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The Influence of Hydration on Thermoregulation During a 161-km Ultramarathon

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Objective.—It is commonly advised that individuals should avoid losing >2% of their body weight during exercise because dehydration can ultimately lead to hyperthermia, which will impair performance. However, body weight losses of ≥3% appear to be well tolerated in those participating in prolonged endurance exercise. This study sought to determine the relationship between hydration status and thermoregulation of runners participating in a hot ultramarathon and to assess whether a weight loss of >2% body weight leads to elevations in core temperature.

Methods.—Thirty runners of the 2014 161-km Western States Endurance Run agreed to take part in the study. Body weight and core temperature were measured at the start, at 3 locations during the race, and at the finish.

Results.—Of the 30 starting participants, 20 finished the race. Ambient temperature at data collection sites ranged from 17°C to 39°C, and the highest core temperature recorded was 39.4°C. Core temperature did not significantly differ during the race ($P = .77$) and was not correlated with body weight change ($P = .19$) or finish time ($P = .11$). However, body weight change was directly associated with finish time ($r = .60$, $P = .006$), such that the fastest runners had the greatest loss in body weight (~3.5–4.0%). Neither core temperature nor percent body weight change differed between race finishers and non-finishers ($P = .63$ and .17, respectively).

Conclusions.—While participating in endurance exercise up to 30 hours in hot conditions, runners can tolerate weight losses of >3% body weight without significant rises in core temperature. Therefore, since body weight losses of >3% were not associated with a rise in core temperature, an emphasis on fluid replacement for weight losses of this magnitude during prolonged exercise is not justified as a preventative measure for heat-related illnesses.
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Weight Change and Hydration Status During a 161-km Ultramarathon

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Objective.—Weight loss during ultramarathon competition is often considered a useful predictor of performance, hydration status, and hyponatremia. The validity of this assumption has not been well studied. This study was designed examine the correlation between weight change and performance, urinalysis, and serum sodium in a 161-km ultramarathon.

Methods.—Runners were weighed at prerace check-in, at the halfway point, and at the finish line. Height was self-reported at prerace check-in. Willing finishers underwent urinalysis and provided a blood sample for serum sodium analysis.

Results.—Out of 672 runners who started the race, 351 (52%) successfully completed the race under the 30-hour cut-off time. Weight was measured on 658, 518, and 344 runners at prerace, halfway, and finish line, respectively. Urinalysis (dipstick) was done on 70 runners (51 finishers), and blood samples were obtained from 84 runners (66 finishers). Mean (± SD) weight and BMI (body mass index) were 73.1 ± 10.3 kg and 23.3 ± 2.3 kg/m^2, respectively. Mean weight change for runners was –2.1 ± 2.1% and –0.84 ± 2.3% of their prerace weight at midpoint and finish line, respectively. Based on linear regression analysis, there was a significant correlation between percentage weight change from prerace to finish line and finish time ($P = .016$, $r^2 = .02$). There was no statistically significant relationship between weight loss and urine specific gravity ($P = .124$, $r^2 = .05$), or between weight loss and serum sodium concentration ($P = .183$, $r^2 = .03$).

Conclusions.—Significant weight fluctuation is common during ultramarathons. Our data show that weight change may be a weak predictor of race performance and that faster finish times tend to occur with more weight loss. Weight change is not a useful predictor of urine specific gravity, nor is it useful as a predictor of serum sodium. More study is needed to determine if weight change during an ultramarathon is correlated with adverse patient outcomes.
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Hydration Guidelines During Exercise: What Message Is the Public Receiving?

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Objective.—To assess the quality of information currently available to the public about hydration needs during exercise.

Methods.—Internet searches were conducted using the terms "hydration," "hydration guidelines," "drinking fluids," and "drinking guidelines" with "and exercise." From the first 50 websites for each search phrase, duplicates were removed, yielding 145 unique websites. Websites were then categorized and examined for specific information and recommendations.

Results.—Overall correct endorsement of current knowledge was as follows (reported as percent endorsing the concept relative to the number of sites addressing the issue): some weight loss should be expected during exercise (67.6% of 102), fluid consumption during exercise should be based on thirst (9.4% of 106), electrolyte intake is not necessary during exercise (12.5% of 112), dehydration is not generally a cause of heat illness (6.9% of 58) or muscle cramping (2.3% of 43), exercise-associated muscle cramping is not generally related to electrolyte loss (6.7% of 15), and overhydration is a risk for hyponatremia (98.5% of 65). There were 7.1% (of 70 websites addressing the issue) indicating that any weight loss during exercise should be avoided. Comparison of website information from those in the categories of medical or scientific organization (15.9%), academic institution (9.0%), peer-reviewed publication (8.3%), and medical professional individual or facility (8.3%) with those in the categories of media (19.3%), sports organization or coach (9.7%), sports drink or electrolyte replacement manufacturer (3.4%), and other (26.2%) revealed no differences ($P = .38$ to 1.0) in the frequency of endorsement of the criteria referred to above.

Conclusions.—Misinformation about hydration needs during exercise continues to be widely spread on the Internet. In general, those websites that should be most trusted by the public appear to be no better than other websites at providing accurate information, and the potential risk of hyponatremia is not often raised.

Food and Fluid Intake During Extreme Heat: Experiences From The Badwater Ultramarathon

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Objective.—The purpose of this paper was to document food and fluid intake of athletes during an ultramarathon held in extreme heat. Our study was conducted at The Badwater Ultramarathon, a nonstop 217-km run across Death Valley, California, USA, in 2012.

Methods.—This study recruited 4 male athletes. The parameters measured were energy intake, fluid intake, energy expenditure, and body mass. The variables were further compared to the athlete's ability to successfully complete a 217-km ultramarathon in extreme heat.

Results.—This investigation recruited 4 male athletes, average age of 43 (± SD) (± 7.35), range, 39 to 54 years. All 4 subjects completed the race with a mean finish time of 36:20:23 (± SD) (± 3:08:38), range, 34:05:25–40:51:46 hours and a mean running speed of 6.03 km/h (± SD) (± 0.05), range, 5.3–6.4 km/h. Our study found (mean and ± SD): energy intake 8036.5 kcal (± 3453.1); fluid intake 33.8 L (± 12.5); energy expenditure 23,920 kcal (± 1749.3); and body mass 79.33 kg (± 6.43). This study also determined body mass decreased 2.52% (± 1.99) over the duration of the event. The maximum ambient air temperature was 46.6°C during the first day and 36.6°C the second day, with a low of 10.1°C during the evening.

Conclusions.—Our data reveal that our subjects were able to complete this event despite an energy intake deficit of 15 883.5 kcal (33.6% of energy expenditure) and a decrease in body mass of >2% during the race, which is in contrast to current recommendations, but in agreement with recent scientific literature. We conclude that the nutritional intake was adequate as our subjects completed the race and that success in longer duration events requires the ability to find a balance between maintaining the ideal hydration status and providing an adequate amount of fuel for each individual athlete.

Body Mass Changes and Fluid Consumption During an 80.5-km Treadmill Time Trial

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Objective.—Fluid consumption and maintenance of body mass is crucial to exercise performance, particularly during ultraendurance events. The current study aimed to assess body mass change and hydration status during an 80.5-km treadmill time trial (TT).

Methods.—Ultrarunners were recruited to complete 80.5 km on a motorized treadmill within an artificial laboratory environment. Body mass (BM) was determined prior to, at 16.1-km intervals, and on completion of an 80.5-km TT using bioelectrical impedance analysis (BIA). Ad libitum fluid intake was permitted during the trial, and total fluid consumption and gastrointestinal (GI) symptoms were noted throughout.

Results.—Total fluid intake was 3294.4 ± 1402.9 mL with an average consumption of 386.9 ± 212.2 mL/h. Prerunning BM (72.59 ± 8.48 kg) was reduced throughout the TT. Overall exercise-induced BM loss averaged 2.78 ± 0.94 kg with a 4.01 ± 1.35% decrease over time, although some retention of BM occurred in the latter stages of the TT. Ambient conditions were maintained throughout with no significant fluctuations in temperature (20.8° ± 0.2°C; $P > .05$) or humidity (35.7 ± 1.3%; $P > .05$). Average time to completion was 7 hours 28 minutes 9 seconds ± 1 hour 25 minutes 12 seconds at an average speed of 10.8 ± 1.5 km/h.

Conclusion.—The current study indicates that participants were unable to maintain prerunning BM following the completion of an 80.5-km TT with an average BM loss of 4%. Consensus guidelines state to avoid BM losses of >3%; therefore this emphasizes the importance of optimal hydration strategies in ultraendurance running.

Energy Cost of Running During a Bout of 80.5-km Treadmill Running

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Objective.—Success in ultraendurance running is composed of many interrelated variables. Notably the involvement of the cardiovascular system has been proposed to explain variance in performance. At present, there is limited data on the changes in the energy cost of running (Cr) during bouts of ultraendurance running. Therefore, the purpose of this study was to identify changes and adjustments in Cr and respiratory variables over an 80.5-km treadmill time trial (TT).

Methods.—Participants were instructed to complete 80.5 km on a motorized treadmill and to cover the distance in the fastest possible time. Respiratory variables ($\dot{V}O_2$ [oxygen consumption], $\dot{V}co_2$ [carbon dioxide production], and RER [respiratory exchange ratio]) were measured via indirect calorimetry every 16.1 km at a set speed of 8 km/h. Running speed and heart rate were continually monitored throughout the 80.5-km TT.

Results.—Average run time to completion was 7 hours 28 minutes 9 seconds ± 1 hour 25 minutes 12 seconds at a mean speed of 10.8 ± 1.5 km/h (pace, 5:34 ± 1:04 min/km). $\dot{V}O_2$ increased by 21.8% from the start of the TT to completion (31.19 ± 2.89 vs 38.0 ± 6.41 $mL \cdot min^{-1} \cdot kg^{-1}$, respectively), while RER decreased from the start to 32.2 km whereupon RER plateaued. There was a significant increase of 24.2% in Cr ($P < .001$) from the start to completion of the TT.

Conclusion.—The current study indicated adjustments in $\dot{V}O_2$, Cr, and substrate utilization during an 80.5-km treadmill TT. Results indicated a shift to fatty acid oxidation as a main fuel source over a bout of 80.5 km, which corresponded with the increase in Cr. These findings may influence pacing strategies and overall success of performance in ultraendurance events.

In-task Assessment of Psychological Changes During an Ultramarathon Race

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Objective.—The primary aim of this study was to collect "real time data" on the psychological experience of runners during an ultramarathon race.

Methods.—Runners were recruited from a 50-mile trail race held in the Northeast region of the United States. Seventeen runners volunteered to provide in-task data at 2 data collection points on a 25-mile loop course. Single-item measures were used to quickly assess the pain, fatigue, energy, affective valence, attentional focus, motivation to finish, and confidence to finish during the previous segment of the race. Participants responded to each item on an 11-point scale (ie, 0–10).

Results.—Full data sets were obtained from 10 runners. Compared to runners who finished the race, nonfinishers reported higher scores for pain and fatigue at 10 miles. Finishers reported having more positive affect at 10 and 25 miles, having more energy at 10 miles, and having greater confidence in their ability to finish the race at 25 miles than did nonfinishers. Faster finishing times were correlated with less reported pain at the finish and more reported internally related thoughts halfway into the race. Participants reported increases in pain and fatigue, decreases in energy, decreases in positive affect, and a more associative attentional focus as the race progressed.

Conclusion.—According to in-task data collected during a 50-mile trail race, the psychological demands of the race were apparent in eventual nonfinishers as early as 10 miles into the race, particularly in terms of pain, fatigue, and affective valence. Faster runners reported significantly lower pain scores at the finish than slower runners, perhaps because of the additional time that slower runners had spent on their feet on-course. In-task data collection may prove useful for researchers to more accurately assess the dynamic physical, affective, and cognitive changes that runners experience during an ultramarathon event.

Would You Stop Running if You Knew It Was Bad for You? The Ultramarathon Runner Response

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Objective.—The Ultrarunners Longitudinal TRAcking (ULTRA) Study is a longitudinal health study initiated in 2011. Herewith are some results from the first follow-up questionnaire distributed in 2014 comparing selected characteristics between those answering "yes" and "no" to the question, "If you were to learn, with absolute certainty, that ultramarathon running is bad for your health, would you stop your ultramarathon training and participation?"

Methods.—ULTRA Study participants who had completed an ultramarathon since study enrollment or intended to run ultramarathons again received the question.

Updated information was obtained on current number of biological children, marital status, and average weekly running distance in the prior 12 months, and the Motivations of Marathoners Scales was completed.

Results.—Among the 1349 runners receiving the question, 349 (25.9%) answered "yes." Those answering "yes" compared with those answering "no" were older (median age, 47.3 vs 43.3 years, $P < .0001$), more likely to be married (76.2% vs 69.6%, $P = .019$), had more children (median number 2 vs 1, $P = .0095$), and ran less (median 48 vs 56 km/wk in past year, $P < .0001$), but did not differ in sex (70.5% vs 67.6% men, $P = .35$). The Motivations of Marathoners Scales showed significant group differences with those answering "yes" to the question having a higher health orientation (median 5.7 vs 5.3, $P < .0001$), and lower personal goal achievement (median 5.0 vs 5.2, $P = .0061$), psychological coping (median 4.4 vs 4.8, $P < .0001$) and life meaning (median 4.6 vs 4.9, $P = .0002$) scores.

Conclusion.—Ultramarathon runners find benefit from participating in ultramarathon running to the extent that most indicate they would not stop doing it even if it was bad for their health. Not surprisingly, those indicating they would stop were older, more likely to be married, had more children, were running less, were more health oriented, were less achievement oriented, and had less psychological motivations for running.

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The Development and Initial Assessment of a Novel Heart Rate Training Formula

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Objective.—To present the initial data behind a running gait-determined training heart rate and the resulting 180-Formula as an exercise intensity guide.

Methods.—In group 1, 223 male and female noninjured, experienced adult runners underwent extensive clinical evaluation and running gait analysis to determine the highest heart rate associated with an optimal running gait. Athletes were assigned training heart rates just below this and told to maintain their previous weekly mileage at or below their assigned heart rate. Pre- and post-study 5-km races were performed on certified courses. In group 2, 38 participants were assigned a training heart rate using the methods above, while 39 controls maintained their normal training schedule.

Results.—In group 1, 223 of 225 (99.1%) runners completed the program; 170 of 223 (76.2%; 95% confidence interval: 70.6–81.9%) runners improved their 5-km race times. In group 2, 42 of 42 completed the program. The monitor group had an injury rate of 2 of 21 runners (9.5%) and the control group had an injury rate of 13 of 21 (61.9%) ($P = .001$). The assigned heart rates of these 2 groups of athletes were used to create a formula, called the 180-Formula, for use as a training intensity guide.

Conclusions.—The described training method and corresponding 180-Formula appear to be a safe and effective gauge of exercise intensity. The target heart rate training method studied here deserves further exploration in endurance athletics and rehabilitation.

Medical Care and Runner Characteristics at a 161-km High Altitude Ultraendurance Run in Colorado, 2014

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Objective.—To examine reported medical events, medical care provided, runner training, and racing characteristics at a high altitude ultramarathon run.

Methods.—Medical personnel reported all significant events to the Race Medical Director during and after the event. Significant medical events were followed up after the race by either the Medical Director or another race medical provider. Seventy-four runners completed an online postrace questionnaire regarding their experience, symptoms during and after the run, training characteristics, medication use, hydration and fueling strategy, and injuries both during the run and in prior ultramarathons. Associations between the medical problems experienced during the race and the runner's hydration, training, and experience were examined.

Results.—Fifty-four percent of runners reported fewer than ten 161-km races, 51% had more than 20 years of running experience, and >75% had more than 7 years of ultramarathon experience. Years of running and years of running ultras were not significantly associated with any of the medical outcomes. Peak training miles per week was significantly negatively correlated with shortness of breath ($P = .0316$). Fifty percent of racers drank to thirst only, 39% on a time schedule and 16% by urine color or amount. The most frequent medical problems experienced during the race were nausea and vomiting (37%), blisters (34%), and shortness of breath (24%). Twenty-three racers reported using pain medication during the race, mainly NSAIDs (nonsteroidal anti-inflammatory drugs). No definite serious altitude illness was reported despite the high altitude during much of the race. No runner received intravenous fluids during or after the race.

Conclusions.—This group of experienced runners appeared to tolerate high altitude within the race, by report. Medical issues were largely minor in nature. Running experience did not correlate strongly with reported symptoms. More study is needed, at this distance and altitude, regarding runner acclimatization practices, serum sodium, body weight, and ADH (antidiuretic hormone) levels as relates to hydration strategy and the possible effects of NSAIDs on the development of altitude illness.

Utility of Urine Dipstick for Detecting Runners With Acute Kidney Injury Following a 161-km Ultramarathon

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Objective.—To evaluate the incidence of acute kidney injury (AKI) during the Leadville 100 ultramarathon held at high altitude (2800–3840 m) and the utility of urine dipstick at detecting AKI.

Methods.—This was a prospective observational study. Blood and urine samples were collected from voluntary athletes before and immediately after the Leadville 100-mile race in August 2014.

Results.—Postrace dipstick urinalysis was done on 70 runners (51 finishers), and a postrace blood sample was obtained from 84 runners (61 finishers). Both prerace and postrace samples were collected from 37 participants, which were included in the analysis. AKI was defined as a serum creatinine increase (≥ 1.5 times or ≥ 0.3 mg/dL from baseline) according to Kidney Disease: Improving Global Outcomes (KDIGO) Group. Eighteen runners (48.6%) met the criteria for stage 1 AKI. Using a binary logistic regression, the only factors statistically correlated with likelihood of AKI were runners who lost more weight at the finish line and male gender ($P < .05$ and $P = .05$, respectively). Age, race time, race completion status, use of NSAIDs (nonsteroidal anti-inflammatory drugs) before or during the race, BMI (body mass index), and postrace creatine kinase and sodium levels were not correlated with presence of AKI. Using urine appearance (color ≥ 4 out of 8 or not-clear) or specific gravity (≥ 1.025) criteria predicted those meeting the stage 1 AKI criteria with sensitivity of 81.3% and specificity of 37.5%. Using urine protein of at least 1+ predicted those meeting the stage 1 AKI criteria with sensitivity of 43.8% and specificity of 87.5%.

Conclusions.—Incidence of stage 1 AKI was relatively high in this ultramarathon. There was a higher rate of AKI among those who lost more weight at the finish line and male runners. Urine dipstick may be a useful screening tool for AKI.

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