illness, there also exist “external factors” pertaining to the environment. In fact, as researchers have looked farther into the epidemiology of EHI in more recent years, one’s environment is often the most significant determinant of risk of EHI. A research paper written by Julien Périard, a professor at the University of Canberra Research Institute for Sport and Exercise and expert on EHI, found that increased ambient temperature, high humidity, low winds, and insulating clothing can all increase risk of people in such an environment developing a heat illness (Périard et al., “Exercise under heat stress” 3-6). This translates into an even higher risk for athletes to develop EHI, combining a sub-optimal environment with high physical exertion. Para-athletes are at an even greater risk in conditions such as these, as they have a lessened ability to maintain their body temperature even in mild climates (Alkemade et al 1). Périard also asserts that overall athletic performance is hindered by these external factors, with heat causing fatigue and increased perspiration rates, which only increases strain to maintain a normal body temperature (Périard at. al., “Exercise under heat stress” 3). Furthermore, a separate study led by Périard listed uniforms as an environmental cause of EHI, as they can “potentially impede skin surface heat dissipation” (Périard et al., “Exertional heat stroke” 2). Heat dissipation is paramount in maintaining a safe core temperature, and so any obstruction to this process can be cause for concern regarding the vulnerability to EHI. All of these factors directly contribute to high core temperature in athletes, as opposed to the predispository nature of internal factors.

Yet another determinant that can magnify the threat of heat illness is the environment that one's body is accustomed to. Environments can be adapted to by either acclimation (artificial adaptation) or acclimatization (natural adaptation), both of which typically entail training and spending time in an environment with a similar temperature and humidity level to the target environment. Failure to acclimate to one's environment can greatly increase fatigue and risk of EHI/EHS in athletes. A study done by Périard in 2015 has shown that it takes approximately 5 days in an unfamiliar environment to fully acclimate to it, at which point 0% of subjects experienced heat syncope during vigorous exercise. This is a significant improvement over the 44% of subjects that experienced such symptoms after the same intensity of exercise and only one day of acclimatization (Périard et al., "Adaptations and mechanisms" 6). These results confirm that athletes need to condition their body to work efficiently in the competition environment, and not doing so can lead to harmful results such as heat syncope. In addition to this, several other studies have concluded that lack of heat acclimation/acclimatization is correlated with lower blood flow rates to crucial parts of the body, most notably, the skin. It is also known to cause increased perspiration in response to thermal strain (Périard et al., "Exercise under heat stress" 45; Périard et al., "Adaptations and mechanisms" 7; Gerrett et al. 1-10), which only decreases hydration levels as well as overall heat dissipation from the body. Greater skin temperature and decreased heat dissipation are textbook causes of EHI, so these circumstances should be avoided at all costs. Dehydration is also known to weaken thermoregulation (Périard et al., "Exertional heat stroke" 4; Périard et al., "Exercise under heat stress" 40-41), so athletes' acclimation to their environment is crucial to maximize performance while minimizing fatigue and susceptibility to EHI.

4. Mitigation Strategies

Much of the earlier research on this topic described the stages of heat illness as a continuum, and most prescribed simply "aggressive cooling" as treatment (Howe & Boden; Périard et al., "Exertional heat stroke"; Périard et al., "Exercise under heat stress" 1; Krohn et al. 1-9). However, as more research has been done on this topic, it appears that it is not enough to simply treat exertional heat illness, and that prevention is far more effective at reducing the overall number of EHI incidents, and most importantly, decreasing fatalities due to EHS.

As with causes, methods proven to have a significant impact on likelihood of a patient to develop an EHI were largely consistent across studies. The most often mentioned methods were ensuring hydration, rest, and prior acclimatization. This means athletes should train in the competition environment for at least 5 days prior to the event, gradually increasing the amount of equipment worn, as some uniforms (e.g., football) may be more insulating than others (Krohn et al.; Howe & Boden 7). Additionally, athletes must consistently drink water throughout the event, even if they do not perceive thirst, as "*ad libitum* [(as needed)] water intake can result in incomplete fluid replacement or voluntary dehydration during exercise heat stress…" (Périard et al., "Adaptations and mechanisms" 5). Athletes cannot purely rely on thirst levels to hydrate themselves, and must do so proactively to maintain a strong thermoregulatory system during exercise. This ensures adequate blood flow performance and thus builds stronger resistance to EHI/EHS. In regards to rest, Périard suggests "mandated work-to-rest ratios," but having had adequate sleep the night before is arguably more important in reducing fatigue and thereby thermal strain. One can have many breaks during exercise, but if they slept for an insufficient amount of time the night before, they will be tired and fatigued no matter what. Rest must be combined with hydration and acclimatization to actively prevent the onset of EHI.

5. Limitations

These strategies have been proven to be effective in mitigating EHI risk, but they can be unfeasible in certain situations. For instance, it may not always be possible for athletes to acclimate to the environment, as the conditions may not allow for it. As previously mentioned, this occurred before the 2020 Olympics in Tokyo, which was the main contributor to the 78 athletes that developed EHI during the games, even with extra precautions in place (Soligard et al.). Moreover, athletes that travel often are at risk because they simply do not spend enough time in each location to become properly acclimated. For athlete rest time, the amount of rest that can viably be offered during exercise may be limited by the sport in question, and it is difficult to mandate a bed time to ensure adequate sleep as well. These things can impede the prevention of EHI through the methods listed.

Simultaneously, limitations concerning treatment of EHI also exist. Typically, a cold bath is prescribed to reduce core temperature (Howe & Boden 7; Hosokawa et al. 3-4), but this is not always possible or trivial to provide. Thick pads such as those used in football can greatly obstruct the administration of care, especially in an instance of EHS, where the athlete may not be able to take it off themselves. Treating para-athletes gives rise to an entirely new set of challenges, mainly due to the lack of resources and studies on EHI/EHS treatment specific to their condition (Fukuhara et al. 1-2). The typical cold bath technique may not be convenient when an athlete is in a wheelchair, and may require a team of people to coordinate. Additionally, some athletes with mental impairments may not be cooperative in efforts to cool them down via cold bath (Hosokawa et al. 2-4). Thus, prevention is the most consequential measure to take against exertional heat illness in para-athletes.

6. Athlete Mentality and Awareness

Toxic mentalities among athletes also hamper EHI prevention, and can indirectly increase risk by decreasing hydration. It was stated previously that *ad libitum* water intake is not sufficient to maintain adequate hydration during exercise, and this is due to a multitude of factors. It seems that athletes aren't taking advantage of their opportunities to maintain their hydration and temperature as much as they need to be. As sports medicine professor Austin Krohn reports in a research paper, "even with increased efforts in promoting education and hydration, the incidence of death from exertional heat stroke continues to rise" (Krohn et al. 1). The answer as to why likely has to do with athlete mentality and stoicism. A study published by Malvin Janal, a Health Research Specialist at NYU, observed the perception of pain among athletes during exercise under different adverse conditions. He discovered that, when he "evaluated the effects of exercise on innocuous as well as noxious intensities of heat and ischaemia[,] [exercise] diminished the perception of painful but not non-painful levels of heat" (Janal 2). As a result, athletes may not realize that they are experiencing hyperthermic (excessively high body temperature) symptoms, and possibly developing EHI. If an athlete does not realize that they are experiencing such symptoms, they are likely to continue play when they should be taking a break and/or hydrating. Thus, athlete awareness of their condition is essential to the prevention of EHI. However, even when athletes are aware of the heat stress they are under, they may continue to play in spite of this, often because of internal pressures to perform well. Périard agrees with Janal, asserting that the high levels of motivation and exertion seen in professional sport can inhibit natural responses to hyperthermia (Périard et al., "Exertional heat stroke" 2). This abnormal ignorance to heat stress can cause escalation of EHI in athletes, and can potentially lead to life threatening consequences. Therefore, athletes must be fully aware of

their cooling and hydration needs, and be consistent with employment of prevention strategies to mitigate risk of EHI during play.

7. Conclusion

In sum, exertional heat illness and exertional heat stroke are extremely serious and prevalent ailments incurred by athletes, and there are many risk factors associated with vulnerability to them. Para-athletes are at an increased risk under all circumstances due to their impaired thermoregulatory system, and should take extra precautions to avoid EHI/EHS development. Para-athletes also introduce complications to the treatment process, and so their condition exponentially decreases their ability to both prevent and treat EHI/EHS. Athletes, and especially para-athletes need to be fully aware of the dangers of these illnesses, and be educated on the correct steps to take to curtail risk. This education combined with increased opportunities for rest, hydration, and cooling for athletes at sporting events can keep heat-related illnesses and deaths to a minimum.

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