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Exertional Heatstroke Survivors' Knowledge and Beliefs About Exertional Heatstroke Diagnosis, Treatment, and Return to Play

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Context: Little information exists regarding what exertional heatstroke (EHS) survivors know and believe about EHS best practices. Understanding this would help clinicians focus educational efforts to ensure survival and safe return-to-play following EHS.

Objective: We sought to better understand what EHS survivors knew about EHS seriousness (eg, lethality and short- and long-term effects), diagnosis and treatment procedures, and recovery.

Design: Multiyear cross-sectional descriptive design.

Setting: An 11.3-km road race located in the Northeastern United States in August 2022 and 2023.

Patients or Other Participants: Forty-two of 62 runners with EHS (15 women and 27 men; age = 33 ± 15 years; pretreatment rectal temperature [T_{REC}] = 41.5°C ± 0.9°C).

Interventions: Medical professionals evaluated runners requiring medical attention at the finish line. If they observed a T_{REC} of ≥40°C with concomitant central nervous system dysfunction, EHS was diagnosed, and patients were immersed in a 189.3-L tub filled with ice water. Before medical discharge, we asked EHS survivors 15 questions about their experience and knowledge of select EHS best practices. Survey items were piloted and validated by experts and laypersons a priori (content validity index of ≥0.88 for items and scale).

Main Outcome Measures: Survey responses.

Results: Sixty-seven percent (28/42) of patients identified EHS as potentially fatal, and 76% (32/42) indicated that it negatively affected health. Seventy-nine percent (33/42) correctly identified T_{REC} as the best temperature site to diagnose EHS. Most patients (74%, 31/42) anticipated returning to normal exercise within 1 week after EHS; 69% (29/42) stated that EHS would not impact future race participation. Patients (69%, 29/42) indicated that it was important to tell their primary care physician about their EHS.

Conclusions: Our patients were knowledgeable on the potential seriousness and adverse health effects of EHS and the necessity of T_{REC} for diagnosis. However, educational efforts should be directed toward helping patients understand safe recovery and return-to-play timelines following EHS.

Key Words: cold water immersion, recovery, rectal temperature, survey

Key Points

- Exertional heatstroke (EHS) patients understood the lethality of EHS but underestimated the potential for short-term and long-term adverse health consequences.
- Clinicians should never hesitate to acquire rectal temperatures if they suspect EHS, and it is noteworthy that EHS patients reported that rectal temperature assessment was not uncomfortable.
- Clinicians should educate EHS patients about the importance of reporting serious health events, like EHS, to their primary care physicians, as well as how and when to return to normal exercise following EHS.

Exertional heatstroke (EHS) is a potentially life-threatening condition characterized by elevations in body temperature and concomitant central nervous system dysfunction.[1] EHS continues to be one of the leading causes of sudden death in athletes, war fighters, and the physically active.[2,3] Encouragingly, patient survivability is near 100% when EHS is diagnosed quickly by rectal temperature (T_{REC}) and treated aggressively with whole-body cold water immersion within 30 minutes of collapse.[4,5]

EHS incidence varies between 0.37 per 1000 person-years and 2.07 cases per 1000 runners in military and athletic venues, respectively.[3,4] Current evidence is conflicting regarding whether heat illness incidence varies between sexes, with field research in runners and retrospective analyses in the military often reporting conflicting results.[4–8]

Men and women have physiological and physical differences that contribute to their ability to thermoregulate.[9] Some authors have proposed that EHS risk is higher in women because they have physical characteristics (eg, less body surface area) and thermal responses (eg, lower sweat rate and evaporative sweat losses) that are less effective than men.[10] To our knowledge, differences in EHS knowledge between sexes has not yet been reported.

Over the last 15 years, researchers have examined various groups' beliefs, attitudes, and knowledge of EHS and its best practices. Specifically, coaches, athletic administrators, athletic training students, athletic trainers, emergency medical service providers, physicians, and athletes have been surveyed to better understand where knowledge gaps and barriers exist surrounding EHS.[11–22] Understanding what these shareholders know about EHS is vital as future work can improve educational efforts to reduce the prevalence of outdated or inaccurate information about EHS.[12,13,20,23] Because many of these individuals also contribute to, or approve, policies pertaining to health and safety, it is crucial that they understand EHS best practices. Importantly, education can effectively improve EHS understanding, which is critical for removing barriers to implementation.[17,24]

Although several studies report the sports medicine teams' knowledge of EHS and its best practices, little information exists on what patients know.[12,13,17,20,22,24] Shendell et al reported that 89% (945 of 1058) of healthy Georgia marathon runners knew that EHS was the most serious heat-related illness and that it was fatal for many individuals.[22] Unfortunately, it remains unknown what EHS survivors know about EHS and how it could affect their health and return to activity. This is concerning because Stearns et al reported that EHS recurrence was 11%, and EHS survivors had a 3.3 times higher risk of developing a subsequent EHS in the 2 years following their first EHS episode.[25] Understanding what survivors know about EHS may help clinicians identify areas where they need to focus educational efforts to reduce recurrence and ensure safe recovery and return to activity.

The purpose of this study was to learn what EHS survivors knew about EHS along with beliefs of the illness and its corresponding best practices. In general, we asked questions surrounding 3 main themes: (1) the seriousness of EHS, (2) EHS diagnosis and treatment, and (3) EHS recovery and return to activity. We hypothesized that (1) EHS knowledge would differ between sexes and that (2) most EHS survivors would recognize the potential fatality of EHS but lack an understanding of safe recovery and return-to-play strategies.

METHODS

Participants

A total of 8611 and 9198 runners (17 809 total) completed an 11.3-km road race in Falmouth, Massachusetts, in 2022 and 2023, respectively. Sixty-two runners were diagnosed and treated for EHS at the finish line medical tent where our questionnaire was administered (39 in 2022 and 23 in 2023). Forty-two EHS survivors (68% response rate) verbally consented to participate in our study after being told the purpose, benefits, and risks. Our study was deemed exempt and was approved by a university institutional review board.

Instrument

We developed a questionnaire to identify EHS patient perspectives on their EHS experience, including the management of their illness. A team of scientists with expertise related to EHS, comprising 2 athletic trainers and 1 sports-medicine physician, developed a 15-item questionnaire asking about patient knowledge and perspectives on EHS diagnosis, treatment, and follow-up care. Following development, the questionnaire was sent to 2 additional athletic trainers and 1 physician with expertise in EHS. Questions were revised based on their feedback.

To further ensure content validity, 2 additional steps were taken. First, the survey was sent to 2 additional EHS experts who evaluated and rated the questions based on importance, relevance, and clarity. Importance was operationally defined as the question being valuable and having significance for the future of EHS patient experience, research, and clinical practice. Relevance was operationally defined as the question being realistic and relevant, reaching the intended audience, and supporting the researcher's purpose. Clarity was operationally defined as believing that the question is simple, clear, and easily understood. The reviewers were also given the opportunity to provide written feedback on questions to clarify the scores that they gave. Questions were then modified as necessary following expert feedback. None of the questions were eliminated due to poor importance, relevance, or clarity, and only minor copyediting revisions were made. Second, a group of 8 physically active lay-persons were sent the revised survey and asked to rate the questions for validity, feasibility, and clarity. Content validity index (CVI) calculations were derived for both the EHS expert review and the lay-person review using the relevance scores.[26] The expert review for each of the items and the scale in each construct demonstrated an acceptable CVI range for the number of experts as the experts were in universal agreement on the relevance of the items.[27] The lay-person reviews also demonstrated acceptable CVI ranges for the items (0.88–1.00) and scale (0.95) in each construct for the number of reviewers.[28]

Procedures

Runners that required medical attention at or near the finish line were brought to the finish line medical tent. They were triaged and treated per medical race protocol based on their presenting signs and symptoms. If EHS was suspected, the medical team measured T_{REC}. If T_{REC} was $\geq$40°C ($\geq$104°F), the patient was placed in a 189.3-L (50-gallon) tub filled with cold water. Ice towels were also placed over the extremities if segments were unsubmerged. When T_{REC} was $\leq$39.4°C ($\leq$103°F), patients were removed from the tubs and moved to a recovery area per race protocol. While in recovery, and after patients had regained normal central nervous system functioning, we obtained verbal consent to participate in the study. A research assistant read each question from the instrument to the patient and recorded their response. If a question required clarification, the assistant provided it at the time. Patients were then

Table 1. Exertional Heatstroke Survivor Responses to Questions Pertaining to the Seriousness of Exertional Heatstroke

Question	Men ($n = 27$)	Women ($n = 15$)	Aggregate ($n = 42$)
How much do you think EHS affects your health and well-being?[a]	–2 (2.5)	–2 (1.5)	–2 (3)
Is EHS fatal?[b]	Yes: 20, 74% No: 7, 26%	Yes: 8, 53% No: 7, 47%	Yes: 28, 67% No: 14, 33%
How concerned are you about short-term (ie, within the next 2 weeks) damage to your body after this EHS event?[c]	2 (3)	2 (3)	2 (3)
How concerned are you about long-term (ie, >1 month) damage to your body after this EHS event?[d]	1 (3)	1 (2)	1 (2.75)

Abbreviation: EHS, exertional heatstroke.

[a] Response options varied in whole integers with the following benchmarks: –4 = *very deadly*, –2 = *moderate effect in a negative way*, 0 = *not at all*, +2 = *moderate effect in a positive way*, and +4 = *very much so in a positive way or performance enhancing*. Data are shown as median (interquartile range).

[b] Data are shown as frequency and percentage of total.

[c] Response options varied in whole integers with the following benchmarks: 0 = *not at all concerned*, 3 = *moderately concerned*, and 5 = *highly concerned*. Data are shown as median (interquartile range).

[d] Response options varied in whole integers with the following benchmarks: 0 = *not at all concerned*, 3 = *moderately concerned*, and 5 = *highly concerned*. Data are shown as median (interquartile range).

discharged by the supervising physician and allowed to leave the medical tent area with the accompaniment of a family member or friend along with printed discharge instructions.

Statistical Analysis

We calculated means and standard deviations for initial T_{REC} and compared sex using an independent *t* test. Response frequencies and percentages were calculated for non-Likert scale questions and analyzed using χ^2 tests for between-sex comparisons. For Likert scale questions, we calculated median and interquartile range and used Mann-Whitney tests to compare sexes. Significance was accepted at a *P* value of <.05 (Number Cruncher Statistical Software version 2007).

RESULTS

Twenty-seven men (age = 36 ± 15 years) and 15 women (age = 29 ± 13 years) had similar T_{REC} values before being treated with cold-water immersion (men = 41.5°C ± 1.0°C, women = 41.4°C ± 0.5°C, $t_{40} = 0.5$, $P = .65$). Regarding responses pertaining to the seriousness of EHS (Table 1), both sexes reported that EHS had a moderate negative effect on health and well-being, but this did not statistically differ between them ($z = 0.7$, $P = .51$). Although most men and women knew that EHS was potentially fatal ($\chi^2 = 1.9$, $P = .17$), they had relatively low levels of concern about any short-term ($z = 0.3$, $P = .75$) or long-term bodily damage following their EHS ($z = 0.5$, $P = .64$; Table 1).

Regarding EHS diagnosis and treatment (Table 2), both sexes reported being neither comfortable nor uncomfortable having their T_{REC} measured ($z = 1.6$, $P = .11$). Both men and women reported that T_{REC} was the best way to measure their body temperature ($\chi^2 \leq 1.2$, $P \geq .28$) and responded overwhelmingly that it was a necessary part of their emergency medical care ($\chi^2 = 0.01$, $P = .91$). Men and women reported a range of mostly negative emotions because of their EHS, with the top 5 responses being uncomfortable ($n = 18$, 43%), anxious ($n = 15$, 36%), confused ($n = 14$, 33%), mentally exhausted ($n = 14$, 33%), and scared ($n = 13$, 31%).

Regarding EHS recovery and return to activity (Table 3), both sexes similarly believed that their EHS episode did not elevate their risk of having future EHS ($\chi^2 = 0.4$, $P = .52$). Both men and women also believed that they would be fully recovered and able to resume their normal exercise routine within 1 week of their EHS ($\chi^2 \leq 2.3$, $P \geq .13$) and that their EHS would not affect the number of future races that they competed in ($\chi^2 \leq 0.62$, $P \geq .54$). Finally, most men and women indicated the importance of telling their primary care physician about their EHS, but this did not differ between sexes ($\chi^2 \leq 1.1$, $P \geq .29$).

DISCUSSION

To our knowledge, we are the first to interview EHS survivors about their knowledge of EHS along with their beliefs about the illness and its corresponding best practices. We believe that there are 4 main observations from this study. First, our patients had an excellent understanding of the seriousness of EHS, its negative health effects, and potential lethality. Second, most EHS survivors recognized the necessity and accuracy of T_{REC} as part of their medical care and did not report T_{REC} as uncomfortable. Third, future educational efforts should be focused on EHS recovery and safe return-to-activity timelines because survivors had unsafe perceptions in these areas.[29] Fourth, contrary to our original hypothesis, men and women had similar EHS knowledge and beliefs of some best practices. This suggests that pre-existing knowledge about EHS did not differ by sex and is unlikely to be a contributing factor to EHS episodes.[6,9]

Seriousness of EHS

Numerous position statements, roundtables, and consensus statements have been published about EHS lethality and best practices.[1,30–33] These documents improved healthcare professionals' knowledge and best practice adoption and positively affected race preparations and educational events for race participants.[4,11,17,23,24,34] Thus, it is encouraging that most (67%) of our survivors knew that EHS was

Table 2. Exertional Heatstroke Survivor Responses to Diagnosis and Treatment Questions

Question	Men ($n = 27$)	Women ($n = 15$)	Aggregate ($n = 42$)
Overall, how physically comfortable were you when the medical team took your rectal temperature?[a]	5 (6), 5 IDR	8 (7), 3 IDR	5 (9), 8 IDR
Where do you think the best place to take body temperature is to get the most accurate measurement in patients with EHS?[b]			
Armpit (axillary)	2, 7%	0, 0%	2, 5%
Ear (tympanic)	1, 4%	0, 0%	1, 2%
Forehead	1, 4%	1, 7%	2, 5%
Mouth (orally)	3, 11%	1, 7%	4, 10%
Rectum	20, 74%	13, 86%	33, 78%
Do you believe it was necessary for the medical team to have taken your temperature rectally?[b]	Yes: 20, 74% No: 3, 11% IDK: 4, 15%	Yes: 12, 80% No: 2, 13% IDK: 1, 7%	Yes: 32, 76% No: 5, 12% IDK: 5, 12%
How did your EHS make you feel? (Choose all that apply)			
Angry	6, 22%	1, 7%	6, 14%
Anxious	8, 29%	8, 53%	15, 36%
Brave	0, 0%	2, 13%	2, 5%
Calm	6, 22%	0, 0%	6, 14%
Cheerful	0, 0%	0, 0%	0, 0%
Confused	10, 37%	4, 27%	14, 33%
Delighted	0, 0%	0, 0%	0, 0%
Depressed	1, 4%	0, 0%	1, 2%
Enthusiastic	0, 0%	0, 0%	0, 0%
Energized	0, 0%	0, 0%	0, 0%
Frustrated	7, 26%	3, 20%	10, 24%
Happy	1, 4%	0, 0%	1, 2%
Mentally exhausted	10, 37%	4, 27%	14, 33%
Scared	7, 26%	6, 40%	13, 31%
Uncomfortable	10, 37%	8, 53%	18, 43%
IDR	3, 11%	2, 13%	5, 12%
Other	6, 22%	5, 33%	11, 26%

Abbreviations: EHS, exertional heatstroke; IDK, I do not know; IDR, I do not remember.

[a] Response options varied in whole integers between 0 and 10, where 0 = *uncomfortable*, 5 = *neither comfortable nor uncomfortable*, and 10 = *comfortable* or *I do not remember*. Data are shown as median (interquartile range).

[b] Data are shown as frequency and percentage of total.

[c] Responses categorized as "Other" included awful ($n = 2$), fine ($n = 2$), silly ($n = 2$), hot ($n = 2$), disappointed ($n = 1$), lightheaded ($n = 1$), and dizzy ($n = 1$). Data are shown as frequency and percentage of total. Responses are reported descriptively and were not statistically analyzed.

potentially fatal and that it had an overall negative effect on health and well-being. This is consistent with the findings from Shendell et al, who, in a prerace survey of healthy Georgia marathon runners, reported that 90% (945 of 1058) of participants knew that EHS was the most serious heat-related illness, with 53% (555 of 1058) correctly stating that EHS was potentially lethal.[22] Unfortunately, our data also showed that EHS survivors had low levels of concern for short-term or long-term damage to their bodies because of their EHS. Animal models for EHS demonstrate that muscles and several internal organs (eg, the kidneys, liver, and intestines) are significantly damaged within hours after EHS.[35] Similarly, human survivors who required hospitalization due to delayed cooling measures also had alterations in muscle, kidney, and liver enzymes for days and even weeks following EHS.[29,36] Because our patients were diagnosed and treated quickly onsite, the extent of their muscle and organ damage was likely minimized. Consequently, our patients may have underestimated the potential short-term and long-term effects of EHS because they generally felt better following treatment. The extent to which muscle and internal organ damage occurs in EHS patients who receive medical care consistent with best practice recommendations remains unknown. Therefore, EHS education efforts may need to incorporate more information about the potential negative short-term and long-term side effects than just the potential for fatality.[22]

EHS Diagnosis and Treatment

Many health care professionals do not use T_{REC} to diagnose EHS despite numerous laboratory studies showing it having higher validity than other body temperature sites and expert recommendations to include it in emergency policy and procedures.[1,17,23,24,31,37–41] Clinicians consistently cite fear of liability as a main reason for not performing T_{REC} measurements.[16,17,38] Our data indicated that, on average, patients felt that the T_{REC} assessment was neither comfortable nor uncomfortable. In fact, 19% (8 of 42) did not remember their T_{REC} experience. More importantly, 78% of patients (33 of 42) recognized that it was an accurate measurement of body temperature, with 76% (32 of 42) stating that it was medically necessary for their care. These observations suggest that medical providers may be unnecessarily fearful about using T_{REC} measurements to diagnose EHS. Instead, patients trust health care providers to act in their best interests and use best practices in emergency situations. It is also important to note that before

Table 3. Exertional Heatstroke Survivor Responses to Recovery and Return-to-Play Questions[a]

Question	Men ($n = 27$)	Women ($n = 15$)	Aggregate ($n = 42$)
Do you believe your EHS will make you at risk for future heatstroke events?	Yes: 6, 22% No: 15, 56% IDK: 6, 22%	Yes: 4, 27% No: 6, 40% IDK: 5, 33%	Yes: 10, 24% No: 21, 50% IDK: 11, 26%
How long do you think it will take you to completely recover from this EHS event and resume your normal exercise routine?			
<1 week	22, 81%	9, 60%	31, 74%
2–4 weeks	4, 15%	5, 33%	9, 22%
1–5 months	0, 0%	1, 7%	1, 2%
>6 months	1, 4%	0, 0%	1, 2%
Do you believe it is important to inform your PCP about your EHS?	Yes: 18, 67% No: 3, 11% Unsure: 5, 19% No PCP: 1, 3%	Yes: 11, 73% No: 2, 13% Unsure: 1, 7% No PCP: 1, 7%	Yes: 29, 69% No: 5, 12% Unsure: 6, 14% No PCP: 2, 5%
Do you believe your EHS episode will change how many competitions or events you participate in in the future?			
Yes, decrease the number of events	6, 22%	5, 33%	11, 26%
Yes, increase the number of events	0, 0%	0, 0%	0, 0%
No	17, 63%	8, 53%	25, 60%
Unsure	4, 15%	2, 14%	6, 14%

Abbreviations: EHS, exertional heatstroke; IDK, I do not know; No PCP, patient reported that they did not have a primary care physician.
[a] Data are presented as frequency and percentage of total.

insertion of the rectal probe at this race, healthcare professionals were encouraged to tell the patients what they were doing. This brief explanation may also explain the large proportion of respondents who knew where the most accurate measurement site was.

EHS Recovery and Return to Activity

Considerable knowledge gaps exist in survivors' knowledge about safe return to activity and recovery following EHS. First, 50% (21 of 42) of our survivors believed that their EHS would not predispose them to future EHS episodes. However, patients who survive EHS are 3.3 times more likely to experience a subsequent EHS episode within 2 years of a previous EHS episode.[25] Similarly, Phinney et al noted that heat-related illness recurrence risk may be even longer and higher.[42] The authors noted recurrence rates between 1.7/1000 person-years and 7.5/1000 person-years over a 4-year period depending on whether the patient was not hospitalized or hospitalized, respectively.[42] Second, our survivors had dangerous beliefs about how and when they would be fully recovered following their EHS. Thankfully, 69% (29 of 42) reported that it was important to disclose their EHS to their primary care physicians. Unfortunately, most (74%, 31 of 42) believed that they would be fully recovered in <1 week, and 60% (25 of 42) had no intention of modifying the number of competitions they competed in in the future.

Full recovery from EHS takes several weeks, as muscle, liver, and kidney biomarkers are often elevated depending on how long the body temperature remained dangerously elevated.[29,43] Once a physician has verified normal internal organ functioning via blood tests and cleared the patient for activity, an incremental functional return-to-activity exercise regimen can be started. Patients can then gradually be reintroduced to exercise of varying durations and intensities in the heat.[29,44] Heat tolerance tests may also be used to aid clinical decision-making regarding the body's ability to thermoregulate in hot conditions.[44,45] Our patients received excellent life-saving medical care, but it is unknown if they experienced any long-term physiological sequalae of injury or what any follow-up hematological tests showed. However, over 450 EHS patients have been treated with best practices at this race, and 100% have survived.[4] Moreover, patients treated with best practices recover faster and return to normal exercise patterns much more quickly than those that do not receive best practices.[36] Future research efforts should examine the responses of EHS survivors who did not receive some, or all, EHS best practices as this would likely alter the patients' perspectives regarding seriousness and return to activity. Regardless, these results strongly suggest that clinicians should focus educational efforts around safe EHS recovery and return to activity to minimize the risk of recurrence.

We acknowledge the limitations of our study. First, our runners participated in a race well known for having a high incidence of EHS and had access to a 2-minute video about EHS before the race.[4,46] This video informs the runner that body temperature is confirmed rectally if EHS is suspected but does not detail the reasons why or its importance. Watching this video is not mandatory to participate in the race, and we do not have data on whether any of our patients watched the informational video before their race. Consequently, it is possible that our patients were more educated on select EHS best practices than runners who participate in races with fewer EHS cases.[46] Second, our patients may have correctly identified the necessity of T_{REC} because they assumed that the medical team used best practices when treating them. Third, we could not standardize the amount of recovery time before our participants completed our questionnaire and patients were asked to recall information from when they were impaired. However, all of our patients were stable at the time of questioning, and all were medically discharged by a physician. Fourth, our patients were adult runners, and our results may not be

applicable to other populations (eg, secondary school patients). Clinicians working with younger populations should be cautious about making inferences from our results, especially as it pertains to the perceived necessity and comfort of rectal thermometry. Fifth, 12% of our survivors (3 men and 2 women) self-reported a prior history of EHS. Thus, a few respondents may have been more familiar with EHS best practices than others, but the low recurrence rate prohibits statistically comparing their responses to first-time EHS patients. Given our sample size and the number of patients experiencing EHS for the first time, we do not believe this affects our interpretation of the data.

In conclusion, our EHS patients, regardless of sex, were well educated on the potential seriousness and adverse health effects of EHS and the necessity of T_{REC} for diagnosis. Clinicians should never hesitate to perform T_{REC} if they suspect EHS due to the importance of accurate temperature measurement, and it is noteworthy that T_{REC} was not deemed uncomfortable. Future educational efforts should be directed toward helping patients understand short-term and long-term effects of having EHS and how and when to safely return to activity.

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