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Knowledge and Belief Toward Heat Safety and Hydration Strategies Among Runners: A Preliminary Evaluation

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Context: Little is known about how educating runners may correct common misconceptions surrounding heat safety and hydration strategies.

Objective: To investigate (1) beliefs and knowledge about heat safety and hydration strategies among recreational runners and (2) the effectiveness of an educational video in optimizing performance in the heat.

Design: Cross-sectional study.

Setting: Survey.

Patients or Other Participants: A total of 2091 (25.1%) of 8319 runners registered for the 2017 Falmouth Road Race completed at least 1 of the 3 administered surveys.

Intervention(s): A 5.3-minute video and an 11-question survey regarding heat safety and hydration strategies were developed, validated, and implemented. The survey was e-mailed to registrants 9 weeks before the race (PRE_{RACE}), after they viewed the video ($POST_{EDU}$), and the afternoon of the race ($POST_{RACE}$).

Main Outcome Measure(s): The total score for responses to 2 multiple choice questions and nine 5-point (response range = *strongly agree* to *strongly disagree*) Likert-scale questions.

Results: The PRE_{RACE} results showed that more than 90% of respondents recognized the importance of staying hydrated beginning the day before the planned activity, correctly identified that dark color urine is not a sign of euhydration, and believed that dehydration may increase the risk for heat syncope. Conversely, fewer than 50% of respondents knew the number of days required to achieve heat acclimatization, the role of sweat-rate calculation in optimizing one's hydration strategy, or the risk of water intoxication from drinking too much water. An improvement in survey score from PRE_{RACE} to $POST_{EDU}$ was observed (mean difference = 2.00; 95% confidence interval = 1.68, 2.33; $P < .001$) among runners who watched the video, and 73% of the improvement in their scores was retained from $POST_{EDU}$ to $POST_{RACE}$ (mean difference = −0.54; 95% confidence interval = −0.86, −0.21; $P < .001$).

Conclusions: The video successfully shifted runners' beliefs and knowledge to enable them to better optimize their performance in the heat.

Key Words: educational video, survey, exertional heat illness, road-race medicine, prevention

Key Points

- Runners shifted their beliefs and knowledge about optimizing their performance in the heat after viewing the educational video.
- A gap remained between runners' knowledge and actual race-day behavior, suggesting that some runners did not follow the recommended heat-safety and hydration-strategy behaviors despite perceiving the importance of these behavioral modifications.
- More investigation is needed to determine the effectiveness of using such an educational intervention to modify runners' race-day behaviors.
- Researchers should examine the association between runners' beliefs and behaviors on being admitted to the medical tent.

Operators of on-site medical care at road-race events confront challenges that are uniquely different from challenges confronted in traditional organized sports. Runners participate in races at their own discretion with no medical screening requirements. Therefore, road-race events attract runners with a wide range of training backgrounds, ages, and health statuses. In 2015, the International Institute of Race Medicine[1] published guidelines addressing evidence-based practices to manage the various medical conditions that are commonly seen at road-race events. In this article, participant education was highlighted as a critical factor in preventing unnecessary medical attention at races.[1] Educational tools have been used in other sport settings, such as the "Heads Up Football" program,[2] which contains materials related to medical conditions of and safety considerations for American youth football players. However, standardized education modules for recreational runners to prevent common injuries observed at road-race events are lacking.

Based on previously published data[3–9] that identified the types of medical conditions and incidents requiring on-site medical care at road-race events, education on heat-related

conditions may have a large effect in reducing road-race medical encounters during summer road races. In particular, DeMartini et al[3] published the largest dataset (n = 274), based on 18 years of medical records, of patients with exertional heatstroke (EHS) or heat exhaustion treated at the Falmouth Road Race medical tents. This is the largest published dataset of patients with EHS treated at a race, and further effort is warranted to reduce the incidence of exertional heat illness (EHI) and decrease the number of medical tent visits.

The risk of EHI is multifactorial and may be heightened at the Falmouth Road Race due to the high prevalence of warm weather when the race takes place (mid-August).[3] Given that the weather conditions, race distance, and competition date may be nonmodifiable, runners should focus on the modifiable risk factors that are unique to them. For example, a lack of heat acclimatization and poor physical fitness are associated with greater risk of EHI.[10–14] The risk of hyponatremia from consuming too much water has also been a concern among runners, so appropriate education regarding hydration strategies is warranted.[1] Authors[14,15] of case reports have suggested that exercise intensity unmatched to one's physical fitness may induce physical strain that is beyond one's capacity to maintain thermoregulatory and cardiovascular stability. Therefore, runners must have adequate training and be able to recognize their own physical capacity when exercising in the heat. Recent illness has also been reported as a risk factor for EHS[15] and increases the likelihood that a runner will not complete a race.[16,17] Using certain medications has been associated with EHI and gastrointestinal distress, suggesting that runners who are ill enough to be taking these medications should consider postponing event participation.[16–19] Moreover, a lack of adequate fluid intake may result in cardiovascular and thermoregulatory strain and increase the risk of EHI.[15,17,20]

Despite the increased prevalence of surveillance studies at road-race events,[4–6,16] few researchers have investigated runners' intentions and actual behaviors on race day. Moreover, assessments of runners' knowledge of the aforementioned risk factors and the usefulness of a standardized education module to improve runners' knowledge are needed to explore methods that can help prevent incidents of EHI. Therefore, the purpose of our study was 2-fold: (1) to investigate the beliefs and knowledge about heat safety and hydration strategies among recreationally active runners who were registered at the 2017 Falmouth Road Race and (2) to evaluate the effectiveness of video education on heat safety and hydration strategies in shifting runners' beliefs and knowledge to better optimize their performance in the heat.

METHODS

Educational Video and Survey Development

One researcher (Y.H.) created (1) a short (5.3-minute) educational video containing evidence-based recommendations to optimize running performance in the heat and mitigate the EHI risk and (2) a set of 11 questions to evaluate beliefs about heat safety and hydration. The content validity of the video and questions was assessed by expert reviewers (not authors), who included 4 certified athletic trainers with doctoral degrees in exercise physiology and specializations in environmental heat, thermoregulation, and hydration. The reviewers were instructed to rank each survey question from 1 (*not relevant*) to 4 (r*elevant*) for its relevance, clarity, and importance in evaluating the effectiveness of the heat safety and hydration educational video to shift runners' beliefs about preparing for exercising in the heat. The criteria used to retain each item depended on overall reviewer agreement about the relevance of the item, and the information was synthesized by the primary researcher. The revised questions were sent to 4 reviewers (not authors) who were recreationally active runners (ie, they regularly ran for at least 30 minutes, 3 or more times each week) who would be similar to the population expected to participate in the Falmouth Road Race. These reviewers followed the same procedure as the expert reviewers to rate the relevance, clarity, and importance of each question, and the questions were further refined according to the overall reviewer agreement.

Survey Distribution

An online survey link (Qualtrics LLC, Provo, UT) to a prerace questionnaire (PRE_{RACE}) was sent to the registrants of the 2017 Falmouth Road Race (n = 8319) 9 weeks before the race. The PRE_{RACE} consisted of 7 questions concerning training history and habitual and planned behaviors associated with the race, 11 questions structured to evaluate beliefs about heat safety and hydration while exercising in the heat (Table 1), and 3 questions on participant demographics. Reminder e-mails were sent 3 and 6 weeks after the initial e-mail to maximize the response rate while allowing time for the runners to implement the suggested behavioral modifications covered in the video.

Registrants who completed the PRE_{RACE} were prompted to view a 5.3-minute educational video that contained evidence-based recommendations for optimizing running performance in the heat and strategies to mitigate the risk of EHI (Appendix). Registrants who viewed the educational video were instructed to complete the same 11 questions from the PRE_{RACE} to assess any shift in their beliefs toward heat safety and hydration immediately after viewing the video ($POST_{EDU}$). Lastly, a postrace questionnaire ($POST_{RACE}$) was sent to registrants (n = 8284; n = 35 opted out from the e-mail list at the PRE_{RACE} mail distribution) on the afternoon of the race day. The $POST_{RACE}$ contained 8 questions concerning behaviors on race day, the same 11 questions regarding their beliefs about heat safety and hydration (Table 1), and 5 questions on the educational video for respondents who indicated they had watched the video before the race. Participation in the surveys was voluntary. Participants indicated written informed consent by completing the survey, and the study was approved by the University of Connecticut-Storrs Institutional Review Board.

Statistical Analysis

We calculated the response rate as the number of survey respondents divided by the total number of runners who received the survey. The survey score was calculated from the 11-question survey by counting the number of correct or favorable answers (ie, those supported by scientific evidence and included in the video). The change in survey score was calculated using a paired *t* test for the PRE_{RACE}

Table 1. Survey Questions[a]

Question/Statement	Answer Choices
1. It is important to stay hydrated starting the day before your activity to ensure better hydration state.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree
2. All runners should always stop at every water station on the race course to maintain your hydration level.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree
3. Of the following, which methods can help you determine if you are dehydrated before the race?	a. Dark urine color b. Thirst c. Acute increase in body weight d. a & b are correct e. b & c are correct
4. A runner may be susceptible to heat syncope (ie, passing out) if the runner is not well hydrated.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree
5. Exertional heatstroke is more common in hot and humid conditions.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree
6. For the body to adapt to exercising in the heat, the body needs at least [_____] of consecutive heat exposure.	a. 3 d b. 10–14 d c. 15–28 d d. 30 d
7. In order to optimize performance in the heat, you should know your sweat rate.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree
8. Lack of sleep may negatively influence your performance in the heat.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree
9. You cannot get intoxicated from drinking too much water.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree
10. You know you are well hydrated before the race if your urine color is dark, like the color of apple juice.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree
11. If you are recovered from fever or recent illness by the morning of the race, your risk of exertional heat illness is low.	a. Strongly agree b. Agree c. Unsure d. Disagree e. Strongly disagree

[a] The instrument is reproduced in its original format.

and $POST_{RACE}$ comparison, an unpaired *t* test for the EDU_{YES} and EDU_{NO} comparison, and 1-way analysis of variance for PRE_{RACE}, $POST_{EDU}$, and $POST_{RACE}$ comparisons. All parametric and nonparametric data are reported as mean ± standard deviation (SD) and median ± SD, respectively. Mean differences (MDs) and 95% confidence intervals (CIs) are reported for group mean comparisons. We used χ^2, Kruskal-Wallis, or Mann-Whitney tests for all nonparametric group comparisons. The α level was set a priori at .05. All statistical analyses were completed using Prism 7 (version 7.0a; GraphPad Software Inc, La Jolla, CA).

RESULTS

Response Rates and Participant Characteristics

The response rate for the PRE_{RACE} was 25.1% (n = 2091), and 10.9% (n = 227) of these respondents participated in the $POST_{EDU}$. A total of 1789 (85.6%) of the PRE_{RACE} respondents reported that they were training for the 2017 Falmouth Road Race. Forty-three respondents (21.1 per 1000 runners) gave a history of heat syncope, heat exhaustion, EHS, classic heatstroke, or rhabdomyolysis in the 3 years before the study.

The response rate for the $POST_{RACE}$ was 22.4% (n = 1854), and 9.4% (172/1831) of the respondents reported that they were ill during the 7 days leading up to the day of the race. Furthermore, 49.1% (n = 84/171) of the respondents who described feeling ill during these 7 days were still ill the day before the race.

Knowledge on Heat Safety and Hydration: PRE_{RACE} Observations

Overall, the PRE_{RACE} respondents demonstrated a fair understanding of heat-safety and hydration-related behaviors and knowledge, with a median score of 8 (Tables 2 and 3). For example, 96.4% (1869/1938) of the respondents answered *strongly agree* or *agree* to the statement about the importance of staying hydrated starting the day before the planned activity (question 1), 73.1% (1417/1938) correctly identified dark urine color and thirst as indicators of dehydration (question 3), 91.7% (1778/1938) believed that dehydration may place a runner at risk for heat syncope (question 4), 89.7% (1738/1938) knew that a lack of quality sleep may negatively influence performance in the heat (question 8), 93.2% (1807/1938) correctly recognized that dark-colored urine is not a sign of euhydration (question 10), and 80.8% (1565/1938) were aware that recent illness may increase the risk for EHI (question 11). However, respondents demonstrated a poor understanding (ie, percentage of correct answers less than 50%) about the number of days required to acquire heat acclimatization (question 6: 47.4% [918/1938]), using sweat rate to optimize a hydration strategy in the heat (question 7: 36.9% [715/1938]), and the possibility of water intoxication from drinking too much water (question 9: 49.6% [962/1938]).

The top 3 plans for optimizing hydration status on the day of the race were drinking an ample amount of water the night before the race (91.3% [1837/2012]), avoiding alcohol the night before the race (74.0% [1488/2012]), and drinking at water station(s) along the course (76.9% [1547/2012]). Only 33.4% (673/2012) of the runners reported "following thirst" as their hydration plan, and 28.8% (579/2012) indicated that they planned to drink at all water stations along the course.

Table 2. Participants' Responses to the Prerace Survey by the Degree of Belief for Each Question (N = 1938)

Question[a]	Answer	Response, No. (%)[b]
1	Strongly agree	1282 (66.2)
	Agree	587 (30.3)
	Unsure	41 (2.1)
	Disagree	20 (1.0)
	Strongly disagree	8 (0.4)
2	Strongly agree	123 (6.3)
	Agree	370 (19.1)
	Unsure	389 (20.1)
	Disagree	895 (46.2)
	Strongly disagree	161 (8.3)
3	a. Dark urine color	1417 (73.1)
	b. Thirst	122 (6.3)
	c. Acute increase in body weight	337 (17.4)
	a & b are correct	49 (2.5)
	b & c are correct	13 (0.7)
4	Strongly agree	953 (49.2)
	Agree	825 (42.6)
	Unsure	151 (7.8)
	Disagree	9 (0.5)
	Strongly disagree	0 (0.0)
5	Strongly agree	406 (20.9)
	Agree	592 (30.5)
	Unsure	723 (37.3)
	Disagree	196 (10.1)
	Strongly disagree	21 (1.1)
6	3 d	647 (33.4)
	10–14 d	918 (47.4)
	15–28 d	230 (11.9)
	30 d	143 (7.4)
7	Strongly agree	160 (8.3)
	Agree	555 (28.6)
	Unsure	1130 (58.3)
	Disagree	82 (4.2)
	Strongly disagree	11 (0.6)
8	Strongly agree	758 (39.1)
	Agree	980 (50.6)
	Unsure	171 (8.8)
	Disagree	27 (1.4)
	Strongly disagree	2 (0.1)
9	Strongly agree	195 (10.1)
	Agree	348 (18.0)
	Unsure	433 (22.3)
	Disagree	615 (31.7)
	Strongly disagree	347 (17.9)
10	Strongly agree	28 (1.4)
	Agree	41 (2.1)
	Unsure	62 (3.2)
	Disagree	365 (18.8)
	Strongly disagree	1442 (74.4)
11	Strongly agree	21 (1.1)
	Agree	52 (2.7)
	Unsure	300 (15.5)
	Disagree	874 (45.1)
	Strongly disagree	691 (35.7)

[a] Survey questions are provided in Table 1.
[b] Some percentages were rounded.

Table 3. Participants' Responses to the Prerace Survey by the Percentages of Correct, Incorrect, and Unsure Answers for Each Question (N = 1938)

	Answer, No. (%)[b]		
Question[a]	Correct	Incorrect	Unsure
1	1869 (96.4)	28 (1.4)	41 (2.1)
2	1056 (54.5)	493 (25.4)	389 (20.1)
3	1417 (73.1)	521 (26.9)	NA
4	1778 (91.7)	9 (0.5)	151 (7.8)
5	998 (51.5)	217 (11.2)	723 (37.3)
6	918 (47.4)	1020 (52.6)	NA
7	715 (36.9)	93 (4.8)	1130 (58.3)
8	1738 (89.7)	29 (1.5)	171 (8.8)
9	962 (49.6)	543 (28.0)	433 (22.3)
10	1807 (93.2)	69 (3.2)	62 (3.2)
11	1565 (80.8)	73 (3.8)	300 (15.5)

Abbreviation: NA, not applicable.
[a] Survey questions are provided in Table 1.
[b] Some percentages were rounded.

Effectiveness of Video Education

A total of 164 runners answered the 11 questions on their beliefs and knowledge about heat safety and hydration at the PRE_{RACE}, $POST_{EDU}$, and $POST_{RACE}$ (EDU_{YES}; Table 4), whereas 826 runners answered the 11 questions at the PRE_{RACE} and $POST_{RACE}$ (ie, no video intervention; EDU_{NO}; Table 5). The Kruskal-Wallis test showed favorable shifts in beliefs and knowledge about heat safety and hydration among EDU_{YES} respondents for 6 of the 11 questions (questions 1 [$H = 32.2$], 2 [$H = 46.1$], 4 [$H = 40.3$], 5 [$H = 31.1$], 7 [$H = 152.9$], and 8 [$H = 136.7$]; all P values $< .001$; Table 4). The Mann-Whitney test showed favorable shifts among the EDU_{NO} respondents in their answers to questions 4 ($U = 321\,351$, $P = .02$), 5 ($U = 310\,547$, $P = .001$), 7 ($U = 293\,974$, $P < .001$), 8 ($U = 317\,403$, $P = .006$), and 9 ($U = 301\,658$, $P < .001$; Table 5) despite no exposure to the video education; however, the percentage of runners with correct answers at the $POST_{RACE}$ was greater among the EDU_{YES} than the EDU_{NO} respondents for all questions (Table 6). We observed a small difference in the survey score for the PRE_{RACE} between the EDU_{NO} and EDU_{YES} respondents (MD = 0.28; 95% CI = 0.03, 0.52; $t_{988} = 2.22$, $P = .03$). Among the EDU_{YES} respondents, survey scores improved from the PRE_{RACE} to the $POST_{EDU}$ (MD = 2.00; 95% CI = 1.68, 2.33; $P < .001$), and 73% of the improvement was retained from the $POST_{EDU}$ to the $POST_{RACE}$ (MD = –0.54; 95% CI = –0.86, –0.21; $F_{2,489} = 15.83$, $P < .001$). The improvement in the survey score from the PRE_{RACE} to $POST_{RACE}$ was greater for the EDU_{YES} than the EDU_{NO} respondents (MD = 0.92; 95% CI = 0.67, 1.17; $t_{988} = 7.28$, $P < .001$).

Intentions and Observed Behaviors Surrounding Race Day: PRE_{RACE} and $POST_{RACE}$ Comparison

A total of 176 runners completed the survey regarding behaviors surrounding race day at the PRE_{RACE}, $POST_{EDU}$, and $POST_{RACE}$ (EDU_{YES}), whereas 884 runners completed the same questions at the PRE_{RACE} and $POST_{RACE}$ (EDU_{NO}). The average number of hours of sleep reported on the PRE_{RACE} was greater than on the $POST_{RACE}$ among the EDU_{YES} ($PRE_{RACE} = 7.00 \pm 0.96$ hours; $POST_{RACE} = 6.57 \pm 1.17$ hours; MD = 0.43; 95% CI = 0.25, 0.62; $t_{175} = 4.60$, $P < .001$) and EDU_{NO} ($PRE_{RACE} = 6.98 \pm 0.91$ hours; $POST_{RACE} = 6.56 \pm 1.13$ hours; MD = 0.41; 95% CI = 0.33, 0.49; $t_{866} = 10.31$, $P < .001$) respondents. The

Table 4. Participants' Responses to the Surveys at the Prerace, Immediately After Viewing the Educational Video, and Postrace (n = 164)

Question[a]	Answer	Survey Response, No. (%)[b]		
		Prerace	After Viewing Educational Video	Postrace
1[c,d]	Strongly agree	96 (58.5)	140 (85.4)	126 (76.8)
	Agree	58 (35.4)	22 (13.4)	34 (20.7)
	Unsure	7 (4.3)	0 (0.0)	1 (0.6)
	Disagree	3 (1.8)	1 (0.6)	2 (1.2)
	Strongly disagree	0 (0.0)	1 (0.6)	1 (0.6)
2[c,e,f]	Strongly agree	5 (3.0)	5 (3.0)	5 (3.0)
	Agree	27 (16.5)	4 (2.4)	23 (14.0)
	Unsure	40 (24.4)	7 (4.3)	17 (10.4)
	Disagree	78 (47.6)	105 (64.0)	86 (52.4)
	Strongly disagree	14 (8.5)	43 (26.2)	33 (20.1)
3	Dark urine color	129 (78.7)	114 (69.5)	129 (78.7)
	Thirst	10 (6.1)	14 (8.5)	6 (3.7)
	Acute increase in body weight	19 (11.6)	36 (22.0)	28 (17.1)
	a & b are correct	6 (3.7)	0 (0.0)	1 (0.6)
	b & c are correct	0 (0.0)	0 (0.0)	0 (0.0)
4[c,d]	Strongly agree	71 (43.3)	110 (67.1)	123 (75.0)
	Agree	80 (48.8)	52 (31.7)	38 (23.2)
	Unsure	12 (7.3)	0 (0.0)	2 (1.2)
	Disagree	1 (0.6)	1 (0.6)	1 (0.6)
	Strongly disagree	0 (0.0)	1 (0.6)	0 (0.0)
5[c,d]	Strongly agree	28 (17.1)	63 (38.4)	66 (40.2)
	Agree	50 (30.5)	58 (35.4)	49 (29.9)
	Unsure	66 (40.2)	27 (16.5)	36 (22.0)
	Disagree	19 (11.6)	15 (9.1)	10 (6.1)
	Strongly disagree	1 (0.6)	1 (0.6)	3 (1.8)
6	3 d	43 (26.2)	2 (1.2)	22 (13.4)
	10–14 d	96 (58.5)	161 (98.2)	131 (79.9)
	15–28 d	16 (9.8)	1 (0.6)	9 (5.5)
	30 d	9 (5.5)	0 (0.0)	2 (1.2)
7[c,d,g]	Strongly agree	16 (9.8)	95 (57.9)	60 (36.6)
	Agree	54 (32.9)	66 (40.2)	81 (49.4)
	Unsure	88 (53.7)	3 (1.8)	21 (12.8)
	Disagree	6 (3.7)	0 (0.0)	2 (1.2)
	Strongly disagree	0 (0.0)	0 (0.0)	0 (0.0)
8[c,d,g]	Strongly agree	68 (41.5)	118 (72.0)	87 (53.0)
	Agree	79 (48.2)	45 (27.4)	71 (43.4)
	Unsure	11 (6.7)	1 (0.6)	5 (3.0)
	Disagree	6 (3.7)	0 (0.0)	1 (0.6)
	Strongly disagree	0 (0.0)	0 (0.0)	0 (0.0)
9	Strongly agree	8 (4.9)	5 (3.0)	6 (3.7)
	Agree	26 (15.9)	7 (4.3)	11 (6.7)
	Unsure	33 (20.1)	10 (6.1)	14 (8.5)
	Disagree	53 (32.3)	55 (33.5)	59 (36.0)
	Strongly disagree	44 (26.8)	87 (53.0)	74 (45.1)
10[h]	Strongly agree	1 (0.6)	4 (2.4)	5 (3.0)
	Agree	2 (1.2)	1 (0.6)	2 (1.2)
	Unsure	7 (4.3)	0 (0.0)	0 (0.0)
	Disagree	30 (18.3)	17 (10.4)	18 (11.0)
	Strongly disagree	124 (75.6)	142 (86.6)	139 (84.8)
11	Strongly agree	2 (1.2)	4 (2.4)	2 (1.2)
	Agree	1 (0.6)	5 (3.0)	1 (0.6)
	Unsure	27 (16.5)	6 (3.7)	27 (16.5)
	Disagree	78 (47.6)	52 (31.7)	78 (47.6)
	Strongly disagree	56 (34.1)	97 (59.1)	56 (34.1)

[a] Survey questions are provided in Table 1.
[b] Responses were scored *correct* if participants chose *strongly agree* or *agree* to questions 1, 4, 5, 7, and 8; *strongly disagree*, *disagree*, or *unsure* to questions 2, 9, 10, and 11; *a & b are correct* to question 3; and *10–14 d* to question 6. Some percentages were rounded.
[c] Difference between responses from prerace to immediately after viewing the educational video ($P < .001$).
[d] Difference between responses from prerace to postrace questionnaires ($P < .001$).
[e] Difference between responses from prerace to postrace questionnaires ($P < .01$).
[f] Difference between responses from after viewing the educational video to the postrace questionnaire ($P < .01$).
[g] Difference between responses from after viewing the educational video to the postrace questionnaire ($P < .001$).
[h] Difference between responses from the prerace questionnaire to immediately after viewing the educational video ($P < .01$).

Table 5. Participants' Responses to the Prerace and Postrace Surveys (N = 826)

Question[a]	Answer	Survey Response, No. (%)[b] Prerace	Postrace
1	Strongly agree	557 (64.5)	578 (66.9)
	Agree	242 (28.0)	226 (26.2)
	Unsure	17 (2.0)	10 (1.2)
	Disagree	6 (0.7)	11 (1.3)
	Strongly disagree	4 (0.5)	1 (0.1)
2	Strongly agree	58 (6.7)	53 (6.1)
	Agree	163 (18.9)	151 (17.5)
	Unsure	160 (18.5)	146 (16.9)
	Disagree	374 (43.3)	405 (46.9)
	Strongly disagree	71 (8.2)	71 (8.2)
3	a. Dark urine color	595 (68.9)	581 (67.2)
	b. Thirst	53 (6.1)	57 (6.6)
	c. Acute increase in body weight	153 (17.7)	157 (18.2)
	a & b are correct	21 (2.4)	22 (2.5)
	b & c are correct	4 (0.5)	9 (1.0)
4[c]	Strongly agree	400 (46.3)	439 (50.8)
	Agree	356 (41.2)	342 (39.6)
	Unsure	65 (7.5)	34 (3.9)
	Disagree	5 (0.6)	8 (0.9)
	Strongly disagree	0 (0.0)	3 (0.3)
5[d]	Strongly agree	174 (20.1)	220 (25.5)
	Agree	246 (28.5)	269 (31.1)
	Unsure	314 (36.3)	254 (29.4)
	Disagree	85 (9.8)	72 (8.3)
	Strongly disagree	7 (0.8)	11 (1.3)
6	3 d	275 (31.8)	253 (29.3)
	10–14 d	398 (46.1)	436 (50.5)
	15–28 d	90 (10.4)	89 (10.3)
	30 d	63 (7.3)	48 (5.6)
7[d]	Strongly agree	73 (8.4)	96 (11.1)
	Agree	220 (25.5)	318 (36.8)
	Unsure	486 (56.3)	369 (42.7)
	Disagree	43 (5.0)	40 (4.6)
	Strongly disagree	4 (0.5)	3 (0.3)
8[c]	Strongly agree	306 (35.4)	338 (39.1)
	Agree	427 (49.4)	442 (51.2)
	Unsure	82 (9.5)	36 (4.2)
	Disagree	9 (1.0)	8 (0.9)
	Strongly disagree	2 (0.2)	2 (0.2)
9[d]	Strongly agree	76 (8.8)	57 (6.6)
	Agree	149 (17.2)	103 (11.9)
	Unsure	191 (22.1)	160 (18.5)
	Disagree	250 (28.9)	321 (37.2)
	Strongly disagree	160 (18.5)	185 (21.4)
10	Strongly agree	13 (1.5)	14 (1.6)
	Agree	17 (2.0)	30 (3.5)
	Unsure	22 (2.5)	21 (2.4)
	Disagree	162 (18.8)	137 (15.9)
	Strongly disagree	612 (70.8)	624 (72.2)
11	Strongly agree	8 (0.7)	21 (2.4)
	Agree	25 (2.9)	25 (2.9)
	Unsure	129 (14.9)	134 (15.5)
	Disagree	387 (44.8)	358 (41.4)
	Strongly disagree	279 (32.3)	288 (33.3)

[a] Survey questions are provided in Table 1.
[b] Responses were scored *correct* if participants chose *strongly agree* or *agree* to questions 1, 4, 5, 7, and 8; *strongly disagree*, *disagree*, or *unsure* to questions 2, 9, 10, and 11; *a & b are correct* to question 3; and *10–14 d* to question 6. Some percentages were rounded.
[c] Difference between responses ($P < .01$).
[d] Difference between responses ($P < .001$).

level of motivation reported on the PRE_{RACE} did not differ between the EDU_{YES} and EDU_{NO} respondents (MD = 0.02; 95% CI = –0.23, 0.27). We observed an increase at the percentage of participants who knew their sweat rate at the $POST_{RACE}$ among the EDU_{YES} (PRE_{RACE} = 12.5%; $POST_{RACE}$ = 23.7%; $x_1^2 = 7.64$; $P = .006$) and EDU_{NO} (PRE_{RACE} = 10.0%; $POST_{RACE}$ = 13.9%; $x_1^2 = 6.52$; $P = .01$) respondents.

The top 3 hydration strategies used by the EDU_{YES} and EDU_{NO} respondents were similar; runners consumed ample amounts of water the night before the race (EDU_{YES} = 89.2% [157/176]; EDU_{NO} = 86.3% [763/884]), drank at water station(s) along the course (EDU_{YES} = 84.1% [148/176]; EDU_{NO} = 75.8% [670/884]), and avoided alcohol the night before the race (EDU_{YES} = 66.5% [117/176]; EDU_{NO} = 56.8% [502/884]). "Following thirst" was reported by only 32.4% (57/176) and 36.8% (325/884) of the EDU_{YES} and EDU_{NO} respondents, respectively. The percentages of runners who drank at all water stations along the course were 26.7% (47/176) and 35.2% (311/884) among the EDU_{YES} and EDU_{NO} respondents, respectively.

DISCUSSION

The main goals of our study were to identify the current beliefs and knowledge about heat safety and hydration strategies among recreationally active runners participating in the 2017 Falmouth Road Race and to investigate the effectiveness of video education in shifting runners' beliefs and knowledge to better optimize their performance in the heat. The results of the PRE_{RACE} showed that runners had some knowledge about good hydration practices and considerations for running in a warm-weather race, which was further improved $POST_{EDU}$ and maintained at the $POST_{RACE}$ by those who had watched the educational video. However, not all runners adopted the recommended practices, such as calculating their sweat rate to establish an individualized hydration plan and using thirst to gauge dehydration status. This suggests that, despite the improved awareness and corrected misconceptions about heat safety and hydration strategies among runners, not everyone achieved successful behavioral adaptations.

Given the results of this study, the transtheoretical model of change that divides behavioral adaptation into 5 stages (precontemplation, contemplation, preparation, action, and maintenance) needs to be considered.[21] For example, one may internalize the need for change (precontemplation to contemplation) through video education, establish a plan for the change (preparation), and finally take action (action and maintenance). At the $POST_{RACE}$, when registrants were asked whether they found the educational video helpful in modifying their behaviors during training and the race, 61.7% (92/149) agreed that the video influenced the way they trained. Of those who responded that the video was helpful, the top modifications they implemented after viewing the video were drinking water the night before an early morning run (96.7% [89/92]), using urine color to gauge hydration status (71.7% [66/92]), and matching training intensity to one's health status and fitness capabilities (62.0% [57/92]). Conversely, runners who did not find the video helpful during their training most commonly indicated that they already followed the outlined recommendations (31.6% [18/57]). This response may

Table 6. Comparisons of Answers on the Postrace Survey

Question[a]	Runner Group: Watched Educational Video?	Response, No. (%)[b]		
		Correct	Incorrect	Unsure
1	Yes	160 (97.6)	3 (1.8)	1 (0.6)
	No	804 (97.3)	12 (1.5)	10 (1.2)
2	Yes	119 (72.6)	28 (17.1)	17 (10.4)
	No	476 (57.6)	204 (24.7)	146 (17.7)
3	Yes	129 (78.7)	35 (21.3)	NA
	No	581 (70.3)	245 (29.7)	NA
4	Yes	161 (98.2)	1 (0.6)	2 (1.2)
	No	781 (94.6)	11 (1.3)	34 (4.1)
5	Yes	115 (70.1)	13 (7.9)	36 (22.0)
	No	489 (59.2)	83 (10.0)	254 (30.8)
6	Yes	131 (79.9)	33 (20.1)	NA
	No	436 (52.8)	390 (47.2)	NA
7	Yes	141 (86.0)	2 (1.2)	21 (12.8)
	No	414 (50.1)	43 (5.2)	369 (44.7)
8	Yes	158 (96.3)	1 (0.6)	5 (3.0)
	No	780 (94.4)	10 (1.2)	36 (4.4)
9	Yes	133 (81.1)	17 (10.4)	14 (8.5)
	No	506 (61.3)	160 (19.4)	160 (19.4)
10	Yes	157 (95.7)	7 (4.3)	0 (0.0)
	No	761 (92.1)	44 (5.3)	21 (2.5)
11	Yes	134 (81.7)	3 (1.8)	27 (16.5)
	No	646 (78.2)	46 (5.6)	134 (16.2)

Abbreviation: NA, not applicable.

[a] Survey questions are provided in Table 1.

[b] Some percentages were rounded.

suggest that these runners were no longer in the precontemplation phase for the recommended behaviors in the video. Lastly, a small number of runners also indicated that they followed their usual routine ($n = 5$) or that the video content did not apply to them ($n = 2$). Some runners learned about the video too late for it to be useful for their training ($n = 3$), affecting their success in the preparation stage of the model.

When asked about the influence of the educational video on race-day behavior, 67.8% (101/149) of the runners answered that the video helped them to modify their race-day behaviors. Thus, 67.8% of the runners reached the action stage of the model. Specifically, 53.5% of runners (54/101) reported that they modified their race-day hydration strategies using the methods outlined in the video (eg, staying well hydrated from the night before, using the sweat rate to calculate fluid needs during exercise, using thirst and urine color to gauge hydration status, not blindly drinking water from all water stations). Twelve (11.9%) runners also commented that they modified their running pace in response to the high air temperature and humidity level during the race. The responses among those who did not find the video helpful in modifying race-day behaviors were similar to those of the runners who noted that they already followed the recommendations outlined in the video (33.3% [16/48]), suggesting that they may have already been in the maintenance stage of the behaviors surrounding heat safety and hydration strategies.

LIMITATIONS

Our observations were restricted to the registrants who completed the surveys. Whereas the response rate for the PRE_{RACE} was 25.1%, the rate of participation was reduced at $POST_{EDU}$ because participation in the survey was voluntary. Consequently, our comparison between the EDU_{YES} and EDU_{NO} respondents was limited to 176 runners who responded to the PRE_{RACE}, $POST_{EDU}$, and $POST_{RACE}$ and 884 runners who responded to the PRE_{RACE} and $POST_{RACE}$ but did not receive video education. Lastly, findings from our study should not be generalized to runners participating in other road-race events.

CONCLUSIONS

The educational video successfully shifted runners' beliefs and knowledge about optimizing their performance in the heat. However, some gaps remained between the runners' knowledge and actual race-day behavior, suggesting that certain runners did not follow the recommended heat safety and hydration strategies despite the perceived importance of these behavioral modifications. The effectiveness of using such an educational intervention to modify runners' behaviors on race day needs further investigation. Furthermore, researchers should examine the association between beliefs and behaviors when runners are admitted to the medical tent.

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Appendix. Script for the Heat-Safety and Hydration Video[a]

This video will go over ways to optimize exercise performance and safety in the heat and prevent exertional heat illness.

Exercising in the heat poses a unique stress on the body. For example, when you are running outdoors, direct sunlight, high air temperature, or high humidity will add heat strain on the body in addition to what is already being produced from the working muscles.

In order to combat the rise in body temperature, the body begins to sweat to remove body heat by evaporation of the sweat from the skin. In fact, sweating is the predominant method of dissipating body heat during exercise in the heat.

When the body is not used to exercising in hot conditions, its ability to dissipate heat is not as efficient. However, through gradual exposure to the heat and exercise in the heat, the body will undergo a series of adaptations to cope with heat stress during exercise to optimize body temperature control. This process is called heat acclimatization. It usually takes between 10 to 14 days to gain the favorable adaptations,[6] which include:

- Increased sweat rate
- Increased exercise capacity
- Decreased heart rate
- Decreased rate of rise in internal body temperature
- Decreased sodium loss in the sweat

Hydration[3] is another component that plays a crucial role in maintaining body temperature stability while exercising in the heat, as well as an optimizing performance. It is important to start exercising in a well-hydrated state, minimize fluid losses during exercise, and replenish the remaining fluid deficit after exercise. A quick way to check your hydration status is by simply looking at your urine color. If the urine color is light yellow, resembling the color of lemonade, it indicates that you are hydrated. On the other hand, if your urine color is dark like the color of apple juice, you are likely to be dehydrated.[10] If you are scheduled to exercise in the morning, it is important to start your hydration regimen the day before to help you start out exercise in a well-hydrated state.[1]

Thirst is another way of your body alarming you that you may be dehydrated. The amount of water you drink during and after exercise should be tailored to your individual needs. This can be accomplished by measuring your body weight before and after exercise to calculate the difference between the two measurements. The difference is the amount of sweat you lost during exercise, and that difference over time is the sweat rate. Calculating your own sweat rate will provide an individualized hydration regimen that will not only help you prevent significant dehydration, but also help prevent overdrinking or in a severe case, water intoxication.[7,9] Depending on your sweat rate, stopping at every water station may not be necessary.[2]

In addition to heat acclimatization and hydration, it is also important to know your general health status and fitness level. To further optimize your exercise performance and ensure safety in the heat, you should:

- Get quality sleep[8]
- Avoid spending long periods of time in non–air-conditioned spaces, especially while sleeping
- Choose an exercise intensity that is matched to your level of fitness

Appendix. Continued

All factors mentioned thus far will also work in your favor to prevent exertional heat illnesses. Here are a few types of exertional heat illnesses for you to think about. Heat syncope refers to a fainting or lightheadedness episode during or immediately after exercise. It is caused by lack of blood returning to the heart and is commonly seen in people who are not used to the heat or are dehydrated.[4] Heat exhaustion is an exertional heat illness that happens when an exercising individual can no longer continue activity in the heat due to fatigue. Although heat exhaustion is not a life-threatening condition, it is important to rehydrate and cool the body down using methods such as water immersion, cold towels, or moving to a cool area. The most severe form of exertional heat illness is called exertional heatstroke. Exertional heatstroke is a life-threatening condition if not recognized and treated appropriately. The key for exertional heatstroke treatment is to reduce the body temperature to a safe range within 30 minutes of collapse.

Taken together, exercise in the heat adds unique challenges to the body, but the challenges can be managed with heat acclimatization, proper hydration, quality sleep, and knowing the exercise intensity that bests fits your fitness level. If you recently had fever[11] or do not feel ready to participate in exercise, it is always important to listen to your body and perhaps postpone the activity until you feel ready again. Recent febrile illness may predispose you to experience exertional heat illness.

Thank you for listening to our heat safety and hydration strategy video. We wish you the best of luck at your upcoming road races.

[a] Numbers in superscript in the video script indicate the corresponding question that was designed to test runners' beliefs toward the content covered in the text.