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ORIGINAL RESEARCH

Exercise-Associated Hyponatremia, Hypernatremia, and Hydration Status in Multistage Ultramarathons

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Objective.—Dysnatremia and altered hydration status are potentially serious conditions that have not been well studied in multistage ultramarathons. The purpose of this study was to assess the incidence and prevalence of exercise-associated hyponatremia (EAH) ($Na^+ < 135$ mmol · L^{-1}) and hypernatremia ($Na^+ > 145$ mmol · L^{-1}) and hydration status during a multistage ultramarathon.

Methods.—This study involved a prospective observational cohort study of runners competing in a 250-km (155-mile) multistage ultramarathon (in the Jordan, Atacama, or Gobi Desert). Prerace body weight and poststage (stage [S] 1 [42 km], S3 [126 km], and S5 [250 km]) body weight and serum sodium concentration levels were obtained from 128 runners.

Results.—The prevalence of EAH per stage was 1.6% (S1), 4.8% (S3), and 10.1% (S5) with a cumulative incidence of 14.8%. Per-stage prevalence of hypernatremia was 35.2% (S1), 20.2% (S3), and 19.3% (S5) with a cumulative incidence of 52.3%. Runners became more dehydrated (weight change <–3%) throughout the race (S1=22.1%; S3=51.2%; S5=53.5%). Body weight gain correlated with EAH (r=–0.21, $P = .02$). Nonfinishers of S3 were significantly more likely to have EAH compared with finishers (75% vs 5%, $P = .001$), but there was no difference in either EAH or hypernatremia between nonfinishers and finishers of S5.

Conclusions.—The incidence of EAH in multistage ultramarathons was similar to marathons and single-stage ultramarathons, but the cumulative incidence of hypernatremia was 3 times greater than that of EAH. EAH was associated with increased weight gain (overhydration) in early stage nonfinishers and postrace finishers.

Keywords: hyponatremia, hypernatremia, ultramarathon running, hydration

Introduction

Participation in ultramarathon races has steadily increased over the past decade.[1] Races are typically >42 km and occur in a single stage or in multiple stages on varied terrain. The diverse extreme locations of multistage ultramarathons (eg, deserts, mountains, river crossings) and the equipment (eg, food, backpacks) that athletes need to carry throughout the race expose the athletes to unique challenges and, potentially, serious illnesses. Serious causes of illness in this population include electrolyte disturbances, hydration imbalances, heat-related illness, and cardiovascular compromise.[2–6]

Dysnatremia has been an area of significant interest in this population of runners. The majority of research has focused on exercise-associated hyponatremia (EAH), which is a potentially serious condition. EAH, defined as a serum sodium concentration ($[Na^+]$) <135 mEq/L, is recognized as relatively common in endurance running events.[7] Symptoms can vary, ranging from nausea, vomiting, and headaches to altered mental status, seizures, and death. The incidence of EAH varies depending on the distance of the race, with reported rates of 3 to 28% for marathons,[8,9] 23 to 38% for

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triathlons,[10] and 4 to 51% for single-stage ultramarathons.[1,11,12] However, there are no published incidence rates for multistage ultramarathons.

Despite being more common than EAH, markedly less is known about hypernatremia.[7,11,13,14] Hypernatremia, defined as $[Na^+]$ >145 mEq/L, can present with symptoms similar to those of EAH, making it challenging to distinguish the 2 entities.[1] The incidence rates of hypernatremia in single-stage ultramarathons are varied, reported in <2% of all participants during the Western States 100-Mile Endurance Run[11] and 48 to 55% of collapsed runners in the Comrades Marathon.[15] As with EAH, there are no published incidence rates of hypernatremia for multistage ultramarathons.

Hydration imbalances in the long-distance runner have been another area of significant research. Several field studies have identified an association between weight gain and EAH in marathon runners.[2,8,11,16,17] These studies would suggest that overconsumption of hypotonic fluids contributes to EAH, significant illness, and decreased performance in runners. In contrast, a study of single-stage ultramarathon runners noted that weight loss (ie, dehydration), especially in warm weather, had a weak but significant association with EAH.[11] In addition, the authors reported a significant relationship between weight loss and performance, such that faster runners lost more weight. These findings are in contrast with controlled laboratory studies that have shown dehydration (>2% body weight) leads to a decrease in athletic performance, which is compounded by heat.[18–20]

Fortunately, research has shown that the majority of athletes who experience dysnatremia or hydration imbalances are often asymptomatic. In addition, symptomatic runners can usually recover quickly with appropriate interventions.[7] Unfortunately, athlete characteristics have not been found helpful in risk stratification.[3,7,11,21] When symptoms do occur, they may be confused with other causes, such as exercise-associated collapse, heat-related illness, or cardiovascular compromise.[4–6] Delayed diagnosis and treatment could result in serious consequences, including seizures, pulmonary edema, or death.[16,17,21] Therefore, understanding dysnatremia and hydration status in multistage ultramarathons is of the utmost importance.

Given the lack of information regarding dysnatremia and hydration in multistage ultramarathon runners, the present observational study sought to examine the serum blood sodium concentration levels and hydration status of athletes during such events to determine whether these values are similar to or different from other long-distance events. The aims of this study were to 1) prospectively analyze the incidence and prevalence of EAH and hypernatremia in multistage ultramarathons and 2) assess the relationship between poststage and postrace $[Na^+]$ levels and the hydration status of finishers and nonfinishers.

Methods

SETTING

This study was conducted across several 4 Deserts multistage ultramarathons: the 2012 Atacama Crossing (Chile), the Sahara Race (Jordan), the Gobi March (China), and the 2013 Atacama Crossing (Chile). In each race, participants completed 4 consecutive stages of approximately 42 km (26 miles) per day followed by a fifth stage of approximately 80 km (50 miles) over 1 to 2 days. All races occurred over similar terrain, including deserts, river crossings, and slot canyons, with little trail or paved road. Participants started at a specific time each morning and completed the stage within an allotted time. Any participant who did not start a specific stage or dropped out of the race during the course of a stage for medical reasons was considered removed from competition (ie, nonfinisher). All participants were offered the same amount of water on any given day (approximately 1.5 L per 10–12 km), had to carry at least 2000 kcal/d (verified during registration) of food, and did not receive any food beyond what they carried. Participants were required to carry all their personal items at all times throughout the entire race, including clothes, sleeping gear, emergency gear, and their supply of food.

Daily maximal temperature was collected using a Suunto Vector (Suunto, Finland) for each stage of a race. The climate conditions of the 4 races had relatively similar average maximal temperatures (Atacama 2012, 33.2±1.1°C; Jordan, 32.1±1.4°C; Gobi, 35.3±1.1°C; Atacama 2013, 34.9±1.6°C). All races occurred in desert settings where the relative humidity is 10 to 20%. The University of Washington and Stanford University School of Medicine Institutional Review Boards approved the study design.

STUDY POPULATION

All entrants competing in a 4 Deserts multistage ultramarathon (Atacama 2012 [n=148]; Gobi 2012 [n=160]; Sahara 2012 [n=134], and Atacama 2013 [n=148]) who understood English were invited to participate in the study. One month prior to the start of a race, all registered race participants received a recruitment flyer via email that described the study. At the time of race registration, study researchers reviewed the study with the interested participants and obtained informed consent. Participants were excluded from the study if they