An Exertional Heat Stroke Survivor's Return to Running: An Integrated Approach on the Treatment, Recovery, and Return to Activity

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Abstract:

Context: Evidence-based best practices for the recognition and treatment of exertional heat stroke (EHS) indicate that rectal thermometry and immediate, aggressive cooling via cold-water immersion ensure survival from this medical condition. However, little is known about the recovery, medical follow-up, and return to activity after an athlete has suffered EHS. Objective: To highlight the transfer of evidenced-based research into clinical practice by chronicling the treatment, recovery, and return to activity of a runner who suffered an EHS during a warm-weather road race. Design: Case study. Setting: Warm-weather road race. Participant: 53-y-old recreationally active man. Intervention: A runner's treatment, recovery, and return to activity from EHS and 2014 Falmouth Road Race performance. Main Outcomes: Runner's perceptions and experiences with EHS, body temperature, heart rate, hydration status, exercise intensity. Results: The runner successfully completed the 2014 Falmouth Road Race without incident of EHS. Four dominant themes emerged from the data: predisposing factors, ideal treatment, lack of medical follow-up, and patient education. The first theme identified 3 predisposing factors that contributed to the runner's EHS: hydration, sleep loss, and lack of heat acclimatization. The runner received ideal treatment using evidence-based best practices. A lack of long-term medical care following the EHS with no guidance on the runner's return to full activity was observed. The runner knew very little about EHS before the 2013 race, which drove him to seek knowledge as to why he suffered EHS. Using this newly learned information, he successfully completed the 2014 Falmouth Road Race without incident. Conclusions: This case supports prior literature examining the factors that predispose individuals to EHS. Although evidence-based best practices regarding prompt recognition and treatment of EHS ensure survival, this case highlights the lack of medical follow-up and physician-guided return to activity after EHS.

Keywords: heat illness | cold-water immersion | road race

Article:

> At about the 5.5-mile mark of the race route I remember running past my daughter in the crowd; then I remember passing the 10K mark as the crowds were building near the finish line of the race. Unfortunately, the last thing I remember on the race route was

passing the 10K mark. My mind blacked out at that point, but my body kept running. Around the final corner and up the last hill my body went while my mind was absent.

This report is similar to those of the 274 exertional-heat-stroke (EHS) patients who have been treated over 18 years at the Falmouth Road Race (FRR).[1] The FRR is an annual race, taking place the second or third weekend in August in Falmouth, MA, USA. The 11.3-km FRR has gained notoriety in both national and international racing circuits, recording an average of 10,669 finishers over the last 5 years. Although marathons are longer in duration, EHS is more likely to occur in shorter races due to runners competing at a higher intensity during these shorter races than during a marathon. For example, the Twin Cities Marathon in Minnesota has approximately 1 or 2 cases of EHS per 10,000 entrants,[2] while the FRR has experienced 15.2 ± 13.0 EHS cases per year with an incidence rate of 2.13 ± 1.62 EHS cases per 1000 finishers over the last 18 years.[1]

Although a high incidence rate of EHS has been observed at the FRR, a 100% survival rate has been reported in runners treated in the finish-line medical tent.[1] Appropriate recognition and care of EHS are not commonplace in many road races across the United States, but the protocol at the FRR uses evidence-based practice for EHS that includes temperature assessment via rectal thermometry[3–5] and rapid cold-water immersion.[6,7]

EHS at Falmouth

Multiple reasons emerge regarding the high incidence rate of EHS at the FRR. First, the FRR is 11.3 km in distance, which enables runners to exercise at a higher intensity for the entire duration of the race. High-intensity exercise rapidly increases metabolic heat production within the working muscles, causing a rapid increase in body temperature to increase the risk of EHS. Second, the FRR takes place in mid-August, exposing runners to extreme environmental conditions. Runners routinely experience high ambient temperatures coupled with high relative humidity and a high radiant load from the sun, especially during the last half of the race.[8] Third, the start time of the race is during the hottest hours of the day, often set at 11:00 AM prior to 2010. Finally, although not a specific factor related to the FRR, the level of heat acclimatization, fitness status, sleep loss, hydration status, and age of the participants vary greatly and are all contributing factors that may predispose one to EHS.

Predisposing Factors for EHS

In an effort to better understand the reason for such high prevalence rates at the FRR, we must first examine what we currently know about the factors that predispose individuals to EHS. Rav-Acha et al[9] identified low physical fitness, sleep deprivation, physical effort unmatched to physical fitness, absence of medical triage, training during the hottest hours of the day, high heat load, and high solar radiation as the top predisposing factors leading to death from EHS. These factors range from intrinsic factors (ie, physiological limitations) to extrinsic factors (ie, environmental conditions or organizational conditions).

High levels of physical fitness benefit individuals exercising in the heat, as they provide physiological adaptations such as increased cardiac output and blood volume, improved oxygen delivery to exercising tissues, and an improved thermoregulatory capacity to improve heat tolerance.[10] Without these adaptations, the body is placed at a disadvantage during exercise in the heat due to the demand for blood both at the skin and the exercising muscle.[10] For example, in the 627 cases of exertional heat illness in Marine recruits, those whose 1.5-mile (~2.4-km) run time was >12.9 minutes were 5.61 times more likely to suffer a heat illness.[11] In addition, sleep deprivation has also been shown to stress the human body by increasing circulating hormones such as cortisol.[12] Sleep deprivation has been shown to increase exercising body temperature and decrease sweat rate, which can negatively influence one's ability to thermoregulate appropriately.[13,14]

The extrinsic factor "physical effort unmatched to physical fitness" identified by Rav-Acha et al[9] is difficult to quantify but is often present in situations with excessive internal or external motivation (ie, military basic training, road races, or competitive sports such as American football). Normally, the critical-internal-temperature hypothesis, whereby the body reduces exercise intensity as it nears 40°C, or the feed-forward- or self-paced-temperature hypothesis, where the body reduces exercise intensity as it anticipates the rise in body temperature, would protect one from EHS. However, it is still unclear how physiological defense mechanisms can be overridden by psychological drive and/or perceptions.[15] Other extrinsic factors such as training during the hottest hours of the day and extreme environmental conditions, specifically, high heat load or wet bulb globe temperature (WBGT) >27°C, drastically alters the body's ability to remove heat and have been shown to increase risk for heat illness.[8,16]

Although there is a firm understanding in the sports-medicine community regarding the evidence-based methods for recognition and treatment of EHS, there is a lack of evidence linking predisposing factors to EHS and about the return to activity of these patients. The purpose of this investigation was to chronicle the treatment, recovery, return to activity, and perceptions of a recreationally active runner competing in a road race exactly 1 year after suffering from EHS. Specifically, we aimed to identify predisposing factors that led to the individual's EHS and his course of recovery, return to activity, and race performance 1-year postincident.

Materials and Methods

We selected a case-study design to describe and understand the experiences of a runner who suffered an EHS while running the FRR. Following the parameters of a case-study design, we bound ours by condition (EHS) and activity (running). Our boundaries allow us to present the findings within a reasonable scope, as well as allowing the findings to be transferrable to others who are bound within the same capacity.[17]

Participant

After approval by the institutional review board at the University of Connecticut, the runner gave both written and verbal informed consent to participate in the study. The runner was a recreationally active man (age 53 y, weight 79.5 kg, body fat 18.9%) who had suffered from an EHS during the 2013 FRR.

Procedures

The runner met with the researchers the day before the 2014 FRR to obtain an ingestible thermistor (HQ Inc, Palmetto, FL) to measure body temperature during the race. After he was given the ingestible thermistor and instructed on its proper use, he was then familiarized to with a global positioning satellite (GPS) –enabled watch with heart-rate monitor (Run Trainer 1.0, Timex Group, Middlebury, CT).

On the morning of the race, the runner arrived at the research tent and provided a urine sample to assess hydration status using urine specific gravity (Atago Model N-1, Tokyo, Japan) and urine color.[18] His body mass was determined using a digital scale (Tanita Model BWB-800A, Tokyo, Japan), and body-fat percentage, using 3-site skin folds (Lange Skinfold Caliper, Cambridge, MD) at the chest, abdomen, and thigh; measurements were obtained using the Jackson-Pollock method.[19] Prerace body temperature was also measured to ensure that the gastrointestinal pill was still present in the body. The runner was then fitted with a heart-rate strap and GPS watch that were to be used to measure heart rate and velocity during the race.

On finishing the race, the researchers met the runner at the finish-line research tent, where they collected the GPS watch and heart-rate monitor and measured gastrointestinal temperature. The runner then provided a postrace body mass and urine sample to assess body-mass losses.

The day after completing the 2014 FRR, we e-mailed the runner a document containing a series of open-ended questions to evaluate his recovery and return to activity after his EHS at the 2013 FRR, as well as his preparation for the 2014 FRR. After completing the questionnaire, the runner returned it to us for analysis.

Open-Ended Questionnaire

Our descriptive case study used a structured-interview guide that allowed us to describe the experiences of our runner in the real-life context in which it occurred. The runner responded to a series of questions designed to learn about the circumstances leading to his EHS and his eventual return to running after it. Question development was made from a literature review, expert knowledge, and the research team’s understanding of the EHS case itself. We reviewed the questions before giving them to our participant. He was given the questions in a written document to allow him time to reflect and gather his thoughts to provide an accurate reflection of his experiences with his EHS before, during, and after its occurrence.

Data Analysis

Data from the questionnaire were evaluated using a general inductive approach, which allowed us to gain a global understanding of the participant’s experiences and focus the main findings to the research agenda. Our study is grounded by the use of a purposeful sample, the use of a research team to limit bias during data collection and analysis, and an independent review of the procedures before data collection.[5] All physiological measures were reported as descriptive measures.

Results

Qualitative Results

After analysis of the open-ended questionnaire, four dominant themes emerged: predisposing factors leading to EHS, ideal treatment, lack of medical follow-up, and patient education with the subthemes prior and current knowledge of EHS. Each theme is presented next, with supporting quotes and data from the participant.

Predisposing Factors Leading to EHS. The runner identified 3 factors he believes contributed to the cause of his EHS at the 2013 FRR based on his discussion with the treating medical staff immediately after his recovery: lack of sleep, dehydration, and lack of heat acclimatization (Figure 1). Lack of sleep, particularly the participant's lack of sleep the night before the race, was identified as a factor that could have led to his EHS. In previous years running the FRR, the runner always planned for 8 hours of sleep the night before the race, but for the 2013 race, he was only able to get 5 hours of sleep. In addition, his occupation required regular conference calls with partners in Asia, requiring him to obtain less than optimal sleep on a regular basis.

Lack of sleep
"I deal with numerous companies and individuals in Asia on a Daily basis. Because of the 12-hour time-zone difference, my workday tends to be quite long."
"But the added work time for me has replaced a few hours of normal deep-sleep time in the early morning."
"I plan on 8+ hours of sleep the night before Falmouth is run but only got 5 hours this year."
Dehydration
"I did not drink enough while running."
"I should have drunk more water along the route to maintain some level of hydration on a hot day."
Lack of heat acclimatization
"Like most runners and humans in general, I do not enjoy running in the heat and burning sun. My preparation for this year's race included about 15–20 runs of 6 miles, but all primarily in the shade and early morning, when the weather was cool and comfortable."
Physical effort and motivation unmatched to physical fitness
"My mind was focused on running the race and breaking my goal of 1 hour. Prior to 2013, the only time I was unable to break 60 minutes was the first year I ran, and that year I ran in 60:04. All other years my times were under an hour so my goal was something certainly attainable."
"I probably could have trained more for the race this year, but I felt confident that I was in good enough shape to run Falmouth and break an hour."

Figure 1. Supporting quotes regarding predisposing factors leading to exertional heat stroke.

Hydration was another area that the runner believes factored into his EHS. Although he drank a bottle of water and a bottle of Gatorade before the start of the race, he took only a few sips of water during the race itself, which occurred during extreme environmental conditions (Table 1). Not minimizing fluid losses during the race may have exacerbated the rise in his body temperature causing his EHS, given that environmental conditions were similar in both races.

Finally, the runner attributes his lack of heat acclimatization and fitness as a causative factor leading to his EHS. The runner cited that his race preparation for the 2013 FRR included only 15 to 20 runs of 6 miles (~9.7 km), each occurring in the early morning when environmental conditions were cool.

Table 1. Comparison of Runner's Performance Between the 2013 and 2014 Falmouth Road Races

	Falmouth Road Race	
	2013	**2014**
Finish time (min)	61:03	62:47
Mean pace (min/mile, min:s)	8:43	8:54
Mean heart rate (beats/min)	unknown	164
Finish body temperature (°C)	42.05	39.67
Body mass loss (%)	unknown	2.01
Environmental conditions		
ambient temperature (°C)	26.5 ± 3.1	25.3 ± 0.6
relative humidity (%)	39.3 ± 9.7	73.9 ± 4.1
wet bulb globe thermometer (°C)	24.3 ± 2.3	23.7[a]
Sleep in 24 h prerace (h)	5	7
Hydration during race	no	yes
Extrinsic motivation	yes	no

[a] Only measured at the start of the race.

Ideal Treatment. On entering the finish-line medical tent at the 2013 FRR, the runner's rectal temperature was assessed and measured at 42.05°C. Although he presented in a lucid mental state, after 2 to 3 minutes he proceeded to experience central nervous system dysfunction including disorientation, confusion, and excessive emotional and repetitive verbal responses. He was immediately taken to an immersion tub, where his torso was placed in ice water. Exposed extremities, including his head, were covered with ice towels that were rotated regularly (Figure 2). Table 2 depicts the runner's time course of treatment in cooling his body to below the critical threshold for cell damage. Due to experiencing hypothermic overshoot from the probable transient paralysis of his hypothalamus, the runner was transported to the local hospital for controlled rewarming. Within 3 hours, all vital signs and body temperature returned to normal and the runner was discharged from the hospital.

"The next thing I remembered was being surrounded by 6 or 7 people working frantically trying to cool my body temperature down in the medical tent that is manned at the finish line of the race route."
"The medical team immediately put me in an ice bath and started working to get my temperature down."
"I am extremely lucky that experts in treating exertional heat stroke grace the medical tent at Falmouth."
"In my mind, if the team from the Korey Stringer Institute and from Cape Cod Healthcare did not treat me that day, I could have died, no doubt about it."
"While others were working on my body, Clinician A was working on my mind to keep me occupied and conscious. This was a huge part of the treatment for me as Clinician A tried to keep me calm and kept me informed of what was going on with my treatment. I can tell you that I was not calm and was panicking for sure due to the heat stroke."

Figure 2. Supporting quotes regarding ideal treatment of exertional heat stroke.

Lack of Medical Follow-Up. The return to activity after the runner's EHS lacked supervision and follow-up by an appropriate medical professional (Figure 3). The runner returned to physical activity 3 days after suffering his EHS by participating in weekly softball games and resuming regular outdoor activities (ie, walking, mowing the lawn and other yard work). He began full-intensity exercise 1 month post-EHS by adding twice-weekly basketball games to his exercise regimen.

Table 2. Time course of Treatment for the Runner's Exertional Heat Stroke

Time of day[a]	RT, °C	Notes
11:09	42.1	Initial RT
11:10	42.1	Placed in cold-water-immersion tub
11:12	41.9	
11:15	41.8	
11:18	41.4	
11:20	41.2	
11:21	40.7	
11:25	40.0	
11:29	39.6	Taken out of tub
11:31	39.8	Placed back in tub[b]
11:33	39.6	
11:35	39.0	Taken out of tub
11:42	36.6	
11:45	35.9	
11:49	35.4	Transported to hospital[c]

Abbreviation: RT, rectal temperature.
[a] All AM. [b] Decision warranted due to increase in RT. [c] Decision based on need to rewarm runner and the capabilities available to do so at hospital (ie, Bearhugger).

"I had my annual physical exam with my primary care doctor several months after my heat stroke. Standard annual blood work taken and all results normal. No other medical test performed."
"I was never given any restrictions by any medical professional as a result of my heat stroke."
"Return to physical activity was done at my own discretion."
"I returned to physical activity 3 days after my heat stroke."
"I took it easy for the first few weeks after exertional heat stroke but then began full activity as I would normally do if the exertional heat stroke never happened."
"First true intense exercise was basketball, which began 9/10/2014. 1.5 hours of full intensity twice per week."

Figure 3. Supporting quotes regarding the runner's lack of medical follow-up.

After being medically discharged from the hospital after his EHS, the runner did not follow up with his primary care physician postincident, nor did he receive any exercise restrictions from a physician. He did, however, have his annual physical exam a few months postincident, in which all laboratory work returned normal. Other than reporting fatigue within the first 3 to 4 days postincident, all return to activity was performed at the discretion of the runner.

Patient Education

Prior Knowledge of EHS*:* Before suffering the EHS, the runner had little to no knowledge of the risk factors leading to EHS. Although he was well aware of the hot conditions commonly observed at the FRR, as the 2013 race was his eleventh time competing in it, he did not think that the 2013 race was going to be different from his previous races. In addition, he had no prior knowledge in preventing or identifying the risk factors for EHS, and it was not until after the collapse that he was able to identify the factors that had predisposed him to suffer EHS (Figure 4).

Current Knowledge of EHS*:* After being treated for EHS, the runner sought out information to get a better understanding of it and the reasons that predisposed him to suffering from this condition. In speaking with a member of the treating medical staff at the FRR, as well as seeking out advice from experts in the study of EHS, he gained knowledge on the causes and prevention strategies of EHS that aided him in his preparation for the 2014 FRR. In becoming educated about EHS, the runner was able to identify the factors that most likely led to his EHS and how to prevent them (Figure 4). It should be noted that the participant's primary physician provided no information during his annual physical examination, conducted in the months after his incident.

Prior knowledge
"I often wondered what went on in the medical tent, as I do not know anybody that had ever had to visit it."
"People, including me, think that running for an hour you don't need to continue to hydrate since it is a pretty short period of time."
Current knowledge
"The reason why I mention this is that I believe this reduction in quality sleep time probably contributed to my frightening experience [exertional heat stroke] on August 11."
"Went to sleep around 10 PM and woke up around 5 AM on race day. Average 7 hours of sleep per night the weeks before the race ."
"Additional hydration prior to hotter runs."
"Day before the race was rest and hydration."
"I stopped at maybe 5 water stops and drank at every one and also poured water on my head. Hydration was much better in 2014, and I felt good the entire race."
"Runs in early August were done in warmer temperatures to help heat acclimate."
"If I had trained more in the hot sunshine, my body would have been more acclimated to the heat on race day and maybe I would have avoided heat stroke."
"I know I will be training longer and in hotter conditions when I prepare for Falmouth in 2014."
"I have learned a lot about exertional heat stroke since my experience at Falmouth Road Race." "Not hydrated sufficiently, lack of sleep, body not acclimatized to the heat" as the predisposing factors; "Elevated body temp, loss of consciousness, mental confusion" as the signs and symptoms; and "Proper hydration, sufficient and consistent sleep, training in the heat to get the body used to race-day conditions" as the prevention strategies.
"Actual time in 2014 ended up being my slowest time ever at 1:02:47, which is about 9-minute-mile pace. I felt great after the race, so my time suffered a little but my health was great."

Figure 4. Supporting quotes regarding the runner's patient education.

Quantitative Results

Table 1 represents the comparison between the participant's performance and other physiological variables in both the 2013 and 2014 FRRs. Figure 5 depicts the estimated rise in body temperature throughout the duration of the race for both races. In addition, the time course of the participant's treatment for his EHS from the 2013 FRR is provided in Figure 5.

Discussion

After suffering EHS at the 2013 FRR, the runner was successfully treated using evidence-based best practices for recognition (rectal temperature) and treatment (cold-water immersion).[3–5,7,20] The prompt recognition and treatment were essential in his survival and long-term health. The runner's experience with EHS helped chronicle and bridge the idea of "evidence to practice" in that the decisions regarding recognition and treatment of his EHS were made based on the current evidence-based research, which attributed to ideal patient-centered outcomes.

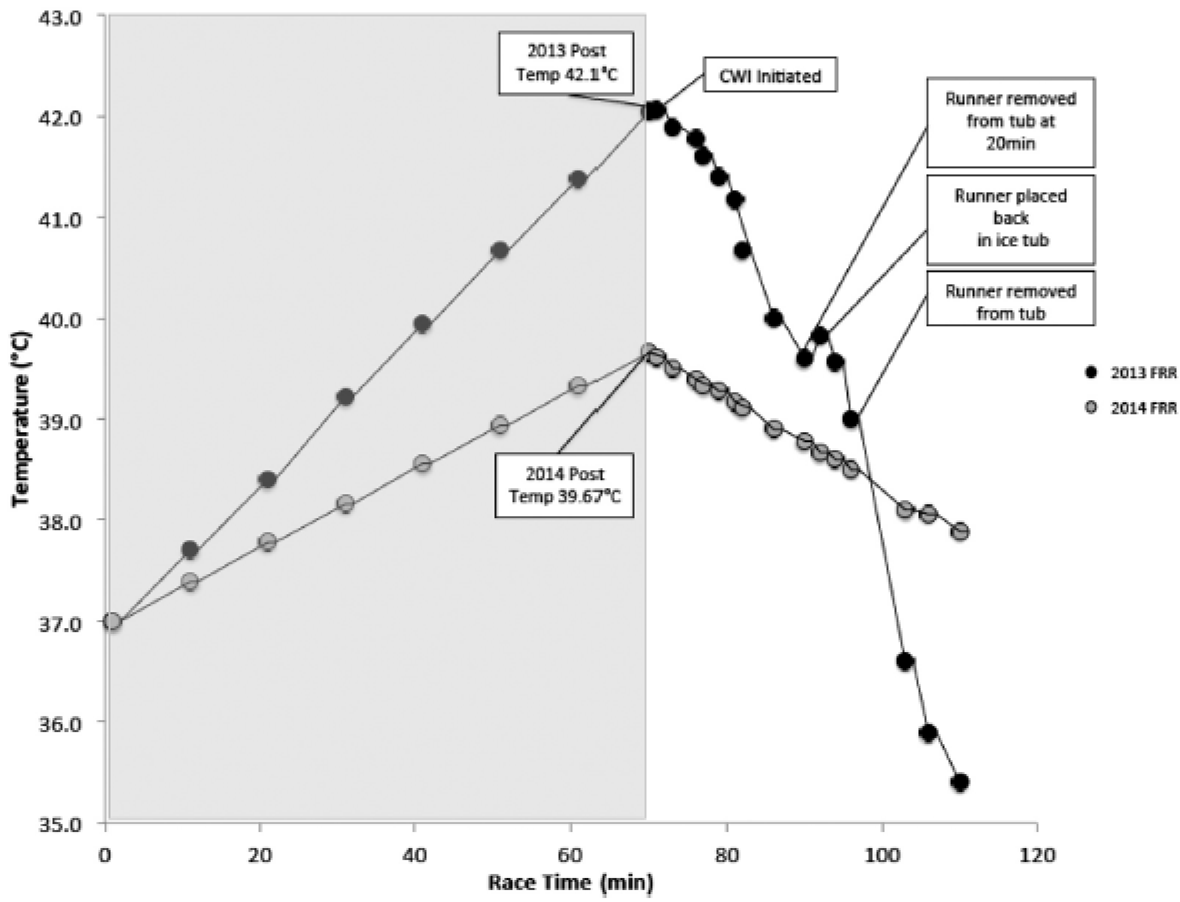

Figure 5. The runner's temperature during the 2013 and 2014 Falmouth Road Races. The shaded box depicts the runner's estimated rate of rise in body temperature based on his immediate postrace rectal temperature and prerace body temperature from the 2014 Falmouth Road Race. The cooling rate in the 2014 race was an estimated value calculated from the passive cooling rates of 32 other runners participating in another study in which passive cooling rate was assessed. Abbreviations: CWI, cold-water immersion; FRR, Falmouth Road Race.

Although the runner was appropriately cared for, there was an obvious lack of medical follow-up after the incident. There were no recommendations given to the runner on discharge from medical care the day of the race by either the medical-tent staff at the race or the hospital providing care, and the runner did not follow up with his primary care physician after the incident. Although most individuals who suffer from EHS fully recover within a few weeks of the injury insult when appropriately cared for,[21,22] some may experience long-term complications such as tissue/organ damage, heat intolerance during exercise in the heat, and cognitive deficits when care is delayed or prolonged.[20,23,24] The potential of long-term, debilitating effects of EHS necessitates the need for supervision from medical professionals familiar with the individual's medical history to oversee all aspects of his or her recovery.[20]

Recommendations from the American College of Sports Medicine[2] suggest that after suffering from EHS, athletes should refrain from exercise and consult a physician for an evaluation and full laboratory workup to ensure normal physiological function. Once all hematologic markers associated with hepatic, renal, and coagulatory function return to baseline values, athletes should then work under the guidance of a physician to begin a progressive return-to-activity protocol back to full activity. This progressive return-to-activity protocol should gradually introduce the individual to increasing intensity, increasing duration, and increasing levels of heat exposure, similar to what is seen during a heat-acclimatization protocol. The goal of this gradual return to activity is to allow the individual to regain his or her heat tolerance during exercise.

Regardless of the follow-up with the patient's primary care physician, the appropriate treatment and initial education were key factors leading to the runner's successful return and completion of the 2014 FRR. For the 2013 FRR, lack of sleep the night before the race and the absent hydration strategy during the race were contributing factors to the runner's EHS. In addition, not having the opportunity to train in hot conditions prohibited him from acquiring the physiological adaptations associated with heat acclimatization. Identifying predisposing factors of hydration, lack of sleep, and lack of heat acclimatization aided in the runner's preparation for the 2014 race. By addressing the predisposing factors of EHS, athletes can reduce the risk of its occurrence during physical activity.[3,9,20,25]

Road races present a unique challenge for medical providers in terms of prevention and predisposing factors associated with EHS. While modifications can be made to help prevent EHS, such as rescheduling the start time or canceling the race when faced with extreme environmental conditions, difficulties arise when attempting to address individual factors such as the runner's fitness level, hydration status, and heat-acclimatization status. In addition, there are no requirements distinguishing who is qualified to participate in these mass-participation events, presenting the possibility of athletes competing with various medical conditions that increase the risk of EHS.

For medical providers at a mass-participation road race, implementing evidence-based protocols for the assessment and treatment of EHS is essential for patient survival. Furthermore, education may prove a useful tool to aid in the prevention of EHS. Race organizers can distribute educational materials related to appropriate hydration before, during, and after training and the race. They can also distribute educational materials discussing the steps to take to acquire the physiological benefits of heat acclimatization and information related specifically to exertional heat illness and EHS for the general knowledge of the runners.

In this case, the athlete was able to return to racing the following year even with less than optimal follow-up. Return to activity after EHS and referral to experienced medical providers needs to be further addressed within the medical community. Furthermore, additional research is needed examining the knowledge of primary care physicians as it relates to return to activity after EHS to allow for the further development of evidence-based recommendations for return to activity. Individuals suffering from EHS need to follow up with their medical providers, who in turn need to work closely with their patients to provide guidance and supervision as they recover and work back to a level of full activity. An example of enhancing the care of runners after EHS can be seen starting at the 2014 FRR, where on discharge from the finish-line medical tent, all EHS patients received a document recommending the course of follow-up and recovery after their incident.

Conclusions

The findings from this study highlight the importance of using evidence-based practice for the recognition and treatment of EHS to ensure patient survival. Nevertheless, there is a lack of evidence supporting return-to-activity guidelines after individuals suffer EHS. Establishing evidence-based return-to-activity guidelines during the recovery from EHS will further enhance patient outcomes and lead to a safer return to physical activity in these individuals.

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