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Nutrient Intake and Body Composition in CrossFit® Athletes: a Cross-sectional Study

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ABSTRACT

Background: Nutritional composition of the athletes' diet in relation to their training routine and body composition is critical in maintaining high performance levels during competitions. **Objective:** This study aimed to investigate the body composition and nutrient intake of CrossFit® athletes. **Methods:** Twenty-five Brazilian CrossFit® athletes (18–50 years old) were evaluated in this study. Height, weight, and body mass index (BMI) were measured. A portable ultrasound was used to assess body composition. Resting energy expenditure was evaluated by indirect calorimetry. To describe the nutrient intake, 175 diets prepared by nutritionists were analyzed (mean diets per athlete = 7). To verify adherence, three non-consecutive self-reported 24-hour dietary recall surveys per diet were analyzed, totaling 525 days of food consumption record, and the mean of these 24-hour dietary recalls was used in this study. **Results:** The mean age was 32.0 ± 8.9 years, with no differences between men and women (P=0.208). The mean BMI was 26.4 ± 2.6 kg/m^2. Energy intake was 2,904.0 ± 697.3 kcal/day. Protein and carbohydrate intake was 2.3 ± 0.4 and 4.5 ± 2.0 g/kg/day, respectively. Regarding carbohydrate consumption, 44% of CrossFit® athletes consumed less than the recommended amount (5–12 g/kg/day). In addition, most athletes (>50%) had insufficient intake of potassium, selenium, calcium, and vitamins A, D, B9, and B12. **Conclusion:** It can be concluded that CrossFit® athletes presented an insufficient intake of some vitamins, minerals, and carbohydrates.

Key words: Exercise, Body Composition, Dietary Intake, Nutrient Intake, Indirect Calorimetry, Energy Intake

INTRODUCTION

The practice of Olympic-style weightlifting (OWL), gymnastics, and aerobic exercises together, for predetermined time intervals, characterizes CrossFit® training (Claudino et al., 2018; Meyer, Morrison & Zuniga, 2017). Greg Glassman developed this training method, which was patented in 1995 and now has countless associates worldwide (Souza et al., 2021). The versatility of training and the benefits to physical conditioning has made CrossFit® a prevalent sport among athletes globally. According to the official CrossFit® website (crossfit.com), there are 533 affiliated boxes in Brazil (Sprey et al., 2016).

Adherents to the CrossFit® high-intensity training routine benefit from improvements in their physical conditioning, body composition, well-being, and quality of life (Sprey et al., 2016; Kephart et al., 2018). Exercises such as OWL, which are part of CrossFit's daily training, have been proven to promote positive gains in body composition and athletes' performance (San Juan et al., 2020).

However, without proper dietary support, intense training can lead to fatigue, incorrect execution of movements related to the sport, and, consequently, injury (Liu et al., 2019; Freire et al., 2020). Furthermore, physical exercise added to the energy deficit caused by training, when not associated with an adequate caloric intake, can also cause dysfunctions in the immune, metabolic, functional, and physiological systems, among others (Sprey et al., 2016; Heikura et al., 2018; Mountjoy et al., 2018).

Thus, to obtain an adequate energy supply and optimal maintenance of physiological processes, in addition to preventing changes that compromise health and performance, knowledge about the body composition of these athletes is

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essential (Capling et al., 2017; Suarez-Arrones et al., 2018). Therefore, from this assessment, it is possible to understand the nutritional status and functional capacity of the athlete's body, in addition to allowing the development of assertive dietary interventions appropriate to the sport's practice (Kuriyan, 2018; Borga et al., 2018).

Understanding the nutritional composition of the athletes' diet in relation to their training routine and body composition is vital to maintain high performance levels during competitions (Black et al., 2019; Posthumus et al., 2021). Thus, nutritional assessments must be conducted to adapt food consumption to the caloric deficit caused by exercise, preventing energy imbalances that lead to metabolic and physiological dysfunctions (Capling et al., 2017; Heikura et al., 2018; Mountjoy et al., 2018).

In addition to data on body structure and food intake, other variables about the CrossFit® athlete, the sport, characteristics of the performed training, and the type of competition are crucial for obtaining a satisfactory diet therapy treatment and energy supply (Capling et al., 2017; Suarez-Arrones et al., 2018; Black et al., 2019; Posthumus et al., 2021).

A systematic review was conducted between March and July 2020 to investigate physiological and metabolic responses to CrossFit®, in addition to evaluating dietary interventions in the sport (Souza et al., 2021). However, there are few studies on nutritional and supplementation strategies that enhance the performance of elite CrossFit® athletes. The authors found that the data gathered in the literature were limited. Therefore, it is necessary to conduct more accurate analyzes to define adequate nutritional and supplementation parameters for elite CrossFit® athletes (Souza et al., 2021).

Hence, our research is the first study conducted with CrossFit® elite athletes that aimed to characterize their body composition, total energy expenditure (TEE), and the intake of macronutrients (carbohydrates, proteins, and lipids), micronutrients (calcium, sodium, selenium, retinol, ascorbic acid, calciferol, tocopherol, thiamine, riboflavin, niacin, pyridoxine, folic acid, cobalamin, iron, phosphorus, potassium, zinc, magnesium, and manganese), dietary fiber and cholesterol during different training periods.

MATERIALS AND METHODS

Design

This is a descriptive and retrospective cross-sectional study conducted by analyzing dietary intake, body composition, and training records of professional CrossFit® athletes aged between 18 and 50 years, evaluated by nutritionists between 2018 and 2021. Dependent variables include anthropometry, body composition, indirect calorimetry, and food consumption. Sex was used as an independent variable.

Study Population, Inclusion and Exclusion Criteria, and Recruitment

The present study included 25 athletes. A convenience sample was used; all athletes who agreed to participate in the study and met the inclusion criteria signed the Informed Consent Term. As inclusion criteria, elite athletes of both sexes, aged between 18 and 50 years old and who had ranked in the Brazil Tournament (TCB) and/or CrossFit® Games were invited as proof of their CrossFit® athlete status. Those who did not agree to participate in the research and those who did not meet the age range of this study were excluded. In addition, athletes with diseases that make swallowing difficult or who had altered eating habits due to a specific disease were also excluded.

The principal investigator contacted the nutritionists responsible for each elite athlete selected during competitions to obtain detailed data regarding their dietary prescription, athletes' food consumption, training period, body composition, and energy expenditure.

Ethical Aspects

This study was approved by the Ethics Committee of University Center Christus – UNICHRISTUS, under protocol number 4.997.195, CAAE 51337221.0.0000.5049. After contacting the responsible nutritionists, all selected participants were contacted and signed the Informed Consent Term after proper explanations about the objectives and methods of the research. The nutritionists responsible for providing the data also signed a letter of agreement, allowing data collection in their space and with their athletes.

Anthropometry and Body Composition

To conduct the research, an attendance protocol was applied for data collection, which addressed demographic and socioeconomic questions on the practice of sport and health history, among others. In the anthropometric assessment, the following parameters were measured: weight and height. From these measurements, the body mass index (BMI) was calculated. The procedures were performed by the nutritionists responsible for each athlete, all certified by the ISAK (International Society for the Advancement of Kinanthropometry). Weight and height were assessed using a scale and stadiometer to measure weight and height, respectively, following the standard proposed by the World Health Organization (World Health Organization, 1995; World Health Organization, 2000).

The estimation of adiposity and fat-free mass was performed using the portable ultrasound system Body Metrix® BX2000 (IntelaMetrix, USA), and the equation used was that of Jackson and Pollock (Jackson, Pollock & Ward, 1980; Jackson & Pollock, 1978), as used in Brazilian studies for Crossfit athletes® (Sena, Souza & Capistrano Jr, 2021), following the standardization and markings proposed by ISAK (Silva & Vieira, 2020) and evaluated by a researcher with more than 3 years of experience with ultrasound.

Indirect Calorimetry (IC)

The Korr® MetaCheck calorimeter was used to evaluate Resting energy expenditure (REE) by indirect calorimetry (IC). The participants were asked to fast for at least five hours and rest for 30 min before starting the indirect calorimetry procedure. The participants were guided not to perform demanding exercises 24 h before the evaluation. Additionally, smoking and consumption of caffeine and other types of stimulants were prohibited one day before the assessment. The equipment calibration and stabilization tests followed the manufacturer's instructions. Every test lasted for 30 min, with the first 5 min being discarded to guarantee sufficient acclimatization. The participants sat and used a rigid breathing mask (Compher et al., 2006; Haugen, Chan & Li, 2007; Oshima et al., 2017). REE was calculated using the Weir equation (Weir, 1949).

Food Consumption

To obtain the athletes' nutritional variables, the main researcher contacted the nutritionists responsible for each athlete and, after contact, received each athlete's eating plans. For the elaboration of the nutritional prescriptions evaluated, particularities were considered, such as the patient's eating habits, food culture, and preferences. An average of seven dietary plans were obtained for each athlete. With the aim of reaching the recommended values of macro and micronutrients intake for high-performance athletes, their 24-hour dietary recalls were also evaluated (a total of three recalls were collected for each diet prescribed to the athlete, two recalls on non-consecutive days of the week, and one referring to the weekend), in addition to the data referring to the training periods, body composition and energy expenditure were detail (Institute of Medicine, 2000).

Subsequently, to perform macronutrient and micronutrient analysis, the main researcher inserted all eating plans, and 24-hour recalls provided by nutritionists in the Dietbox® software, which has a Brazilian table of food composition reference, and nutritional information obtained from food labels when dealing with specific brands.

Food intake was compared with the recommendations of the American College of Sports Medicine (ACSM) (Thomas, Erdman & Burke, 2016), and caloric intake according to their energy needs, determined by an IC device and using metabolic equivalents (METs) (Cunningham, 1980; Ainsworth et al., 1993).

The relative distribution of macronutrients in relation to the total energy expenditure (TEE) was also analyzed using the Acceptable Macronutrients Distribution Range (AMDR): carbohydrate, 45%–65%; protein, 10%–35%; and lipids, 20%–35% of the total energy consumed value (TEV) for adults, as proposed in the DRI (Dietary Reference Intake) (Institute of Medicine, 2005). The consumption of these macronutrients was considered adequate when the average percentage was within the range defined by the AMDR. The other values were classified as below or above AMDR.

For a qualitative analysis of micronutrients and fibers, the RDA (Recommended Dietary Allowance) values recommended in the DRI were used. When a nutrient does not have the RDA value, the AI (Adequate Intake) values are used as an individual recommendation. In the qualitative analysis, athletes were classified in consumption above or below this individual recommendation (Institute of Medicine, 2000).

The DRI does not define an exact recommendation for cholesterol and saturated fat, suggesting that consumption be as low as possible in a nutritionally adequate diet. For the analysis of these dietary components, the values recommended by the WHO were used, considering that saturated fatty acids account for up to 10% of the TEV, monounsaturated fatty acids between 15% and 20%, and polyunsaturated fatty acids are between 6% and 11% (World Health Organization, 2008). A maximum cholesterol intake of 300 mg per day was considered in this study as a parameter of normality (World Health Organization, 2003).

Statistical Analysis

For statistical analysis, the database was created using the Microsoft Excel program (Office 2013®) and analyzed using the Statistical Package for Social Sciences (SPSS®) version 19.0 for Windows (SPSS Inc, Chicago, IL, USA). The Kolmogorov–Smirnov test was used to assess normality and indicate the statistical test to be used. If the p-value is less than 0.05, the distribution is not normal, and above 0.05, the distribution is normal. Qualitative (categorical) variables were described using absolute and relative frequency (percentage). Quantitative variables with normal distribution were presented as mean and standard deviation, and quantitative variables that did not have normal distribution were presented as median, minimum, and maximum. For comparison between men and women, categorical variables were compared using Chi-square or Fisher's exact test, and quantitative variables with normal distribution were compared using Student's T-test for independent samples. The results that presented a significance level of 95% (p-value ≤ 0.05) were considered statistically significant associations.

RESULTS

Twenty-five elite CrossFit® athletes were evaluated, 12 women (48%) and 13 men (52%), aged between 18 and 50 years. The mean age was 32.0 ± 8.9 years, with no differences between men and women (29.9 ± 8.7 years; 34.4 ± 8.9 years, respectively) (P=0.208).

Table 1 shows the anthropometric and body composition profile of the CrossFit® athletes. The mean BMI was 26.4 ± 2.6 kg/m^2, and 64% were classified as overweight, which is not an isolated parameter to be analyzed in sports. As for the percentage of fat, the mean value found was 12.0 ± 4.9%, ranging from 4.9% to 21.5%. These differences between men and women in body composition are expected.

Regarding nutrient intake, the analysis involved 175 diets prescribed for one year to 25 athletes, with an average of seven dietary plans per athlete. For each dietary plan prescribed, three 24-hour food recalls were collected, totaling 525 recalls, to verify adherence. All athletes were monitored by nutritionists, and food plans were prepared by these professionals according to the training phase they were in within a complete training cycle. In our study, the values consumed and obtained through 24-hour food recalls are presented in Tables 2, 3, and 4.

Table 1. Body composition and anthropometry crossfit® athletes

	Total (n = 25)	Men (n = 13)	Women (n = 12)	*P* value#
Weight (kg) – Mean ± SD	79.1 ± 14,2	88.0 ± 10.7	69.5 ± 11.0	<0.001
Height (m) – Mean ± SD	1.72 ± 0,09	1.77 ± 0.08	1.67 ± 0.07	0.006
BMI (kg/m²) – Mean ± SD	26.4 ± 2,6	28.0 ± 1.5	24.7 ± 2.5	0.001
BMI categorization – n (%)				0.008
Low weight (IMC < 18,5 kg/m²)	0	0	0	
Normal weight (18,5 ≤ IMC < 25 kg/m²)	9 (36%)	1 (4%)	8 (32%)	
Excess weight (IMC ≥ 25 kg/m²)	16 (64%)	12 (48%)	4 (16%)	
Fat (%) – Mean ± SD	12.0 ± 4.9	8.5 ± 2.6	15.9 ± 3.6	<0.001
Fat mass (kg) – Mean ± SD	9.2 ± 3.7	7.4 ± 2.3	11.2 ± 4.0	0.008
FFM (kg) – Mean ± SD	71.5 ± 14.5	80.5 ± 10.5	61.6 ± 11.7	<0.001
FFM (%) – Mean ± SD	86.2 ± 9.2	91.5 ± 2.6	80.5 ± 10.4	0.001

Legend: SD: standard deviation; BMI: body mass index; FFM: free fat mass; kg: kilogram; cm: centimeter; m: meter; #: comparison between men and women

Table 2. Resting energy expenditure, total energy expenditure, and total energy ingested of crossfit® athletes

	Total (n = 25)	Men (n = 13)	Women (n = 12)	*P* value
REE	1,935.1 ± 285.2	2,122.0 ± 230.7	1,732.8 ± 183.1	<0.001
TEE	2,951.0 ± 647.9	3,117.8 ± 635.9	2,770.4 ± 637.3	0.093
Ingested energy (kcal/day) Mean ± SD	2,904.0 ± 697.3	3,224.7 ± 649.4	2,556.5 ± 589.5	0.013
Ingested energy per kg of weight (kcal/kg/day) Mean ± SD	37.4 ± 9.8	36.8 ± 6.8	38.0 ± 12.5	0.758
Energy spent by hour of training (kcal/h/day) Mean ± SD	340.3 ± 151.9	350.2 ± 153.5	329.6 ± 156.3	0.331

Legend: SD: standard deviation; REE: resting energy expenditure; TEE: total energy expenditure; kcal: kilocalories; kg: kilogram; h: hour

Table 3. Ingestion and categorization of crossfit® athletes regarding macronutrients values consumed

	Total (n = 25) Mean ± SD	Men (n = 13) Mean ± SD	Women (n = 12) Mean ± SD	*P* value
Carbohydrates (g)	344.0 ± 133.2	388.8 ± 115.4	295.4 ± 138.5	0.079
Carbohydrates (% of TEV)	46.1 ± 8.8	47.6 ± 6.4	44.5 ± 10.9	0.388
Carbohydrates (g/kg/day)	4.5 ± 2.0	4.4 ± 1.2	4.5 ± 2.6	0.939
Proteins (g)	176.5 ± 39.7	192.2 ± 36.9	159.6 ± 36.8	0.037
Proteins (% of TEV)	25.0 ± 5.5	24.2 ± 3.9	25.8 ± 7.0	0.479
Proteins (g/kg/day)	2.3 ± 0.4	2.2 ± 0.3	2.3 ± 0.5	0.462
Fat (g)	91.3 ± 21.5	100.1 ± 21.4	81.8 ± 17.9	0.031
Fat (% of TEV)	28.9 ± 5.7	28.2 ± 4.5	29.7 ± 6.8	0.518
Fat (g/kg/day)	1.2 ± 0.3	1.1 ± 0.3	1.2 ± 0.3	0.640
Macronutrients categorization regarding AMDR – n (%)				
Carbohydrates				0.418
Consume below levels	11 (44%)	5 (38.5%)	6 (50.0%)	
Consume within levels	13 (52%)	8 (61.5%)	5 (41.7%)	
Consume above levels	1 (4%)	0	1 (8.3%)	
Proteins				0.288
Consume below levels	0	0	0	
Consume within levels	24 (96%)	13 (100%)	11 (91.7%)	
Consume above levels	1 (4%)	0	1 (8.3%)	
Fat				0.076
Consume below levels	2 (8%)	0	2 (16.7%)	
Consume within levels	21 (84%)	13 (100%)	8 (66.6%)	
Consume above levels	2 (8%)	0	2 (16.7%)	

Legend: SD: standard deviation; AMDR: Acceptable Macronutrients Distribution Range; TEV: total energy value of diet

Table 4. Median, minimum, and maximum values, and qualitative analysis of micronutrients and fibers consumed by for crossfit® athletes

Nutrients	Median	Minimum	Maximum	Categorization – n(%)	
				< RDA or AI	≥ RDA or AI
Fiber (g)	36.0	17.0	59.0	11 (44%)	14 (56%)
Calcium (mg)	800.0	300.0	1900.0	19 (76%)	6 (24%)
Magnesium (mg)	370.0	235.0	635.0	9 (36%)	16 (64%)
Phosphorus (mg)	1800.0	800.0	3600.0	0	25 (100%)
Iron (mg)	14.0	8.0	30.0	9 (36%)	16 (64%)
Sodium (mg)	1902.0	903.0	3600.0	9 (36%)	16 (64%)
Potassium (mg)	3600.0	2300.0	6500.0	20 (80%)	5 (20%)
Manganese (mg)	6.0	2.3	50.0	1 (4%)	24 (96%)
Zinc (mg)	12.0	5.0	25.0	3 (12%)	22 (88%)
Selenium (mcg)	55.0	13.0	150.0	13 (52%)	12 (48%)
Vitamin A (mcg)	330.0	180.0	1500.0	20 (80%)	5 (20%)
Folic acid (B9) (mcg)	149.0	18.0	900.0	19 (76%)	6 (24%)
Cobalamin (B12) (mcg)	1.5	0.4	7.0	13 (52%)	12 (48%)
Thiamin (B1) (mg)	1.2	0.3	3.0	8 (32%)	17 (68%)
Riboflavin (B2) (mg)	1.2	0.9	3.6	4 (16%)	21 (84%)
Pyridoxin (B6) (mg)	1.4	1.0	6.0	9 (36%)	16 (64%)
Niacin (B3) (mg)	25.0	11.0	52.0	2 (8%)	23 (92%)
Vitamin C (mg)	200.0	60.0	580.0	2 (8%)	23 (92%)
Vitamin D (mcg)	0.6	0.1	3.2	25 (100%)	0
Vitamin E (mg)	6.0	1.0	65.0	21 (84%)	4 (16%)

Legend: RDA: Recommended dietary allowance; AI: *Adequate Intake*

Table 2 presents the REE, evaluated by IC, and TEE. Also, it presents energy consumption, energy ingested by kilogram of body weight, and energy spent per hour of training. There were differences between men and women regarding energy consumption per day (*P*=0.013), but the calories per kilogram of body weight were not different (*P*=0.758).

Table 3 shows the values of macronutrients obtained through the 24-hour food recall. The average consumption of carbohydrates per kilogram of body weight was 4.6 ± 1.9 g/kg/day, and 11 athletes (44%) were below the 45%–65% of the TEV range proposed in the DRI. The average protein intake was 2.2 ± 0.4 g/kg/day, and 24 athletes (96%) reached the percentage range in relation to the TEV proposed in the DRI (10%– 35% of the TEV). As for the consumption of lipids, 22 (88%) consumed the values proposed in the DRI (20%–35% of the TEV).

Regarding micronutrient intake, Table 4 shows the median consumption of each micronutrient evaluated in this study, as well as a categorization, defining those who consume above or below the RDA or AI values proposed by the DRI. At least 70% of athletes consumed nutrients such as calcium, potassium, and vitamins A and E below the individual recommendations proposed in the DRIs. In addition, all CrossFit® athletes consumed less vitamin D than recommended by the DRI.

The mean cholesterol prescription was 867.0 ± 463.5mg and 24 athletes (96%) ingested above the 300mg recommended by the WHO (World Health Organization, 2008). Also, according to the WHO, 24 (96%) athletes consumed above the saturated fatty acid recommendation, which is 10% of the TEV. As for polyunsaturated fatty acids, 10 athletes (40%) had adequate ingestion (6%–11%), and 15 (60%) consumed above the percentage range. As for monounsaturated fatty acids, all research participants consumed below the WHO recommendation (15%–20% of VET). The following are the average fatty acids consumption in this study: 31.3 ± 12.7 grams of monounsaturated fatty acids, 14.0 ± 5.7 grams of polyunsaturated fatty acids, and 30.8 ± 16.1 grams of saturated fatty acids.

To verify adherence, our study compared the mean for the seven diets prescribed for each athlete with the mean of the 21 food recalls obtained, and there were no differences for any nutrient evaluated (energy, macronutrients, and micronutrients) (P>0.05).

DISCUSSION

This study aimed to characterize for the first time the dietary intake of energy, macronutrients and micronutrients, and body composition of Brazilian elite CrossFit® athletes during training periods. This study showed an insufficient consumption of carbohydrates among CrossFit® athletes. In addition, insufficient intake of calcium, potassium, selenium, and some vitamins was observed.

Anthropometric analysis of participants trained in CrossFit® showed that 16 of the 25 athletes were overweight when classified only by their BMI, with a mean BMI of 28.0 ± 1.5 kg/m^2 among male athletes and 24.7 ± 2.5 kg/m^2 among women. In a study that included trained athletes, but not elite in CrossFit®, aged between 27 and 35 years, mean BMI values were 21.3 ± 1.9 kg/m^2 for women and 26.0 ± 1.9 kg/m^2 for men, characterizing eutrophic, and of, overweight, respectively (Gogojewicz, Sliwicka & Durkalec-Michalski, 2020). In another study that evaluated 18 participants aged between 22 and 26 years, CrossFit® practitioners on diets with moderately low and high carbohydrate intake, the BMI values were 22.7 ± 5.5 g/m^2 for women and 24.3 ± 8.8 kg/m^2 for men (Escobar, Morales & Vandusseldorp, 2016).

Despite the overweight status indicated by the BMI, the mean fat percentage of the elite athletes evaluated in this study was only 8.5 ± 2.6% for men and 15.9 ± 3.6% for women. These differ a little, in absolute values, from the fat percentages described in other studies on CrossFit®, but not in elite athletes. In a study conducted with 12 volunteers (7 men and 5 women) undergoing 3 months of CrossFit® training, researchers found a decrease in the percentage of body fat [23.95 ± 3.39% to 22.28 ± 3.04% in women (P=0.05); and 17.31 ± 4.06% to 16.86 ± 4.27% in men, with no statistical difference] (Escobar, Morales & Vandusseldorp, 2016). CrossFit®, as well as other sports with a combination of high-intensity training, contributes to changes in the percentage of body mass and distribution of body compartments in those who practice them (Gogojewicz, Sliwicka & Durkalec-Michalski, 2020).

The caloric intake was higher in our study than those obtained in another study, which was conducted with elite athletes (Gogojewicz, Sliwicka & Durkalec-Michalski, 2020). The study showed that the mean consumption of the trained individuals was 1,736 ± 407 kcal in women and 2,265 ± 417 kcal in men. The study showed that these mean values were below the energy expenditure calculated for each CrossFit® practitioner, demonstrating an imbalance between energy expenditure and caloric intake, which has been proven to cause consequent harm to the health of athletes of both sexes (Heikura et al., 2018; Statuta, Asif & Drezner, 2017). It is important to mention that elite athletes may have a higher energy demand due to the high level of training. Furthermore, in our study, eating plans were drawn up by nutritionists respecting individual recommendations, while the study by Gogojewicz et al. (2020) only described the food intake of volunteers.

Another particularity of the present t study was the monitoring of elite athletes for seven training periods, where some athletes underwent periods of energy restriction with the objective of weight maintenance. The difference in absolute values between total energy expenditure and energy consumption in the athletes' diets of is more evident in women than in men (106.9 vs. 213.9 kcal for men and women, respectively). For that, women are considering the target of a more critical and careful look, as proposed by the International Olympic Committee (IOC), once they are more sensitive to energy deficit (Carter, 2018).

According to the IOC, extreme energy deficits cause behaviors that harm athletes' physical and psychological health (Mountjoy et al., 2018). However, studies that characterize dietary interventions for CrossFit® athletes to promote ergogenic nutritional practices are scarce and have low quality, either because of the methodology used or because of the small sample size (Gogojewicz, Sliwicka & Durkalec-Michalski, 2020; Souza et al., 2021). In this sense, eating plans designed for high-performance athletes, such as those from CrossFit®, should aim to meet their dietary habits and cultural diversity, in addition to the ideal energy values for the individual daily needs of each athlete (Souza et al., 2021). In our study, we observed how dietary prescriptions that respect the athlete›s individuality have a higher level of adherence because when comparing prescribed consumption data with those actually ingested, collected through the 24-hour food recall, there were no differences in the values found.

As for the consumption of macronutrients, in our study, 44% of the athletes consumed carbohydrates below the range of 45%–65% of the TEV proposed in the DRI, with a mean of 4.5 ± 2.0 g/kg of weight per day. Non-athlete CrossFit® practitioners had a CHO consumption of approximately 3.9 g/kg of body mass in women and 3.3 g/kg of body mass among men, below the ideal reference values used as a parameter for this study (Gogojewicz, Sliwicka & Durkalec-Michalski, 2020). Regarding the effects of dietary interventions and supplementation on the performance of CrossFit® athletes, carbohydrate is a macronutrient that must be met in its reference values to maintain optimal physiological processes, including cellular adaptations and injury prevention (Souza et al., 2021). However, more research is needed to understand the real needs of this nutrient in relation to the exercises performed during CrossFit® training (Souza et al., 2021).

An analysis of 18 athletes compared the effect on the performance of high (6–8 g/kg/day) and reduced (<6 g/kg/day) amounts of carbohydrates over a training period of CrossFit® with a duration of 12 min (Escobar, Morales & Vandusseldorp, 2016). It showed that diets of 6–8 g/kg/day did not promote gains in athletes' performance compared to diets of close to 6 g/kg/day. However, the group that received the highest carbohydrate input obtained considerable gains in yield (Escobar, Morales & Vandusseldorp, 2016). Furthermore, when evaluating carbohydrate consumption in eight male CrossFit® practitioners, with a mean age of 22 years, no indications of performance evolution were observed in those who supplemented 16g of carbohydrates during training compared to a group that received a placebo (Rountree et al., 2017).

The average protein intake among the 25 athletes evaluated was 2.3 ± 0.4 g/kg/day, and 96% reached the percentage range in relation to the TEV proposed in the DRI (10%–35% of the TEV) when 24-hour food recalls were evaluated. Protein is the macronutrient that must be prioritized when adjusting the amounts consumed in nutritional plans adopted for CrossFit® athletes. This macronutrient, in addition to being available in ideal amounts, must come from good sources, thus allowing for improvements in the performance of athletes, especially during muscle recovery. In this research, the authors observed a mean protein consumption of 1.6 ± 0.4 g/kg/day (Gogojewicz, Sliwicka & Durkalec-Michalski, 2020).

The importance of adequate protein intake is further reinforced in a detailed systematic review (Souza et al., 2021). This study indicated that protein intake during physical activity and competition should be about 1.6–2.2 g/kg of weight per day to improve muscle repair and gain of skeletal muscle mass. It also highlighted that adequate protein consumption is crucial to avoid loss of lean mass due to the energy overload caused by the performance of the exercises (Souza et al., 2021).

As for fat, a consumption above the reference value proposed in the DRI (20%–35% of the VET) was observed in 8% of the athletes. Also, 21 athletes (84%) consumed a mean of 1.2 g/kg/day, adequate values for this macronutrient. As for cholesterol values, the mean value was 867.0 ± 463.5 mg, and 24 athletes (96%) consumed above the 300 mg recommended by the WHO (World Health Organization, 2003; 2008). In one study, they did not observe higher values of lipid consumption in their sample; however, the average cholesterol intake in the diets of women and men who participated in the research exceeded the reference values used (Gogojewicz, Sliwicka & Durkalec-Michalski, 2020). The study showed that cholesterol values tend to increase due to the high intake of animal foods in the diet of athletes. In addition, a lack of compliance with the quality of fat consumed was perceived. In our study, of the 25 athletes evaluated, 24 (96%) consumed above the saturated fatty acid recommendation, which is 10% of the TEV, while 15 (60%) consumed polyunsaturated fatty acids above this indicated percentage range and 100% of the sample presented a consumption below the WHO recommendation (15%–20% of the TEV) for monounsaturated fatty acids.

Regarding the consumption of vitamins and minerals, our study showed a consumption below the recommended values for calcium, potassium, selenium, and vitamins A, B9, B12, and D in at least 50% of the athletes. Ideal consumption of vitamins was verified by another study including male and female athletes as part of the sample (Gogojewicz, Sliwicka & Durkalec-Michalski, 2020). This study showed that only vitamin E in women was inadequate. In our study, 84% (21 athletes) of the sample had inadequate values for this vitamin.

Practical Implications

To estimate the energy needs of athletes and avoid caloric deficits in CrossFit® athletes, one of the suggested calculation methods is the Kcal recommendations per kg of weight. This simplified and quick approach estimates energy expenditure (Silver et al., 2013). The calorie range used in the calculation should be between 35 and 40 kcal per kilogram of total body mass, according to our results.

Another method indicated to calculate the total energy requirement is the multiplication of the REE by the daily physical activity factor, adding to the final result of this calculation the average caloric value of 340 kcal for each hour of CrossFit® training performed. To assess REE in Crossfit, a study with 142 practitioners defined the best equations for men and women (Sena, Souza & Capistrano Jr, 2021).

According to our results, the macronutrient recommendation for CrossFit® athletes for carbohydrate, protein, and lipid is 5–6, 1.6–2.2, and 0.8–1 grams per kilogram of weight per day, respectively. Additionally, extra attention to food sources containing multiple vitamins and minerals should be stimulated in a CrossFit® elite athlete's diet to avoid micronutrient deficiency. These recommendations can guide the work of nutritionists and other professionals who accompany these athletes.

Limitations

The present study has limitations, such as the convenience sample composed of athletes who agreed to participate. However, even with this limitation, the study stands out for the unprecedented nature of describing food consumption and body composition in elite CrossFit® athletes, which may contribute to a better understanding of these characteristics, helping nutritionists and other professionals to define the best strategies seeking to increase performance in these athletes. Further studies, especially with good methodological designs, are needed to verify the impact of different nutritional interventions on the performance of CrossFit® athletes. It is an area open to new data collection and interpretation, and the present study can contribute in part to this knowledge.

CONCLUSION

This study demonstrated an insufficient consumption of carbohydrates in CrossFit® athletes. Also, an insufficient intake of calcium, potassium, selenium, and some vitamins was observed. It is important to educate athletes and coaches about individual nutritional needs to preserve health and improve sports performance in all phases of CrossFit® training. More studies are needed to evaluate the specific recommendations in CrossFit®.

AUTHOR CONTRIBUTIONS

All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

CONGRESSES

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