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# Nutritional status of adventure racers

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**Abstract**

**Objective:** We describe the usual food intake, body composition, and biochemical profile of adventure racers during their training season and evaluate their energy and nutrient intake in relation to current recommendations for ultraendurance athletes.

**Methods:** Twenty-four adventure race athletes (18 men and 6 women), 24 to 42 y of age, participated in the study. Food intake was determined with a 3-d food record and body composition by plethysmography. Blood samples were obtained from all subjects for biochemical analyses. All assessments were made during the usual training phase.

**Results:** Female athletes had a higher body fat percentage than did male athletes (20.2 ± 5.7% versus 12.5 ± 3.5%). For men and women, food intake was high in protein (1.9 ± 0.5 g/kg in men, 2.0 ± 0.4 g/kg in women) and fat (1.6 ± 0.3 g/kg in men, 1.5 ± 1.3 g/kg in women). Carbohydrate intake of male athletes was at the lower limit of that recommended (5.9 ± 1.8 g/kg). For most vitamins and minerals, athletes' intake was adequate, with the exception of magnesium, zinc, and potassium in men and women and vitamin E and calcium in women, which presented a high probability of being inadequate compared with reference values. High blood levels of total cholesterol and low-density lipoprotein cholesterol were found in female athletes (201.0 ± 44.7 and 104.1 ± 43.1 mg/dL, respectively) and all other biochemical analyses were within normal reference values.

**Conclusion:** The adventure racers presented an inadequate nutritional profile when compared with recommendations for endurance exercise. These athletes need to be educated about consuming an adequate diet to meet the nutritional needs of their activity. 

*Keywords:* Nutritional status; Ultraendurance; Adventure race; Athletes; Food intake

## Introduction

Athletes' participation in ultraendurance sports events, such as ultramarathons, long-distance triathlons, cycling, swimming, adventure races, and other events lasting >6 h has increased in recent years [1,2]. Despite the intensive and vigorous training demanded by these sports, a large number of contestants do not complete the competitions. This failure might be explained by the intense fatigue, injury, dehydration, hyponatremia, or hypoglycemia that are faced by the athletes [3,4].

In the previous decade, adventure racing has increased in popularity all over the world, with a consequent increase in the number of events and participants [5]. The competitions may last several uninterrupted days, and mixed-gender teams of three to five members need to use specific abilities to complete trekking, mountain biking, vertical techniques (rappelling, climbing, and Tyrolean traverses), horse riding,

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Alpinism, swimming, canoeing, sailing, rafting, and orienteering. Each team apportions its time between activities for rest, sleep, and food/fluid intake. The winning team is the one that passes through the checkpoints previously designated by the organization [6]. These sports demand great physical preparation, refined technical knowledge, successful strategy, emotional control, and sufficient team spirit [7].

During intensive training periods, recommendations for energy and macronutrient intake, especially for carbohydrates and proteins, must be achieved to maintain body mass, recover muscle glycogen stores, and offer adequate amounts of protein to build and regenerate tissues. Fat intake must be adequate to supply essential fatty acids and liposoluble vitamins and to provide adequate energy intake to maintain body mass [8]. However, it is common that ultraendurance athletes, who train several hours a day, have an inadequate energy intake, due to restricted available time for eating combined with a high-energy expenditure originated by the training. If maintained, this deficit can lead to chronic fatigue, body mass loss, and/or decreased performance [9]. Notwithstanding these problems, studies on such sports and their impact on the individual are very scarce, and effects of fatigue, stress, sleep deprivation, and environmental changes may confound interpretation of the collected data. Knowledge of these athletes' food habits is necessary to provide them with appropriate nutritional advice. Therefore, the aim of this study was to describe the normal food intake, body composition, and biochemical profile of adventure racers during the usual training phase and evaluate the adequacy of energy and nutrient intake in relation to the current recommendations for endurance athletes.

## Materials and methods

### *Subjects*

The present study was conducted during the usual training phase of the adventure racers. Twenty-four adventure race athletes (18 male and 6 female), 24 to 42 y of age, who had been practicing this sport for at least 3 y, and had participated in national and international competitions and placed within the first positions of the Brazilian ranking, participated in this study. Their enrollment was voluntary, after being informed about the procedures and objectives of the study.

This study was approved by the Committee of Ethics of the Federal University of Sao Paulo, under appraisal no. 1435/04, and informed written consent was obtained from all volunteers before starting the study. Participants had the option to leave the study whenever they wished.

### *Dietary intake*

Three-day food records were collected during the usual training phase of these adventure racers, including 2 nonconsecutive weekdays and 1 weekend day. It has been shown that 3-d food records are adequate in estimating habitual energy intake to within 90% of actual values in groups as small as 13 individuals [10]. The athletes were instructed to provide as much detail as possible of the foods and fluids consumed, including brand names and recipes for home-cooked foods. Portion sizes were estimated using common household measurements such as cups, glasses, bowls, teaspoons, and tablespoons in addition to individual food items/units. The athletes discussed their reported food intake with a qualified nutritionist and the information was amended to include additional explanations and detail, thus improving the accuracy of the information obtained. The Virtual Nutri 1.0 software (University of Sao Paulo, Brazil, 1996) was used for the quantitative analysis of energy and nutrient intake. Energy intake was compared with the estimated energy requirement according to the equation of the Food and Agriculture Organization (FAO)/World Health Organization (WHO)/United Nations University (UNU) equation [11]. Basal metabolic rate (BMR) was calculated based on height and weight. Energy requirements were estimated using a physical activity level of $1.7 \times$ BMR. Carbohydrate, protein, and fat intakes were compared with the recommendations proposed by the American Dietetic Association (ADA), Dietitians of Canada (DC), and American College of Sports Medicine (ACSM) [8]. Fiber, cholesterol, vitamins A, C, B1, B2, B6, B12, and E, and the minerals, sodium, calcium, magnesium, zinc, potassium, and iron were compared with the values recommended by the dietary reference intake (DRI) [12–17]. For the calculation of adequacy of intake, the statistical approach proposed by the DRI committees, which compares the difference between the reported intake and the estimated average requirement (EAR), was used. This equation also takes into consideration the variability of the requirement and the day-to-day variability of nutrient intake within an individual. The result is a $z$ score, from which a probability value, that reflects the degree of confidence that the individual's usual intake meets his/her requirement, is determined [18]. A $Z$ score $\geq 0.85$ was adopted as a cutoff point, which assures an 80% probability of adequate intake. Nutrients that have a skewed distribution or with no established EAR were compared with EAR or recommended dietary allowances (RDA) and adequate intake (AI) values, respectively.

### *Laboratory testing*

Subjects' body mass, and percentages of fat mass and fat-free mass were measured by total body plethysmography (BOD POD) composition system. Body weight was measured to the nearest 0.01 kg using the BOD POD electronic scale, calibrated before each BOD POD test. Height was measured with a Sanny stadiometer (American Medical do Brazil, Sao Paulo, Brazil) with a 0.1-cm precision. All measurements were determined according to recommended techniques [19,20].

Peak oxygen consumption ($\dot{V}O_2$ peak) was determined from a standardized incremental test up to voluntary exhaustion on a treadmill ergometer. The treadmill test (Life Fitness 9700HR, Life Fitness, Schiller Park, IL, USA) began after a 1-min rest followed by a 2-min warm-up at 8 km/h$^{-1}$, with a fixed inclination at 1% [14]. Volunteers were asked about the frequency and duration of their training schedule.

### Biochemical analysis

All volunteers attended the laboratory in the morning after a 12-h fast and blood samples were taken from the antecubital fossa by vein puncture within 2 min of being seated. Each blood sample was stored at −40°C until analysis. All samples were analyzed using commercial kits, following all the recommended procedures. Hematological profile (hemoglobin, hematocrit, ferritin, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and the size distribution of the erythrocytes) were measured by ethylene-diaminetetra-acetate (Vitros Chemistry, Ortho-Clinical Diagnostic, Los Angeles, CA, USA) and serum iron was determined by enzyme (Vitros Chemistry). Glucose, total cholesterol, high-density lipoprotein cholesterol (HDLc), triacylglycerides, calcium, phosphorus, magnesium, and total protein were analyzed calorimetrically (Vitros Chemistry). Low-density lipoprotein cholesterol (LDLc) was calculated (in mg/d) by LDLc = cholesterol − HDLc − (triacylglycerides/5). Sodium and potassium were determined by the potentiometric method (Vitros Chemistry). Creatinine was determined enzymatically (Vitros Chemistry). Thyroid-stimulating hormone, tri-iodothyronine, and free thyroxine were determined by chemiluminescence (Advia Centaur, Bayer Healthcare, Tarrytown, NY, USA) as was insulin (Immulite 2000 Insulin, Los Angeles, CA, USA).

### Statistical analysis

Data were analyzed with Statistica 6.0 (StatSoft, Inc., Tulsa, OK, USA). Gender comparisons between individuals' characteristics, their food intakes, and biochemistry used Student's $t$ tests for independent samples. Statistical tests with $P \leq 0.05$ were accepted as significant. All values were expressed as mean ± standard deviation (SD).

## Results

Characteristics of the participants are presented in Table 1. Body mass, height, BMI, body fat, and fat-free mass results showed significant statistical differences between the genders. Females had a higher body fat percentage compared with males (20.2% versus 12.5%, $P < 0.005$). For the remaining anthropometric variables, male adventure racers presented significantly higher values than did female athletes ($P < 0.05$).

Adventure racers train an average of 12 h/wk, divided into four basic modalities (running, cycling, rowing, and strength exercises) and performed at different periods of the day (morning, afternoon, and/or night). On weekends, training is more specific than on weekdays, being conducted in environmental conditions that are closer to those found in the competition itself.

Table 1
Athletes' characteristics*

| Variable | Men ($n$ = 18) | Women ($n$ = 6) |
|---|---|---|
| Age (y) | 30.9 ± 5.8 | 30.3 ± 7.8 |
| Body mass (kg) | 75.5 ± 5.1 | 63.7 ± 4.0† |
| Height (cm) | 176.0 ± 5.6 | 168.0 ± 5.3† |
| Body mass index (kg/m$^2$) | 24.3 ± 1.0 | 22.6 ± 1.8† |
| Body fat (%) | 12.5 ± 3.5 | 20.2 ± 5.7‡ |
| Fat mass (kg) | 9.4 ± 2.8 | 12.9 ± 4.0‡ |
| Lean mass (kg) | 65.9 ± 5.4 | 50.85 ± 4.4† |
| Training sessions (h/wk) | 13.1 ± 2.7 | 12.5 ± 3.4 |
| Peak oxygen consumption on treadmill (mL · kg$^{-1}$ · min$^{-1}$) | 58.6 ± 6.6 | 52.8 ± 5.5 |

* Values are presented as mean ± SD.
† Significantly smaller compared to the other gender ($P < 0.05$, Student's $t$ test).
‡ Significantly larger compared with the other gender ($P < 0.05$, Student's $t$ test).

### Food intake evaluation

The analysis of the normal intakes of energy, macronutrients, fiber, and cholesterol in relation to the recommendations of the FAO/WHO/UNU [11], ADA, DC, and ACSM [8], and DRI [17] are presented in Table 2. Women had energy intakes above the recommendation of the FAO/WHO/UNU [11] (48.1 versus 41 kcal · kg$^{-1}$ · d$^{-1}$). It was observed that, independent of gender, adventure racers had diets high in fat and protein. Carbohydrate intake was adequate for women; however, in men, carbohydrate intake was at the lower limit of recommended values. In relation to the DRI [17] recommendations, both genders presented a low intake of fiber and a high intake of cholesterol.

The most frequently consumed supplements were sports drinks (37%), carbohydrates in gel and powder forms (33%), protein supplements (29%), vitamin C (20%), multivitamins (20%), isolated amino acids (16%), glutamine (12%), meal replacement (12%), vitamin E (8%), and ferrous sulfate (4%).

The mean daily intakes of vitamins and minerals were compared with the DRI recommendations [12–17] (Table 3). With the exception of potassium and magnesium, all micronutrients exceeded the recommended values (RDA or AI) in men. For women, potassium, iron, and zinc levels were below recommended values.

Table 4 describes the probabilities of adequate intakes of vitamins B1, B2, and B6, and of magnesium, zinc, phosphorus, and iron. Most athletes had a >80% probability of adequate intake of vitamins B1, B2, and B6, and phosphorous. Although the iron intake of all the males was adequate,

Table 2
Mean daily energy and macronutrients intake of adventure racers*

| Nutrient | Recommendation | | Intake | |
|---|---|---|---|---|
| | Men | Women | Men ($n$ = 18) | Women ($n$ = 6) |
| Energy (kcal/kg)† | 44 | 41 | 44.6 ± 8.0 | 48.1 ± 19.8 |
| Macronutrients (g)‡ | | | | |
| Protein | 91–105 | 76–89 | 147.1 ± 36.4 | 129.9 ± 27.3 |
| Carbohydrate | 453–755 | 380–633 | 428.9 ± 132.9 | 439.7 ± 118.9 |
| Fat | 69–86 | 58–73 | 120.0 ± 24.8 | 96.2 ± 81.8 |
| Macronutrients (g/kg)‡ | | | | |
| Protein | 1.2–1.4 | 1.2–1.4 | 1.9 ± 0.5 | 2.0 ± 0.4 |
| Carbohydrate | 6–10 | 6–10 | 5.9 ± 1.8 | 6.9 ± 1.9 |
| Fat | 0.9–1.1 | 0.9–1.1 | 1.6 ± 0.3 | 1.5 ± 1.3 |
| Macronutrients (%E)‡ | | | | |
| Protein | 12–15 | 12–15 | 17.6 ± 6.4 | 18.1 ± 3.6 |
| Carbohydrate | 55–58 | 55–58 | 49.9 ± 8.7 | 60.7 ± 14.0¶ |
| Fat | 20–25 | 20–25 | 32.3 ± 5.7 | 24.8 ± 11.0‖ |
| Fiber (g)§ | 38 | 25 | 21.2 ± 5.7 | 20.7 ± 7.8 |
| Cholesterol (mg)§ | <200 | <200 | 414.3 ± 163.7 | 315.7 ± 208.5 |

* Values are presented as mean ± SD.
† Values based on the FAO/World Health Organization equation [20].
‡ Recommendations of the American Dietetic Association, Dietitians of Canada, and American College of Sports Medicine [8].
§ Dietary reference intake (adequate intake) reference values [16].
¶ Significantly larger compared with the other gender ($P < 0.05$).
‖ Significantly smaller compared with the other gender ($P < 0.05$).

only 50% of the female athletes took in enough iron. There was a low probability of adequate intake of magnesium (78% of men and 50% of women) and zinc (50% of men and women) for most athletes.

Most adventure racers presented an intake of vitamins A, C, and B12 above the cutoff point of the RDA (Table 5). Only 50% of male and 33% of female athletes had a vitamin E intake above the cutoff point.

Table 6 shows an adequate intake of calcium for most male athletes, but 50% of female athletes had an inadequate calcium intake. All adventure racers had an adequate sodium intake.

### *Biochemical analysis*

Results of the biochemical evaluation are listed in Table 7. All values were within normal limits, with the exception of total cholesterol and LDLc plasma concentrations, which were slightly above reference values in women.

## Discussion

It is commonly observed that, in ultraendurance sports such as ultradistance triathlon and marathon events, participants are older than the average age found in those partic-

Table 3
Mean daily micronutrient intakes of adventure racers in relation to nutritional recommendations of dietary reference intake [11–16]*

| Nutrients | Reference values | | Intake | |
|---|---|---|---|---|
| | Men | Women | Men ($n$ = 18) | Women ($n$ = 6) |
| Vitamin A (μg RE)† | 900 | 700 | 1782.6 ± 1180.9 | 1712.7 ± 580.2 |
| Vitamin C (mg)† | 90 | 75 | 301.6 ± 334.9 | 462.8 ± 414.7 |
| Vitamin B1 (mg)† | 1.2 | 1.1 | 3.5 ± 3.2 | 5.2 ± 6.5 |
| Vitamin B2 (mg)† | 1.3 | 1.1 | 2.3 ± 0.6 | 3.3 ± 0.9 |
| Vitamin B6 (mg)† | 1.5 | 1.7 | 3.1 ± 1.1 | 3.1 ± 1.0 |
| Vitamin B12 (μg)† | 2.4 | 2.4 | 5.8 ± 2.5 | 5.7 ± 3.5 |
| Vitamin E (mg TE)† | 15 | 15 | 15.7 ± 5.2 | 15.4 ± 9.7 |
| Sodium (mg)‡ | 1500 | 1500 | 4427.2 ± 1427.6 | 3543.9 ± 2985.0 |
| Calcium (mg)‡ | 1000 | 1000 | 1326.9 ± 383.5 | 1316.9 ± 598.0 |
| Magnesium (mg)† | 420 | 320 | 325.0 ± 97.6 | 339.5 ± 113.7 |
| Zinc (mg)† | 11 | 11 | 13.9 ± 4.9 | 10.4 ± 5.5 |
| Potassium (mg)‡ | 4700 | 4700 | 3233.2 ± 1014.9 | 3348.9 ± 1047.1 |
| Iron (mg)† | 8 | 18 | 31.3 ± 48.47 | 16.1 ± 9.2 |

* Values are expressed as mean ± SD.
† Recommended dietary allowance.
‡ Adequate intake.

Table 4
Male and female adventure racers distributed by gender according to level of probability of adequacy for vitamins B1, B2, and B6, magnesium, zinc, phosphorous, and iron micronutrients

| Nutrients | Probability of adequacy | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100% | 90% | 80% | 70% | 60% | 50% | 40% | 30% | 20% | 10% | 0% |
| Vitamin B1 (mg) | | | | | | | | | | | |
| Men | 14 | 1 | 2 | 1 | — | — | — | — | — | — | — |
| Women | 3 | — | 2 | — | 1 | — | — | — | — | — | — |
| Vitamin B2 (mg) | | | | | | | | | | | |
| Men | 11 | 6 | — | — | 1 | — | — | — | — | — | — |
| Women | 3 | 1 | — | 2 | — | — | — | — | — | — | — |
| Vitamin B6 (mg) | | | | | | | | | | | |
| Men | 14 | 3 | — | 1 | — | — | — | — | — | — | — |
| Women | 3 | 3 | — | — | — | — | — | — | — | — | — |
| Magnesium (mg) | | | | | | | | | | | |
| Men | 2 | 1 | 1 | 1 | 0 | 2 | 2 | 2 | 1 | 1 | 5 |
| Women | 2 | — | 1 | — | — | 1 | 1 | 1 | — | — | — |
| Zinc (mg) | | | | | | | | | | | |
| Men | 3 | 2 | 4 | 4 | 1 | 1 | 1 | — | 2 | — | — |
| Women | 2 | — | 1 | — | — | 1 | — | 2 | — | — | — |
| Phosphorous (mg) | | | | | | | | | | | |
| Men | 13 | 5 | — | — | — | — | — | — | — | — | — |
| Women | 3 | 2 | — | 1 | — | — | — | — | — | — | — |
| Iron (mg) | | | | | | | | | | | |
| Men | 15 | 2 | 1 | — | — | — | — | — | — | — | — |
| Women | 2 | — | 1 | — | 1 | 1 | 1 | — | — | — | — |

ipating in endurance and resistance sports [2,21,22]. In our study, the athletes' ages were similar to those described in other studies of ultraendurance athletes. These results suggest that the athletes have a greater maturity and better emotional balance in addition to their physical conditioning.

The $\dot{V}O_2$ peak values of our athletes determined on a treadmill (58.6 $mL \cdot kg^{-1} \cdot min^{-1}$ in men, 56.0 $mL \cdot kg^{-1} \cdot min^{-1}$ in women) were similar to those described by Kimber et al. [23] in triathletes (58.3 $mL \cdot kg^{-1} \cdot min^{-1}$ in men, 53.6 $mL \cdot kg^{-1} \cdot min^{-1}$ in women). However, our athletes had lower values in comparison with male (68.5 $mL \cdot kg^{-1} \cdot min^{-1}$) [24] and female (66.9 $mL \cdot kg^{-1} \cdot min^{-1}$) [25] ultramarathoners. Usually, athletes involved in sports with several different disciplines, such as the triathlon, have lower values for maximum oxygen intake ($\dot{V}O_2$ peak) when compared with athletes whose sport involves only one discipline (such as cycling or running). That difference may be related to the demand to maintain aerobic performance in multidiscipline sports [26,27].

In five of the six women in this study, percentage body fat was above the ideal values suggested for women athletes. According to ADA, DC, and ACSM [8] recommendations, the percentage fat for female cyclists, triathletes, and runners varies between 6% and 16%. However, Kimber et al. [23] and Nogueira and Da Costa [28] found female triathletes with fat values above ours (22.2% and 24.3%, respectively). Prolonged exercise seems to favor greater

Table 5
Male and female adventure racers distributed by gender in relation to adequacy intake of vitamins A, C, E, and B12, considering the cutoff points of the EAR and RDA values for age and gender

| Nutrient | <EAR | EAR–RDA | >RDA |
|---|---|---|---|
| Vitamin A ($\mu$g) | | | |
| Men | 1 | 2 | 15 |
| Women | — | — | 6 |
| Vitamin C (mg) | | | |
| Men | 2 | 1 | 15 |
| Women | — | 1 | 5 |
| Vitamin E (mg) | | | |
| Men | 5 | 4 | 9 |
| Women | 3 | 1 | 2 |
| Vitamin B12 ($\mu$g) | | | |
| Men | 1 | 1 | 16 |
| Women | 1 | — | 5 |

EAR, estimate average requirement; RDA, recommended dietary allowance

Table 6
Male and female adventure racers distributed considering the cutoff point of AI values

| Nutrient | <AI | ≥AI |
|---|---|---|
| Calcium (mg) | | |
| Men | 4 | 14 |
| Women | 3 | 3 |
| Sodium (mg) | | |
| Men | — | 18 |
| Women | — | 6 |
| Potassium (mg) | | |
| Men | 17 | 1 |
| Women | 5 | 1 |

AI, adequate intake

Table 7
Biochemical profile of male and female adventure racers*

| Biochemical examinations | Recommendations | | Athletes | |
|---|---|---|---|---|
| | Men | Women | Men ($n$ = 18) | Women ($n$ = 6) |
| Iron (μg/dL) | 40.0–160.0 | 40.0–160.0 | 101.9 ± 30.5 | 67.7 ± 19.2† |
| Ferritin (ng/dL) | 20.0–320.0 | 10.0–290.0 | 107.3 ± 40.2 | 48.2 ± 39.7† |
| Hemoglobin (g/dL) | 13.0–17.0 | 12.0–15.0 | 15.2 ± 0.9 | 13.9 ± 1.1† |
| Hematocrit (%) | 40.0–50.0 | 36.0–46.0 | 45.6 ± 2.8 | 40.7 ± 3.1† |
| Erythrocytes ($10^6/mm^3$) | 4.5–5.5 | 3.8–4.8 | 5.2 ± 0.3 | 4.5 ± 0.3† |
| MCV (fl) | 80.0–100.0 | 80.0–100.0 | 88.0 ± 3.6 | 90.3 ± 3.7 |
| MCH (pg) | 27.0–32.0 | 27.0–32.0 | 29.4 ± 1.5 | 30.4 ± 1.6 |
| MCCH (%) | 31.5–36.0 | 31.5–36.0 | 33.4 ± 1.3 | 33.1 ± 1.1 |
| SDE (%) | 11.9–15.4 | 11.9–15.4 | 13.3 ± 0.8 | 12.5 ± 1.1 |
| Glucose (mg/dL) | 70.0–110.0 | 70.0–110.0 | 86.9 ± 5.6 | 87.3 ± 8.7 |
| Creatinine (mg/dL) | 0.4–1.3 | 0.4–1.3 | 1.0 ± 0.1 | 0.8 ± 0.1† |
| Cholesterol (mg/dL) | <200.0 | <200.0 | 175.3 ± 25.9 | 201.0 ± 44.7 |
| HDL (mg/dL) | >40.0 | >40.0 | 59.6 ± 10.4 | 79.7 ± 12.1‡ |
| LDL (mg/dL) | <100 | <100 | 97.4 ± 21.7 | 104.1 ± 43.1 |
| VLDL (mg/dL) | 10.0–50.0 | 10.0–50.0 | 18.3 ± 6.7 | 17.2 ± 9.1 |

MCH, mean corpuscular hemoglobin; MCCH, mean corpuscular hemoglobin concentration; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SDE, size distribution of the erythrocytes; MCV, mean corpuscular volume; VLDL, very low-density lipoprotein

* Values are expressed as mean ± SD.

† Significantly smaller compared with the other gender ($P < 0.05$, Student's $t$ test).

‡ Significantly larger compared with the other gender ($P < 0.05$, Student's $t$ test).

body fat stores in response to high metabolic demand and consequent high-energy intake [29]. In our group, women exceeded the recommended daily energy intake by 17%, which may contribute to body fat storage.

Several studies have reported that ultraendurance athletes have high energy intakes in response to the high energy demand during training [22,23,28,30,31]. The energy intake of our male athletes was adequate (44.6 kcal/kg); however, the women's intake was above requirements (48.1 kcal/kg$^{-1}$) according to calculations based on the FAO/WHO/UNU [11] equation. Our values were above those suggested for female long-distance runners [32] and triathletes [28] (42.9 and 42.2 kcal/kg$^{-1}$, respectively). Nevertheless, it is important to remember that the suggested values are estimates only, and these may under- or overestimate the true energy needs of the athletes we have studied. De Lorenzo et al. [33], in a comparative study involving several equations predicting resting metabolic rate equations and indirect calorimetry, observed that the equations proposed by the FAO/WHO/UNU [11] underestimated the energy needs of some athletes.

Macronutrient intake, both quantitatively and qualitatively (that is, distribution in the diet), plays a fundamental role in performance during training and competition [8]. In our study we found an imbalance in macronutrient intake in both men and women during their training period. The low-carbohydrate intake in male athletes was similar to that found by Grandjean [34] in cyclists (386 g/d) and Singh et al. [30] in ultramarathoners (410 g/d). However, carbohydrate intake, which is usually insufficient in female endurance athletes [35], was in accord with ADA, DC, and ACSM [8] recommendations. An inadequate carbohydrate intake may result in insufficient muscle glycogen storage, early onset of fatigue, and the use of protein stores for energy production [35]. The excessive protein and fat intake observed was similar to values found in other studies [28,31,34,36]. It has been observed that excess protein intake might impair performance because there is an increased use of amino acids as the main energy source [37], a higher risk of dehydration [38], and increased calcium excretion [39]. The excessive consumption of fat decreases the storage of glycogen in both muscles and liver. Therefore, training intensity may be compromised in individuals who consume a fat-rich diet. An impairment in exercise capacity is likely to result from a combination of premature depletion of (lowered) muscle glycogen stores and absence of any effective increase in the capacity for fat utilization during exercise to compensate for the reduction in available carbohydrate [40].

Unexpectedly, slight increases in total cholesterol and LDLc fraction levels were found in the women in our study. Usually, athletes have an adequate lipid profile, with exercises acting to reduce total cholesterol and LDLc and increases HDLc [41]. Although our female athletes presented a high level of training, apparently their diet appears to have influenced negatively their lipid profile.

A low fiber intake was found in both genders when compared with the DRI. Data on fiber intake show that athletes usually do not achieve recommended values [42–44]. The low fiber intake could be related to the high intake of high-energy density foods that is required to meet the energy expenditure due to training.

In relation to the intake of micronutrient, it was observed that, on average, athletes consumed more than the RDA/AI of almost all micronutrients. This may be related to the use of food supplements, especially the meal replacement, vitamin C, and multivitamins. Nevertheless, it must be taken into consideration that there are no specific recommendations for athletes. There is evidence that physically active individuals may have specific vitamin and mineral losses during exercise through greater sweating and urinary losses [45,46]. Those losses may indicate a greater need for vitamins and minerals, which may be 1.5 to 3 times greater in ultraendurance athletes than in non-athletes [47].

However, although the conventional approach showed that the athletes are consuming above or equal to, the RDA/AI values, we also used the new intake-evaluation technique proposed by the DRI [18]; this method enables the probability of intake values being adequate or inadequate to be evaluated. Most athletes showed a probability of adequate intake greater than, or equal to, 80% for vitamins B1, B2, and B6 and for the minerals phosphorous and iron. By contrast, magnesium intake had a high probability of being inadequate in 78% of male and 50% of female athletes, and this can lead to negative consequences on performance because it is involved in energy metabolism, nerve conduction, and muscle contraction [48].

Vitamins A, C, E, and B12 were separately analyzed because they have a coefficient of variation of intake that is greater than 60% to 70%. This demonstrates that the distribution of intake is skewed and requires additional days for accurate evaluation. These vitamins had only a low probability of inadequate intake, with the exception of vitamin E for both genders. For 28% of male and 50% of female athletes, vitamin E intake needs to be improved; vitamin E has an important antioxidant action [48], so its dietary intake should be increased.

For nutrients with no established EAR, a comparative analysis was done using the AI values. Because calcium intake for men and sodium intake for both genders are above the AI, those values are almost certainly adequate [18]. On the other hand, although the intakes of calcium (for most women) and potassium (for the majority of all participants) were below the AI, we cannot classify them as inadequate because, according to the DRI [18], this method is unreliable.

Although other studies [46,49,50] have reported low iron intake in women, we found normal iron status in our study, even though iron deficiency and anemia are frequently reported in female athletes [51–53].

These data suggest that food selection must be qualitatively re-evaluated so that it becomes possible to meet recommendations regarding micronutrients intake through a balanced diet.

## Conclusion

Adventure racers have an inadequate feeding pattern during the training phase similar to reports of other studies on ultraendurance athletes. The diet is characterized by high protein and fat intakes at the expense of carbohydrate intake. However, it was observed that most athletes had an adequate intake of vitamins and minerals, with the exception of magnesium, zinc, and potassium in both genders and vitamin E and calcium (in females). The results indicate that counseling and education in nutrition are essential to guarantee that adventure racers achieve an adequate diet, which can improve their performance as well as maintain their health.

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