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Lower calcium and iron intake in adolescent gymnasts: A case of concern for youth sports nutrition

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ABSTRACT

Objectives: Diet is important for the appropriate development and maturation of young amateur athletes. The aim of this study was to determine whether young gymnasts were consuming adequate amounts of nutrients, particularly calcium and iron.
Methods: This cross-sectional survey was conducted in Portugal's Almada and Lisbon regions in 2020. To determine if participants' diet was adequate, weight, height, and skinfold measurements were taken. Dietary consumption was examined using two 24-h recalls. We collected data from 66 participants (60% females, 12–18 y of age), of whom 82% had normal weight and 39% had ideal body fat.
Results: The daily total energy intake (TEI) was1605 ± 601 kcal. Of the TEI, 19%, 31%, and 50% were comprised of protein, fat, and carbohydrates, respectively. The most often consumed protein sources were poultry and ultra-processed meat products (52% and 45%, respectively). The average daily consumption of calcium and iron was 626 ± 293 and 9 ± 3 mg, respectively. Only 2 of the 66 participants had calcium intake within recommended levels, and 1of 5 had iron intake within recommended levels, the percentage of which was lower in girls than boys (7.5% versus 38.5%, $P < 0.05$).
Conclusions: Despite having a sufficient macronutrient distribution, Portuguese gymnasts consume a high amount of ultra-processed items and a low amount of calcium and iron. The low proportion of female gymnasts with adequate iron consumption is cause for worry in sports nutrition.
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Introduction

Proper nutrition is essential for the well-being and health of athletes. Additionally, it has a recognized role in performance, providing energy for physical exertion and aiding in muscle repair and recovery during training sessions [1]. In the case of young athletes, adequate energy and nutrient intake for growth and development must be balanced with the increased calorie and nutrient demands of physical activity [2].

Some sports, such as gymnastics, require intense practice that begins at a very young age. Gymnastics is a discipline in which physical and mental talents, such as strength, balance, agility, coordination, and flexibility, predominate. Initial contact with this modality typically begins in preschool but is frequently limited to amateurism. However, there is still a great need for these amateur training sessions, as achieving presentations and performances remains an essential objective [3].

According to the few studies that have examined this aspect of their training, gymnasts have an inadequate calorie and food intake. These studies noted low intakes of iron in female gymnasts and calcium in both sexes were noted in these studies, which is cause for concern given the importance of these two micronutrients [4–7].

Calcium is a mineral that is essential for bone formation and, consequently, skeleton development; therefore, adolescents must consume enough calcium [8]. The recommended dietary allowance for this mineral in teenagers is 1150 mg/d [9]. Dairy products are essential sources, and their absence, due to intolerances or personal preferences, may be related to intakes below the dietary guidelines [10,11]. Although numerous nutrients significantly affect bone health, adequate calcium intake has been linked to

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greater bone mass density [12]. In Portugal, 64% of adolescents have insufficient calcium intake [13], raising some concerns about the probable repercussions and warrants vigilance.

Iron also may be a deficient mineral. Patton et al. [14] identified iron deficiency anemia as a significant indicator of teenagers' nutritional status. This micronutrient contributes to cellular growth, enzymatic reactions, immunologic function, cognitive function, and oxygen binding and transport. Consequently, iron deficiency can impair health, well-being, growth, development, and academic achievement. This deficiency may be caused by increased demand and/or exacerbated in cases of blood loss. Inadequate iron intake through diet is also a significant factor influencing iron status, particularly in women who must compensate for monthly losses. Iron deficiency anemia is the primary cause of disability-adjusted life-years lost at such a young age, and the severity of this problem has been acknowledged globally [15]. Researchers have estimated that 20% of female adolescents in Portugal do not consume enough iron [13].

These inadequacies can be exacerbated when sports are aesthetic, and there is a desire to restrict food intake for weight loss or control. The prevalence of eating disorders among adolescent athletes is greater than that of their non-athlete peers [6,7], and this might increase suboptimal energy intake and contribute to micronutrient deficiencies.

Gymnastics is a sport that begins at young ages with exponential growth and development, which is problematic for the future of these young athletes and calls for monitoring [16]. Given the scarcity of research on the nutritional status of young gymnasts, this study aimed to assess the intake of two essential micronutrients for growth and development in a sample of amateur youth gymnasts. Therefore, this study aimed to assess the calcium and iron intake of an amateur gymnastics sample.

Materials and methods

Sample and study design

This cross-sectional study used a convenience sample of 11- to 18-y-old amateur gymnasts recruited by emails sent to local clubs and amateur teams. Participants belonged to several local teams from the Almada and Lisbon cities in Portugal. Recruitment took place between September and October 2020.

Each participant attended a private session that included a clinical anamnesis, anthropometric measurements, and a first 24-h dietary recall (24HDR). A second session was undertaken 7 to 10 d after the first 24HDR. Both nutritional interviews were completed when a caregiver was present.

Inclusion and exclusion criteria

Included in the present sample were female and male gymnasts ages 11 to 18 who engaged in at least three weekly training sessions.

Gymnasts who trained less than three times per week over the previous 6 mo and those who did not complete all anthropometric and food intake evaluations were eliminated. The existence of any ailment (e.g., diabetes) was also a reason for exclusion.

Anthropometric and body composition evaluation

All anthropometric procedures were performed in a private room with a temperature of 20°C, and gymnasts wore light-weight clothing and no footwear. Height was measured to the millimeter using a wall-mounted precision stadiometer (SECA). Participants maintained shoulder blades, the back of the head, and buttocks against the board while keeping the head in the horizontal plane of Frankfurt. Weight was measured to an accuracy of 100 g using a Tanita BC-543 scale; both measurements were made after a full expiratory movement. Body mass index (BMI) was determined and further classified as normal or overweight. Using an INNOVACARE Cescorf caliper, the skinfolds of the biceps, triceps, subscapular, supra iliac, and abdomen were measured. According to World Health Organization growth curves, BMI was computed and further classified as normal or overweight [17].

As suggested by the International Society for the Advancement of Kinanthropometry, duplicate measurements were taken to ensure uniformity [18]. Using the Lohmann equation, body fat mass was determined and categorized according to the age-specific reference body fat. The Durnin & Womersley method was used to compute body density, which was then converted to body fat using the Siri Equation and compared with the acceptable body fat values for children and adolescents [19,20]. Supplementary Table 1 presents the ideal body fat percentages for children and adolescents ages 7 to 17 y and Supplementary Table 1B refers to adults [19,21]. Female participants were also asked about menses regularity.

Food intake assessment

Two 24HDRs were administered within a 7- to 10-d interval by a certified dietitian to assess food intake. Weekends and holidays were eliminated to ensure that training weekdays at school and gymnastics activities were adequately represented. Participants were required to report all foods and beverages consumed the previous day, including time, location, and preparation information. A typical pictorial model book containing three alternative portion sizes for the most frequent dishes consumed in Portugal aided the estimation of portion sizes. Each interview lasted between 20 and 30 min, and younger gymnasts were interviewed in the presence of a parent or guardian [22].

The 24HDR data was then imported into an Excel spreadsheet and translated to total energy intake (TEI), macronutrients, calcium, and iron intake. A Portuguese-specific food composition table and a European table of homogeneous, multi-ingredient foods were used [23,24]. Individuals' energy intakes were assessed using a formula developed by the Institute of Medicine based on their height, weight, age, and sex [25].

Five major dietary groups were included during this study:

- Fresh fruits alone;
- Vegetables (soups, salads, and cooked vegetables);
- Dairy products (milk, cheese, and yogurt);
- Animal protein sources (meat, fish, and eggs, including processed products such as fish fingers and nuggets) as well as vegetable protein sources such as, soy, tofu, tempeh; and
- Legumes and pseudo cereals: beans, chickpeas, quinoa.

Micronutrient consumption was compared with the Recommended Dietary Allowance (RDA) or appropriate intake if the RDA was not available.

Statistical analysis

All analyses were carried out using SPSS version 20 (IBM, Armonk, New York, USA). For categorical data, descriptive results were presented as the number of participants (%), and for Gaussian and non-Gaussian distributed continuous variables, as the mean SD or median (interquartile range).

TEI was compared to needs using the Wilcoxon signed-rank test, and micronutrient intakes were compared to dietary reference intakes using a one-sample t test, with $P < 0.05$ indicating statistical significance for a two-sided test.

Ethical statement

All parents and/or legal guardians were informed of the study's objectives and methodology. Informed consent was given by 18-y-old athletes. Legal guardians of younger athletes and the athletes themselves signed informed consent forms. The research was sanctioned by the Egas Moniz Ethical Committee, and all procedures adhered to the Helsinki Declaration for human studies.

Results

Demographic characteristics and body composition

Of 75 gymnasts, 9 did not sign the informed consent form. Thus, 66 gymnasts were included (61% females, 12−18 y of age range). Most (81%) were average weight, whereas only one participant was underweight. Regarding body composition, five participants had low body values, whereas >50% (75% of female gym-goers) exceeded the required body fat levels (Table 1). All female gymnasts were already menstruating.

Food intake: calcium and iron

Table 2 summarizes the 24HDR results. TEI comprised 20% protein, 30% fat, and 49% carbohydrates. There were significant sex

Table 1
Sample characteristics of amateur gymnasts, overall and stratified by sex, Almada and Lisbon regions, Portugal

	Female (n = 40)	Male (n = 26)	Total (N = 66)
Age (y)	15 ± 2	14 ± 2	15 ± 2
BMI (kg/m^2)	21.1 ± 2.5	19.7 ± 3.2	20.6 ± 2.8
BMI categories, n/%*			
Underweight	0/0	1/3.9	1/1.5
Normal weight	33/82.5	20/76.9	53/81.8
Overweight	7/17.5	5/19.2	12/18.2
Body fat categories, n/%†			
Low	0/0	5/19.2	5/7.6
Optimal	10/25	16/61.5	26/39.4
High	30/75	5/19.2	35/53

BMI, body mass index
Results expressed as number/% for categorical variables and average ± SD for continuous variables
*According with World Health Organization growth curves.
†Determined considering the reference values presented in Supplementary Tables 1 and 1B.

differences in TEI and macronutrient intake; however, TEI was below the recommended energy needs ($P < 0.0001$).

The average calcium consumption was significantly lower than the RDA ($P < 0.05$), and almost none of the participants had appropriate calcium intake. Less than 25% of male and 10% of female gymnasts had appropriate iron consumption. The average iron consumption of female participants was considerably lower than recommended ($P < 0.05$).

Food groups intake

Figure 1 presents the results for the food groups. Only 56% of the adolescents consumed fresh fruits daily; vegetable soup and salads were the primary vegetable sources, although only 35% and 28% of participants had them daily. The daily intake of dairy products was low, with only 18% drinking milk. The most consumed protein source was poultry meat, followed by ultra-processed meat products. Participants did not report on the consumption of fish.

Table 2
Energy and nutritional intakes of amateur gymnasts, stratified by sex, based on a 24-h recall of their meals

	Female (n = 40)	Male (n = 26)	Total (N = 66)
TEI (kcal)			
11–13 y old	1298 ± 313*	1731 ± 792	1576 ± 680*
14–18 y old	1612 ± 608*	1614 ± 551*	1613 ± 584*
Macronutrients (g/d)			
Protein	71 ± 25	88 ± 31	78 ± 29
Fat	54 ± 31	56 ± 23	55 ± 28
Carbohydrates	183 ± 73	228 ± 95	201 ± 85
Macronutrient (% TEI)			
Protein	19.9 ± 7.36	20.4 ± 4.2	20.1 ± 5.2
Fat	31.2 ± 8.2	28.3 ± 5.8	30.1 ± 7.4
Carbohydrates	49.1 ± 7.4	51 ± 7.6	49.9 ± 7.4
Protein (g/kg body weight)	1.4 ± 0.6	1.8 ± 0.8	1.6 ± 0.7
Micronutrients (mg/d)			
Calcium	586 ± 299	688 ± 277	626 ± 293*
Iron	8 ± 2*†	10 ± 4†	9 ± 3
Micronutrients adequacy, n/%			
Calcium	1/2.5	1/3.8	2/3
Iron	3/7.5	10/38.	13/20%

TEI, total energy intake
Results expressed as number/% for categorical variables and as average ± SD for continuous variables
*The intake is significantly lower than recommended ($P < 0.05$).
†There were significant differences between sexes ($P < 0.05$).

Discussion

Given the scarcity of research on the nutritional status of young gymnasts, the purpose of this study aimed to assess the intake of two essential micronutrients for growth and development in a sample of amateur youth gymnasts. According to our results, one in five gymnasts was overweight, but >50% had high body fat percentages. Female gymnasts had significantly lower calcium intake than their male counterparts, and female gymnasts were iron deficient.

It is important to note that all the participants in this sample were amateurs, which raises additional concerns because the training frequencies and volumes are comparable to those of elite levels. It is exceptionally demanding for those who wish to evolve, and this group needs more access to the assistance of health professionals [26,27]. This may explain why amateur athletes are more likely to engage in risky behaviors, such as using banned ergogenic substances, which pose a significant risk if not monitored [28]. Additionally, our results demonstrated that, even though most participants were average weight, more than half had high body fat percentages that could only be detected through an accurate body composition analysis. In previous studies, body composition was determined using bioimpedance analysis [5–7] and skinfold measurements [4]. In the present study, four skinfold measurements were taken, and an age-appropriate formula was applied. Even though bioimpedance can be accurate and less invasive, it underestimates body fat values. It is highly influenced by hydration status [29], which is a significant bias in samples such as those used in the present study. The use of skinfolds is well established in these age groups and levels of practice. Although most adolescent studies have employed Slaughter equations [30], it employs only two skinfold sites and excludes the abdominal site, which has been cited as crucial in estimating truncal body fat [31]. In this study, four skinfolds were measured, and the Durnin & Womersley equation was chosen because it had previously demonstrated some agreement in a sample of adolescent athletes [32].

In terms of food and nutrient intake, the present results corroborate the previous data on gymnasts, which indicated an insufficient intake of energy, calcium, and iron. Given the acceptable macronutrient dietary ranges, macronutrient intake was sufficient [25]. The average protein intake was comparable to a previous study conducted on adolescents, whereas the fat and carbohydrate intakes were lower and higher, respectively. Despite this, the average energy intake was significantly lower than the estimated energy needs, consistent with previous findings [4,5,7]. Although these participants were not elite athletes, the risk for relative energy deficiency in sport in aesthetic modalities such as gymnastics, which Villa et al. previously studied, is especially concerning if these habits are maintained [7].

Although there are no clearly defined reasons why normal-weight athletes chronically restrict their energy intake, participation in aesthetic sports or sports where it is assumed to have a low body mass may contribute, barriers to nutritional support that would be expected among amateur athletes can exacerbate this behavior [33,34].

Additionally, calcium and iron intake fell below the recommended levels. The present study confirmed findings indicating low calcium and iron intake [5,6]. These results are consistent with the last Portuguese food and physical activity survey, in which 63.5% of adolescents had inadequate calcium intake, 20% of female and 32.5% of male adolescents had inadequate iron intake [13].

Calcium deficiency has been identified as a potential risk factor for stress fractures in athletes and its potential adverse effects on bone health [35]. The present findings suggested that the low

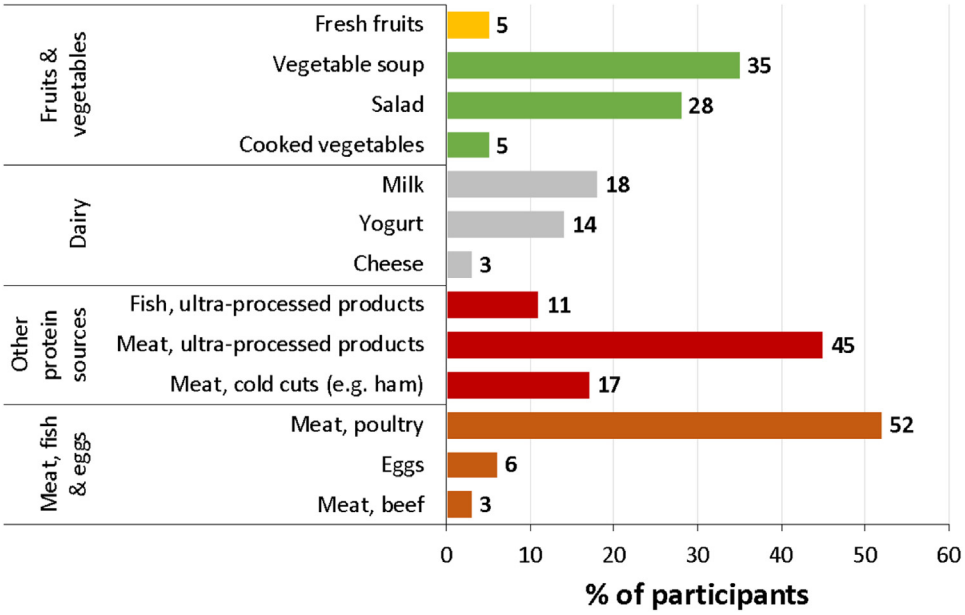

Fig. 1. Daily intake of specific food groups. The % refers to the proportion of participants that had at least one portion of each food/food group daily.

calcium intake of amateur gymnasts may increase their risk for stress fractures. This may also affect body weight and composition, given that adequate dairy consumption, and milk, have been linked to a lower BMI in this age group [36,37], even though it is impossible to establish a causal link.

Nine of 10 female gymnasts had low iron intake, which is concerning because the consequences can be severe and made worse by menstrual loss and intense physical activity [38].

It is essential to implement a dietary intervention that includes iron-rich foods and enhances iron absorption to prevent and treat this condition [39].

Previous evidence suggested that this inadequate intake may be due to dietary restrictions common in aesthetic sports such as gymnastics [40]. However, it is also important to note that the increased autonomy and the picky eating behavior observed in this age group are also risk factors for poor diet quality and decreased intake of certain minerals, including iron [41,42]. This could be exacerbated by inadequate body weight and composition, given that previous research [43,44] indicates that obese individuals are at a greater risk for iron deficiency.

It is also essential to note that the current work significantly affected food intake assessment. Previous research employed a variety of methods, including food diaries [4,7] and food frequency questionnaires [6,7,45], although some also referred to 24HDR [5,6]. In fact, for the target micronutrients, Shoemaker [38] used the 24HDR to evaluate iron intake, and this instrument was also previously used to evaluate calcium intake in adolescents [46]. Dietary assessment in this age group is challenging. In this study, the methodology recommended by European researchers was considered [13,47]. The 24HDR conducted by a certified dietitian via interview, not self-reporting, is a reference for accurately estimating food, energy, and nutrient intake. It is frequently used to validate other methods [48,49]. These recalls also permit a qualitative evaluation of food intake and food preferences, and in the present study, it was crucial to evaluate the reasons for this micronutrient deficiency. As in other studies [4,6], these participants did not consume the recommended amount of dairy products, which is not consistent with national data [13]. It is difficult to identify the reasons for such low consumption. The most common reasons adults cite for avoiding dairy products are the fear of weight gain and intestinal gas [50]. As gymnasts' food choices are influenced by their parents' beliefs and the availability of food at home, it is possible that such myths could reduce their dairy consumption [51]. Vegetable consumption was also below the recommended amount and in line with other findings for this age group. Considering the vitamin C content of these foods, low vegetable consumption may contribute to decreased iron absorption and intake [44]. Low iron intake may be attributable to the protein sources found in this sample. The analysis revealed that many participants consumed ultra-processed fish and meat (e.g., deli foods, mixed fish and chicken products such as nuggets or fish fingers) in their main meals. It is essential to note that the consumption of ultra-processed foods has been associated with a decline in nutritional quality, particularly micronutrient intake [52].

We are aware that our study's sample size was small and that this may be its most significant limitation. We did not intend to compare groups to identify statistical differences but to compare intake with age-specific recommendations. Considering the importance of nutrition for the health and development of children, particularly those who participate in sports, any number of young people in a population whose intake falls below recommended levels is significant, even if the population is small. In the present sample of 66 athletes, 64 had inadequate calcium intake, and 53 had inadequate iron intake. Thus, the prevalence of inadequate calcium and iron intake was 96.7% and 80.3%, respectively. Although it is not possible to extrapolate these results to other populations of amateur gymnasts, nor is it possible to guarantee that these prevalences would be maintained if the sample size were increased, the relevance of this finding in this population remains and serves as an impetus for the development of new studies in larger populations; as well as a warning sign for those who follow young athletes. Additionally, previous studies with comparable objectives used comparable [2,3] or smaller [4,5,36] sample sizes.

The present results demonstrated the importance of having a dietitian on these teams and the urgency of keeping a close eye on food and nutrient intake in amateur athletes who have the potential to become elite in the near future. It is essential to increase awareness and knowledge through food and nutritional education

programs, mainly because they have demonstrated positive results in this age group [6].

Conclusions and future directions

According to the present results, female gymnasts have a deficient calcium and iron intake despite an adequate macronutrient intake. The low consumption of dairy products and the preference for ultra-processed foods as protein sources may explain this finding. The present findings highlighted the significance of close monitoring of young athletes and the need for parents and coaches to emphasize the importance of a healthy diet.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2023.112020.

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