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ORIGINAL RESEARCH

The Impact of an Ultramarathon on Hormonal and Biochemical Parameters in Men

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Objective.—To examine circulating hormonal responses in men competing in the Western States Endurance Run (WSER, June 23 to 24, 2012): a 161-km trail run that starts in Squaw Valley, CA, and concludes in Auburn, CA.

Methods.—We examined 12 men who completed the WSER. Blood samples were obtained the morning before the race, immediately postrace (IP), and 1 (D1) and 2 (D2) days after the conclusion of the WSER. The hypothalamic-pituitary-testicular (HPT) axis was assessed by measuring testosterone and luteinizing hormone (LH). We also examined sex hormone-binding globulin (SHBG) and cortisol. Biochemical and muscle damage markers were also measured.

Results.—Relative to prerace, there were significant ($P \leq .05$) decreases in testosterone, LH, and SHBG, whereas cortisol showed a significantly marked elevation at IP. Testosterone, LH, SHBG, and cortisol remained significantly different from prerace at D1. Additionally, the testosterone to cortisol (T:C) ratio, a marker of anabolism, was decreased at IP and D1. Serum total protein, albumin, and globulin significantly decreased at IP, and remained decreased at D1 and D2. Bilirubin increased significantly IP and D1, whereas alkaline phosphatase decreased at D1 and D2. Creatine kinase, myoglobin, aspartate aminotransferase, and alanine aminotransferase increased at IP, and continued to be significantly elevated at D1 and D2.

Conclusions.—Training for and completing the WSER produced a significant suppression in the HPT axis as seen by decreased levels of testosterone and LH. Additionally, running the WSER continued to influence endocrine function until 2 days after the race. Furthermore, the stress caused by the WSER produced severe muscle damage.

Key words: ultramarathon, testosterone, luteinizing hormone, sex hormone-binding globulin, cortisol, tissue injury

Introduction

Participation in running events such as marathons, Ironman triathlons, and ultramarathons has gained increased popularity. Ultramarathons in particular have become increasingly popular as the number of events and participants has dramatically risen during the last 30 years.[1] The Western States Endurance Run (WSER), one the oldest and most prestigious 161-km ultramarathons, involves not only running for a prolonged duration but also exposes the athlete to numerous environmental stressors, including marked fluctuations in temperature and altitude. Thus, the body is exposed to multiple stressors in this competition.

Prolonged strenuous endurance exercise can alter normal physiological processes including induction of severe muscle damage,[2–4] imbalance in fluid and electrolyte levels,[5–8] changes in immune function,[9] increased inflammation,[4,10] alterations in coagulatory and fibrinolytic systems,[3] and increased risk of exertional heat stroke.[11] Additionally, long-duration events are known to affect endocrine function, reflected by alterations in the hypothalamic-pituitary-testicular (HPT) axis. Events of this duration and magnitude can suppress gonadal

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function in men as denoted by significant decreases in the anabolic hormone testosterone,[12–14] an effect that has been shown to last for days after the race.[15]

The impact of prolonged endurance events on luteinizing hormone (LH), the main regulator of testosterone, is less consistent. Concentrations of LH are either decreased[12,14] or remain constant[15–17] after prolonged endurance events, an effect potentially related to the pulsatile nature of LH and the highly individual response to the exercise stress. In addition, prolonged strenuous exercise decreases sex hormone-binding globulin (SHBG),[14,18] the primary carrier of testosterone. The physiological stress produced by endurance events greatly increases hypopituitary-adrenal stress as measured by cortisol concentrations,[13,19] possibly serving as a mechanism to increase blood sugar levels, suppress the immune system, and to assist in fat and protein metabolism.[20,21]

To date, it appears that only one study has examined how an ultramarathon affects anabolic hormonal response,[13] and so the recovery of endocrine responses after an ultramarathon remains to be determined. In the present study our primary purpose was to examine the hormonal responses in men competing in the WSER and determine the time course of recovery after the event. A secondary purpose was to document changes in markers of tissue function or injury compared with data obtained in previous endurance events. The present study complements our prior report on findings that running the WSER activated the coagulation and fibrinolytic systems.[3] We hypothesized that completion of the WSER would suppress the HPT axis, with the stress produced from running this ultraendurance event delaying the recovery of the endocrine system.

Methods

SUBJECTS

Subjects were recruited from 381 entrants in the 2012 WSER, who were invited to participate in the study during the registration and information meetings and medical symposium held 2 days before the race. To be considered for the study, participants were males between the ages of 21 and 70 years who had completed an ultramarathon previously. In total, 22 healthy men from various parts of the United States volunteered to be subjects. All participants were non-tobacco users and reported no history of cardiovascular disease. Exclusion criteria included the following: 1) no reported use of cholesterol lowering or blood pressure medications; 2) no reported use of anticoagulant medications (eg, coumadin); 3) never had been diagnosed with liver, kidney, blood, or gastrointestinal disease or severe metabolic or endocrine disorders; and 4) no reported use of hormonal substances including testosterone, anabolic steroids, or growth hormones. The Institutional Review Board for use of human subjects in research at the University of Connecticut approved this study. All subjects provided written informed consent after having the study risks and benefits carefully explained to them.

Subjects also completed training logs, which were used to determine how many kilometers each subject ran in the preceding 4 weeks before the WSER. Additionally, subjects completed food history questionnaires to estimate nutrient intakes before, during, and after the WSER.

ANTHROPOMETRICS

Body composition was determined via skinfold measurements obtained from the subject's right side (chest, abdomen, and thigh) using calibrated calipers (Harpenden Skinfold Caliper; Body Care Direct, Southam, Warwickshire, England). Body fat percentage was estimated using a 3-site skinfold equation[22] with the mean of 3 measurements used in the equation. Body mass was obtained with subjects wearing running clothes and sneakers on a digital scale (model 349KLX; Health o Meter, Bridgeview, IL).

SETTING

The WSER is a 161-km (100.2 miles) trail run that follows the Western States Trail. Beginning in Squaw Valley, CA, the course traverses the Sierra Nevada mountain range and ends in Auburn, CA. During the race, runners climb approximately 6000 m (maximum elevation: 2655 m) and descend about 7000 m through the Granite Chief Wilderness and canyons of California Gold Country. The 39th WSER started at 0500 h on June 23, 2012, and had a 30-hour time limit for completion. During the race, nearby temperatures ranged across the course from approximately 1°C (34°F) to 28°C (82°F).

BLOOD COLLECTION

Prerace blood samples were obtained after an overnight fast 20 hours before the start of the race (0700–1000 h; June 22, 2012). Additional blood samples were collected immediately postrace (IP; within 10 minutes of finishing the race) and 1 (D1) and 2 (D2) days after race completion (corresponding to 51–54 hours and 75–78 hours from the start of the race, respectively [0700–1000 h; June 25 and 26]). Similar to prerace, D1 and D2 blood samples were both obtained after an overnight fast between 0700 h and 1000 h. At each time, 20 mL of whole blood was obtained from an antecubital vein and