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Anthropometric profile and dietary intake of amateurs and professional mixed martial arts athletes

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ORIGINAL PAPER

Abstract

Nutritional habits and anthropometric profiles are directly linked to competitive performance; however, there is a great lack of information on amateur or professional mixed martial arts (MMA) athletes outside the competitive period. The aim of this study was to compare food consumption and anthropometric profile of amateur and professional MMA fighters. The sample was composed of 24 male MMA athletes, middleweight category (age: 27.5 ± 5.0 years; body mass: 79.0 ± 12.1 kg; height: 173.5 ± 0.1 cm; %BF: 19.5 ± 4.0 %, BMI: 26.0 ± 2.8 kg/m^2). Food consumption was evaluated based on three 24-hour food diaries using the Multi-Step method in a non-competitive period and analyzed using the Dietbox v2.92 software. The professional group was younger (p = 0.001) than the amateur group. Total energy expenditure was similar between amateur (4364 ± 469 kcal) and professional (4312 ± 381 kcal). Amateur and professional reported an energy deficit between the estimated energy requirement and energy intake. Carbohydrate consumption was below the suggested minimum limits (amateur: 3.3 ± 1.6g/kg/day and professional: 3.3 ± 1.4g/kg/day). Protein intake was within the suggested limits (amateur: 1.4 ± 0.9g/kg/day and professional: 1.8 ± 0.8g/kg/day) and lipids presented borderline values about to with concerning the recommendations in the literature (amateur: 0.9 ± 0.6 / g/kg/day and professional: 1.8 ± 0.9 g/kg/day). Amateur and professional athletes did not differ in terms of food consumption and anthropometric profile. Both groups, amateur and professional, demonstrated negative energy balance and inability to reach the suggested levels of macronutrient intake according to the classification. Thus, it is recommended that both MMA groups receive attention regarding nutritional strategies.

Keywords: Martial arts; combat sports; MMA; sports nutrition; diet; energy expenditure.

Perfil antropométrico e ingesta dietética de atletas amateurs y profesionales de artes marciales mixtas

Resumen

Los hábitos nutricionales y los perfiles antropométricos están directamente relacionados con el rendimiento competitivo; sin embargo, existe una gran falta de información sobre los atletas aficionados o profesionales de artes marciales mixtas (MMA) fuera del periodo competitivo. El objetivo de este estudio fue comparar el

Perfil antropométrico e consumo alimentar de atletas amadores e profissionais de artes marciais mistas

Resumo

Hábitos nutricionais e perfis antropométricos estão diretamente ligados ao desempenho competitivo; no entanto, há uma grande carência de informações sobre atletas amadores ou profissionais de artes marciais mistas (MMA) fora do período competitivo. O objetivo deste estudo foi comparar o consumo alimentar e o perfil

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consumo de alimentos y el perfil antropométrico de luchadores de MMA aficionados y profesionales. La muestra estaba compuesta por 24 atletas masculinos de MMA, categoría de peso medio (edad: 27,5 ± 5,0 años; masa corporal: 79,0 ± 12,1 kg; altura: 173,5 ± 0,1 cm; %BF: 19,5 ± 4,0 %, IMC: 26,0 ± 2,8 kg/m2). El consumo de alimentos se evaluó sobre la base de tres diarios de alimentos de 24 horas utilizando el método Multi-Step en un período no competitivo y se analizó utilizando el software Dietbox v2.92. El grupo profesional era más joven (p = 0,001) que el grupo amateur. El gasto energético total fue similar entre aficionados (4364 ± 469 kcal) y profesionales (4312 ± 381 kcal). Aficionados y profesionales declararon un déficit energético entre las necesidades energéticas estimadas y la ingesta de energía. El consumo de carbohidratos estaba por debajo de los límites mínimos sugeridos (amateur: 3,3 ± 1,6g/kg/día y profesional: 3,3 ± 1,4g/kg/día). El consumo de proteínas estaba dentro de los límites sugeridos (amateur: 1,4 ± 0,9g/kg/día y profesional: 1,8 ± 0,8g/kg/día) y los lípidos presentaban valores limítrofes con respecto a las recomendaciones de la literatura (amateur: 0,9 ± 0,6 / g/kg/día y profesional: 1,8 ± 0,9 g/kg/día). Los atletas aficionados y profesionales no difirieron en términos de consumo de alimentos y perfil antropométrico. Ambos grupos, amateur y profesional, demostraron un balance energético negativo e incapacidad para alcanzar los niveles sugeridos de ingesta de macronutrientes según la clasificación. Por lo tanto, se recomienda que ambos grupos de MMA reciban atención en cuanto a estrategias nutricionales.

Palabras clave: Artes marciales; deportes de combate; MMA; nutrición deportiva; dieta; gasto energético.

antropométrico de lutadores amadores e profissionais de MMA. A amostra foi composta por 24 atletas de MMA do sexo masculino, categoria peso médio (idade: 27,5 ± 5,0 anos; massa corporal: 79,0 ± 12,1 kg; altura: 173,5 ± 0,1 cm; %GC: 19,5 ± 4,0%, IMC: 26,0 ± 2,8 kg/m2). O consumo alimentar foi avaliado com base em três diários alimentares de 24 horas pelo método Multi-Step em um período não competitivo e analisado pelo software Dietbox v2.92. O grupo profissional era mais jovem (p = 0,001) que o grupo amador. O gasto energético total foi semelhante entre amadores (4364 ± 469 kcal) e profissionais (4312 ± 381 kcal). Amadores e profissionais relataram déficit energético entre a necessidade energética estimada e a ingestão energética. O consumo de carboidratos ficou abaixo dos limites mínimos sugeridos (amador: 3,3 ± 1,6g/kg/dia e profissional: 3,3 ± 1,4g/kg/dia). A ingestão de proteínas ficou dentro dos limites sugeridos (amador: 1,4 ± 0,9g/kg/dia e profissional: 1,8 ± 0,8g/kg/dia) e os lipídios apresentaram valores limítrofes em relação ao recomendado na literatura (amador: 0,9 ± 0,6/g/kg/dia e profissional: 1,8 ± 0,9g/kg/dia). Atletas amadores e profissionais não diferiram quanto ao consumo alimentar e perfil antropométrico. Ambos os grupos, amador e profissional, demonstraram balanço energético negativo e incapacidade de atingir os níveis sugeridos de ingestão de macronutrientes de acordo com a classificação. Dessa forma, recomenda-se que ambos os grupos de MMA recebam atenção quanto às estratégias nutricionais.

Palavras-chave: Artes marciais; esportes de combate; MMA; nutrição esportiva; dieta; gasto energético.

1. Introduction

Competitive success in sports is multifactorial and dependent on physical, psychological, and nutritional aspects (Andrade et al., 2020; Bueno et al., 2022; Spanias et al., 2019). Also, in combat sports, technical-tactical and strategic factors are of interest (Bueno et al., 2022; Miarka et al., 2018). Specifically, in Mixed Martial Arts (MMA), athletes perform acyclic efforts distributed among physical, technical, and tactical preparation throughout pre-fighting preparation (Bueno et al., 2022; Miarka et al., 2018). In this context, high-performance athletes are often subjected to high workloads without proper control over the distribution of these training loads (Kirk et al., 2021), which, consequently, increases the need for recovery strategies. Allied with the prescription and monitoring of training loads, nutritional aspects gain relevance, as they relate to the management of body mass, recovery status, and performance (Thomas et al., 2016).

In MMA, the use of weight, gender, and competitive performance categories is proposed to balance physical conditions between fighters (Alves et al., 2018). However, some weigh-ins may take place between 24h and 32h before the competition (Matthews et al., 2019), which encourages the use of rapid weight loss (RWL) methods, such as manipulating body fluids by dehydration and caloric restriction or deprivation (Alves et al., 2018), to those who intend to fight in lighter-weight categories (Artioli et al., 2016). However, not the loss of body mass, but the magnitude of body mass regain has been suggested as a potential predictor of competitive success in MMA (Coswig et al., 2019; Faro et al., 2022). While there is still controversy over the role of body mass regain in MMA's competitive success (Kirk et al., 2020), the anthropometric profile deserves attention.

MMA-specific data are still emerging, which limits the use of anthropometric data to predict performance (Spanias et al., 2019). On the other hand, the analysis of the anthropometric profile could provide information regarding physical performance, as already evidenced in other modalities (Barr et al., 1994). According to Venkata Ramana et al. (2004) understanding the morphological needs in the face of the sport practiced can favor an ideal morphological condition. For example, maintaining high levels of body fat was negatively associated with locomotion performance, techniques (Franchini et al., 2007), lower limb muscle power, and strength endurance (Marinho et al., 2012).

To the authors' knowledge, only three studies investigated nutritional practices among MMA athletes (Anyżewska et al., 2018; Coswig et al., 2019; Matthews & Nicholas, 2017). Anyżewska et al. (2018) reported insufficient energy intake coming from carbohydrates, in addition to a decrease in minerals (iodine, potassium, calcium) and vitamins (D, folate, C, E) throughout a day of training, while Coswig et al. (2019), reported that athletes who performed rapid weight loss presented low consumption of carbohydrates, proteins, or fats. Matthews and Nicholas (2017) demonstrated that although there is an increase in body mass between moments (official weighing and pre-competition), the values obtained from carbohydrate consumption (gr/kg) are still below those recommended. Regarding the consumption of vitamins and minerals, there is quite limited information reported in MMA studies.

Based on the premise that professional athletes would show greater engagement during training and eating routines the present study considers that amateur and professional fighters could present different anthropometric and food consumption profiles (Andreato et al., 2017). The rationale is that amateur fighters may have different access to sponsorships and specialized health professionals compared to professional athletes, which may rely on different support for anthropometric and nutritional management and monitoring. Thus, this study aimed to compare the food consumption and anthropometric profiles of male amateur and professional MMA fighters. The main hypothesis is that nutritional habits and anthropometric profiles of MMA fighters are dependent on competitive level amateur vs professional.

2. Methods

2.1. Study design

A cross-sectional study design was followed. Anthropometric and food intake characteristics were measured at the first meeting. Then, over 10 days, three food recalls were applied on three non-consecutive days during the week and one on the weekend (Saturday or Sunday). MMA athletes were submitted to the same volume, intensity, number of training sessions, and internal load (subjective perceived exertion - (RPE) x session time (min). Perceived subjective exertion - (RPE) was calculated using a modified OMNI RPE scale that includes a visual component (Robertson et al., 2003). The application of perceived subjective exertion application was performed up to 30 minutes after the training session to ensure that the external stress prescribed by the athletes internally matched the fighter's experience. The frequency of participation in (combat training or physical preparation) sessions among fighters was 98.8%. To characterize a training microcycle, the number of training sessions per day, the number of training sessions per week, the duration of a combat sport session, the number of combat sport modalities practiced, the number of physical fitness per week, and the duration of physical fitness training were noted. Data were collected outside the competition period in the afternoon (13:00-15:00) and the subjects received explanations about the research protocol. This research was approved by the Research Ethics Committee of the Federal University of Paraná CAEE: 03682912.6.0000.0117 and was carried out by the Declaration of Helsinki.

2.2. Settings

This study was carried out between March and June 2017 with 24 MMA male athletes. The athletes were recruited at a martial arts academy in the city of Curitiba, southern Brazil, by convenience sampling, and among the athletes who trained at the academy, the snowball method was applied, so sample size estimation procedures were not used. There was no dropout of any athlete from the beginning to the end of the study.

2.3. Participants

Twenty-four middleweight male MMA athletes were divided into two groups: professionals (n = 12) and amateurs (n = 12), with a mean age of 27.6 ± 7 years; body mass of 78.4 ± 12 kg and height of 174 ± 1.2 cm. The athletes had 6 ± 4 years of MMA experience. Amateur and professional groups performed all training sessions together, with similar frequency, intensity, exercises, and number of sessions. Professional athletes were considered to be those who presented records with the local MMA federations and fights registered as professionals. The other athletes were considered amateurs.

The following inclusion criteria were adopted: i) at least 3 years of experience in MMA; ii) at least one participation in fight at the national-level combat; iii) regularity and at least 5 hours of martial arts training per week; iv) absence of chronic diseases. As exclusion criteria, the following were adopted: i) presenting positive answers to any question of the Physical Activity Preparation Questionnaire (PAR-Q); ii) starting a competitive period during data collection; iii) presenting an injury that could influence the training routine; iv) self-reported ingestion of a nutritional supplement or irregular substance that could influence physical performance. All athletes signed the consent form to participate in the study. This research was approved by the Research Ethics Committee of the Federal University of Paraná CAEE: 03682912.6.0000.0117 and was carried out by the Declaration of Helsinki.

2.4. Outcomes

Body composition assessment: Body mass (BM; kg) was measured on a scale (Filizola®) with a precision of 0.1 kg and height (cm) on a portable stadiometer (Sanny®) with a precision of 0.1 cm. The body mass index was calculated by the ratio between body mass/height squared (Kg.m^{-2}). Body composition was measured using skinfolds measured at eight points on the body (i.e. triceps brachii, biceps, suprailiac, supraspinatus, abdominal, subscapularis, anterior thigh and calf) using a Harpenden caliper (West Sussex, UK) accurate to within 0.2 mm. 8 points were adopted for descriptive purposes to observe possible significance ($p<0.05$) in the face of a modality that frequently adopts RWL methods for adequacy in fighting categories. The median of three values was used for data analysis. To measure the neck circumference (midpoint of the neck, just below the upper edge of the prominence of the larynx, the athletes were positioned in the orthostatic position - horizontal plane, with the face turned forward and the shoulders relaxed (Ben-Noun et al., 2001). From this position, the inelastic measuring tape was positioned perpendicular to the long axis of the neck, at the midpoint just below the epiglottis (Ben-Noun et al., 2001).

From the thickness of the skin folds, the body density was determined using the Lohman protocol (Boileau, 1993). After the determination of body density, a percentage of Siri (1961) was used to estimate body fat. Muscle mass was proposed by Lee et al. (2000).

Food Frequency Questionnaire: To assess food consumption, a semi-quantitative food frequency questionnaire validated for the Brazilian population was used (Sichieri & Everhart, 1998). This questionnaire contains 73 food items, and the subjects should inform the frequency of consumption of each one, daily, weekly, or monthly. For each item, three portion size options were given, in household measures. All measurements were made by the same nutritionist. The Multiple Pass Method was used to reduce bias in food intake interviews (Moshfegh et al., 2008). Athletes were instructed to complete three food diaries on non-consecutive days, including three working days and one weekend. This information should be reported with great care and as accurately as possible.

24-h Dietary Recall: A single 24-hour dietary recall was performed by nutritionists to determine nutritional irregularities on the training day, and the diet during that day was typical for each of the athletes. Portion sizes of foods consumed were evaluated through the photo album of products and dishes and data were calculated with the software based on tables of nutritional values of foods and dishes. Information on the consumption of food and beverages consumed 24 hours a day, in household measures. The questionnaire contained additional questions about using dietary and sports supplements in the previous three months. The data acquired after completing these forms were converted into total energy intake, macronutrients, and micronutrients using the Dietbox software. After obtaining the results, they were compared against the value established by the current Dietary Reference Intakes (DRI), American College of Sports Medicine (ACSM), Academy of Nutrition and Dietetics Dietitians of Canada statement (Otten et al., 2006; Thomas et al., 2016), and the American Society of Sports Nutrition (ISSN, 2018). ISSN and Academy of Nutrition and Dietetics references were used for macronutrient adequacy (Kerksick et al., 2018). Micronutrient adequacy was made based on reference food intake references (DRIs) (Otten et al., 2006).

Energy expenditure: Anthropometric measurements were used as a basis for calculating the athletes' energy needs at baseline. Thus, basal energy expenditure (BEE; kcal/day) was calculated according to the FAO/WHO/UN predictive equation, for adults over 18 years of age as follows: i) BEE = 15,4 x $MC_{(Body\ mass)}$ + 27 x $E_{(Stature)}$ + 717 (FAO/WHO/UNU) (World Health Organization, 1985). ii) Diet-induced thermogenesis (DIT) 10% of the basal energy expenditure was adopted (World Health Organization, 1985), energy expenditure of physical activity (EEP_a; kcal/day) was estimated using the factor 2.1 (corresponding to vigorous-intensity activity) and multiplied by basal energy expenditure and added to the Diet-induced thermogenesis for both groups (World Health Organization, 1985).

2.3. Data analysis

All statistical analyses were performed using SPSS (IBM SPSS version 24.0, Chichago, IL, United States) software package. Descriptive statistics of the dependent variables are presented as means and standard deviations, and frequency. Normal distribution of data was assessed using Shapiro-Wilk tests, while homogeneity was assessed with Leven's tests. A two-tailed unpaired *t*-test was performed to compare the groups. Cohen's d effect size (d) was used to quantify the magnitude of the differences, using the following interpretation: trivial (<0.25); small (0.25 a 0.5); moderate (0.5 a 1.0); Large (>1); (Rhea, 2004). Significance level was set at p < 0.05 (two-tailed)

3. Results

Anthropometric and demographic characteristics are shown in Table 1. Significant values were observed for professional with lower values for age than the amateur group.

Table 1. Anthropometric characteristics of MMA athletes

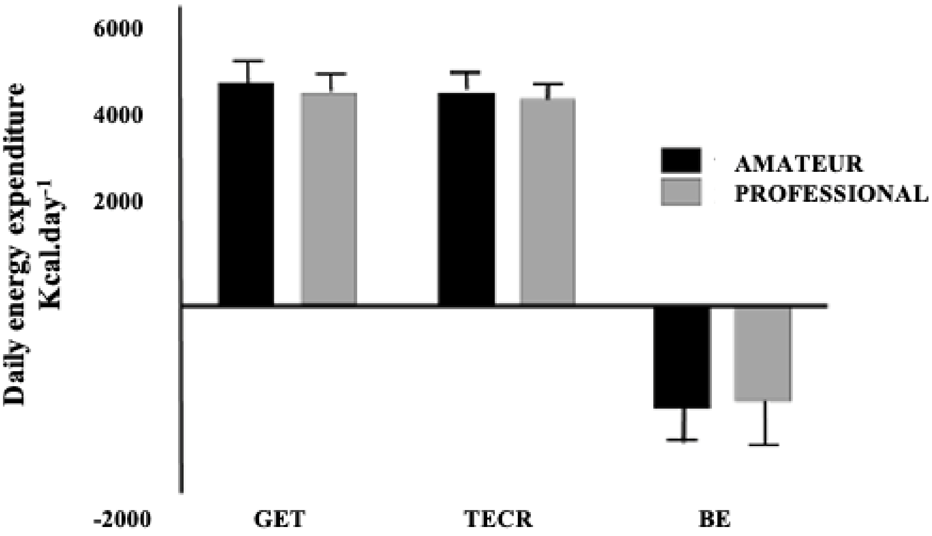
	Professional (n = 12)			**Amateur (n=12)**				
	M	**SD**	**Range**	**M**	**SD**	**Range**	***Cohen's d***	***p***
Age (years)	23	4	18 – 27	32	6	27 – 45	1.8	0.001*
Body mass (kg)	79	13	69 – 78	79	11	67 – 79	0.0	0.910
Height (cm)	174	0.1	162 – 198	173	0.6	160 – 183	0.3	0.821
Body Fat (%)	18	4	13 – 24	21	4	16 – 30	0.7	0.072
BMI (kg/m^2)	26	3.2	22 – 33	26	2.3	23 – 31	0.0	0.731
Neck circumference (cm)	40	1.8	37 – 42	40	2.0	37 – 43	0.0	0.720
Skinfold thickness								
Biceps (mm)	7	4	1 – 14	9	4	4 – 18	0.5	0.441
Triceps (mm)	13	4	7 – 19	11	4	5 – 16	0.5	0.372
Subescapular (mm)	15	5	11 – 27	18	6	9 – 28	0.5	0.241
Supra-iliac (mm)	15	8	1 – 28	14	6	5 – 29	0.1	0.694
Waist (mm)	8.4	10	7.1 – 10.3	8.4	6	7.7 – 9.8	0.0	0.991
Biceps (mm)	3.3	2.9	2.8 – 3.7	3.5	2.6	3.0 – 3.9	0.1	0.871
Calf (mm)	3.8	2.9	3.1 – 4.2	3.8	2.3	3.5 – 4.4	0.0	0.874
Σ7	65.5	36.8	27 - 80	67.7	30.9	29.5 - 89	0.1	0.494

BMI = body mass index; Σ7 = sum of 7 skinfold thickness; * $p \leq 0.05$

Professional and amateur MMA athletes performed 2 ± 0.3 sessions of combat sports training per day and 12.5 ± 1.7 per week. Training sessions lasted 80 min each. Regarding strength and conditioning training, five sessions were performed per week, lasting 60 min per day. The training program was carried out between them during the period without competition.

The estimate of total energy expenditure was similar between amateur (4,364 ± 469 kcal) and professional (4,312 ± 381 kcal), and not significant ([t(22) = 0.30; p = 0.768; CI 95% [-309.75; 413.75]] and with ES = 0.12 trivial/null. Total energy expenditure was similar between amateur (4,166 ± 447 kcal) and professional (4,116 ± 363 kcal), and not significant ([t(22) = 0.30; p = 0.766; 95%CI [-294.73; 394.73]] and with ES = 0.12 trivial/null. Amateur and professional showed negative energy balance (amateur, -1,855 ± 712 kcal; professional, -1,925 ± 1,028 kcal) with no significant difference between the groups ([t(22) = 0.19; p = 0.848; 95%CI [-678.64; 818.64] and with ES = 0.07 trivial/null) (Figure 1).

Figure 1. Comparison between the total energy consumption report (TECR) and the estimated total energy expenditure (GET) and Energy balance (BE) of amateur (AM; n = 12) and professional (PRO; n = 12) fighters



Note: Results are expressed in (± SD). * Significance p<0.05.

Both groups, amateur and professional, showed similarity in the absolute (g/day) and relative (g/kg/day) consumption of the macronutrient carbohydrate, representing a low consumption, both being below the recommended level. Regarding Lipids, both groups reported similar values in absolute consumption (g/day), and only the amateurs demonstrated relative consumption (g/kg/day) adequate and within the recommended indices, while the professionals demonstrated values superior to the indices of recommendation. For proteins, both amateur and professional groups demonstrated similarity in absolute (g/day) and relative (g/kg/day) consumption and within recommended consumption values (Table 2).

Table 2. Distribution of macronutrients on professional and amateur MMA athletes

Nutrients	Professional (n = 12)			Amateur (n = 12)		
	%	g/day	g/kg/day	%	g/day	g/kg/day
Carbohydrate	44.6	243.9 ± 85.6	3.3 ± 1.4	44.5	257.9 ± 108.0	3.3 ± 1.6
Lipids	31.3	74.8 ± 40.0	1.1 ± 0.6	28.8	74.3 ± 45.7	0.9 ± 0.6
Protein	24.1	130.4 ± 59.4	1.8 ± 0.8	26.7	155.1 ± 81.7	1.4 ± 0.9

Results expressed as mean ± standard deviation; Recommendations: Kerksick et al., 2018 (Carbohydrate: 8 to 10 g/kg/day; Protein: 1.2 to 2.0 g/kg/day; Lipid: 0.5 to 1.0 g/kg/day).

Professional athletes had a higher intake of vitamins than recommended by the dietary reference intakes for B1, B2, B3, and B12; and below the recommended for A, D, B5, B6, C, and E. amateur athletes consumed values above the dietary reference intakes of B1, B2, B3, B12, and C; and below that recommended by A, D, B5, B6, C, and E (Table 3). No differences were identified between the groups.

Table 3. Vitamin ingestion profile of professional and amateur athletes

Vitamins	DRI’s	Professional	Amateur	*Cohen’s d*	*p*
A (µg)	900	521.4 ± 732.6	479.4 ± 492.5	-0,06	0,871
Thiamin (Vit B1) (mg)	1.2	1.6 ± 1.0	1.8 ± 0.9	0,21	0,612
Riboflavin (Vit B2) (mg)	1.3	1.4 ± 1.3	1.4 ± 1.0	0,00	1,000
Niacin (Vit. B3) (mg)	16	38.0 ± 37.8	64.1 ± 69.8	-0,46	0,267
Pantothenic Acid (Vit B5 (mg)	5	2.6 ± 1.3	3.0 ± 1.7	0,26	0,524
Piridoxin (Vit B6) (mg)	1.7	1.6 ± 1.5	1.6 ± 1.3	0,00	1,000
Cianocobalamin (Vit B12) (µg)	2.4	5.5 ± 4.9	3.4 ± 3.6	0,48	0,244
Vit C (mg)	90	37.4 ± 31.5	90.8 ± 151.7	-0,49	0,245
Vit D (µg)	15	2.2 ± 2.2	2.4 ± 2.3	0,08	0,830
Vit E (mg)	15	14.8 ± 10.5	11.3 ± 9.8	0,34	0,408

Results expressed as mean ± standard deviation; DRI'S* = 19-70 years about DRI's Note: DRI = dietary reference intakes; Cozzolino, S. M. F. (2015).

The profile of micronutrient intake among professional athletes is presented in Table 4. Low folate, calcium, magnesium, copper, and iodine consumption were evidence, while values above the recommended were found for phosphorus, iron, zinc, selenium, potassium, and sodium. Among amateur, values below the dietary reference intakes are reported for Folate, magnesium, copper, iodine, and manganese, and values above the dietary reference intakes for phosphorus, iron, zinc, potassium, and sodium (Table 4). No differences were identified between the groups.

Table 4. Micronutrient ingestion of professional and amateur athletes

Micronutrient	DRI*	Professional	Amateur	*Cohen's d*	*p*
Folate (µg)	400	96.5 ± 45.7	122.5 ± 93.9	0,35	0,398
Calcium (mg)	1000	397.6 ± 331.8	560.3 ± 258.8	0,55	0,194
Phosphorus (mg)	1250	1385.5 ± 660.3	1694.1 ± 794.7	0,42	0,312
Magnesium (mg)	420	208.7 ± 68.2	237.68 ± 84.2	0,37	0,364
Iron (mg)	11	14.9 ± 5.5	13.48 ± 4.7	-0,27	0,504
Zinc (mg)	11	14.6 ± 9.4	13.02 ± 7.7	-0,18	0,657
Copper (µg)	900	1.0 ± 0.5	1.03 ± 0.5	0,06	0,884
Iodine (µg)	150	43.8 ± 43.2	59.63 ± 52.5	0,32	0,429
Selenium (µg)	55	64.8 ± 44.9	63.21 ± 50.7	-0,03	0,936
Manganese (mg)	2.3	2.1 ± 1.7	1.46 ± 0.5	-0,51	0,224
Potassium (mg)	3.400	2252.2 ± 853.0	2858.38 ± 1347.6	0,53	0,202
Sodium (mg)	1.5	2.3 ± 1.6	1.74 ± 1.0	-0,42	0,315

Note: DRI = Dietary Reference Intake; *reference for 19-70 years old Cozzolino, S. M. F. (2015).

Table 5 shows the comparison of macronutrients, vitamins, and micronutrients between the groups. There were no significant differences for any nutrient between groups (all p>0.05).

Table 5. Dietetic ingestion of nutrients in professionals and amateur MMA athletes

Variables	Professional			Amateur			*p*
	M	*Min.*	*Max.*	*M*	*Min.*	*Max.*	
Macronutrients							
Carbohydrate (g/kg)	3.2	2	5.9	2.8	1.4	5.3	0.572
Lipids (%)	29.6	15.5	46.1	29.8	0.8	48.1	0.921
Protein (g/kg)	1.8	0.8	4.2	1.4	0.9	4.1	0.643
Vitamin							
A (µg)	250.8	123.9	2492.3	234.1	13.9	1583.6	0.181
D (ug)	1.6	0	7.3	1.8	0	9	0.571
Thiamin (Vit. B1) (mg)	1.4	0.9	3.5	1.2	0.5	4.0	0.303
Riboflavin (Vit. B2) (mg)	1.1	0.4	3.3	1.1	0.3	5.6	0.797
Niacin (Vit. B3) (mg)	63.1	6.9	252.5	21.5	0.9	154.1	0.165
Pantothenic Acid (Vit. B5) (mg)	2.1	1.4	7.8	2.5	1.2	6.3	0.959
Piridoxin (Vit. B6 (mg)	1.2	0.3	4.7	1.1	0.6	6.1	0.738
Cianocobalamina (Vit. B12 (µg)	3.1	0	6.4	5.2	0.2	18.9	0.181
Vit. C (mg)	33.2	4.9	569.5	33.3	1	88	0.643
Vit. E (mg)	13.3	0.7	37.1	8.4	2.3	28.5	0.572
Micronutrients							
Folate (µg)	108.9	26.3	386.5	88.8	39.2	196.3	0.328
Calcium (mg)	361.6	172.9	838.5	396.1	139.7	1436.8	0.837
Phosphorus (mg)	1357.8	868.9	3227.5	1144.4	779.1	2781.8	0.181
Magnesium (mg)	228.7	117.5	346.8	203.6	151.4	369.9	0.938
Iron (mg)	13.6	5.7	17.5	14.2	5.1	28	0.503
Zinc (mg)	10.3	4.7	21.7	14.4	3.9	40.8	0.181
Copper (µg)	0.8	0.5	1.9	1.2	0.5	2.3	0.392
Iodine (µg)	38.1	0	148.8	45.6	0.8	166.7	0.607
Selenium (µg)	51.1	5.8	188.6	63.8	6.5	186.2	0.758
Manganese (mg)	1.3	0.7	2.1	1.9	0.7	7.5	0.134
Potassium (mg)	2518.5	1221.2	6314.1	2120.4	1447.4	4556.6	0.537
Sodium (mg)	1412.1	358.6	3751.5	1966.3	868.0	649.0	0.150

***Predictive values:** Recommendations: Kerksick et al., 2018; ACSM/ADA/ISSN: position statement (ACSM. 2019), Cozzolino (2015).

In percentual terms, 100, 16.7, and 25% of the professional athletes were below the dietary reference intakes recommendations for carbohydrates, lipids, and proteins, respectively. Regarding amateurs, 100, 28.6, and 42.9% were below carbohydrates, lipids, and protein recommendations, respectively.

Prevalence of professional attendance of vitamins recommendations was 66.7% for B6 and C, 100% for E, 41.7% for B12, 91.7% for D, and 75% for A. Regarding micronutrients 100% attended recommendations for magnesium, copper, iodine, phosphorus, folate, calcium, and sodium; while 58.3 % for selenium, and 50% for zinc). Among the amateur athletes, the prevalence of attendance of vitamin recommendations was 100% for C and E; 50% for B6; 85.7% for D and A; and 35.7% for B12), while regarding micronutrients (100% attended Magnesium, Copper, Iodine, Phosphorus, Folate, Sodium recommendations; while 92.9% attended for Calcium; 42.9% for Selenium; and 35.7% for Zinc).

4. Discussion

The present aimed to compare the food consumption and anthropometric profile of male amateur and professional mixed martial arts (MMA) fighters. This study did not confirm the hypothesis of differences between amateur and professional athletes. Both groups had similar anthropometric and nutritional profiles. Body mass, height, fat percentage, total energy expenditure, body mass index, neck circumference, basal energy expenditure, energy balance, daily energy intake, and compliance with nutritional recommendations were similar between groups. Only age differed significantly between fighters.

The anthropometric profile observed in the present study was similar to the results previously reported by (Anyżewska et al., 2018; Coswig et al., 2019) in samples of MMA fighters. The similarity of the anthropometric profile between the different studies can be explained by the fact that body composition constitutes one of the criteria for selecting the fighting categories. Originally, our findings indicate that this anthropometric profile of MMA athletes is similar between amateur and professional. It is important to note that amateur and professional athletes in this study were subjected to similar average training loads (± SD) number of fight training sessions, and the number of physical preparation sessions). Regardless of the high intensities generated during training performed jointly and similarly by both groups. In this way, it is possible to justify such similarities resulting from the training loads and the selection process verified, as well as in other modalities (Cócaro et al., 2012). In addition, associated with similar training loads, the equivalent energy balance between amateur and professional fighters (total energy expenditure and macronutrients) is also similarly related to body composition.

Body composition has been linked to the performance of combat sports athletes (Franchini et al., 2007; Marinho et al., 2011; Reale et al., 2020). In general, combat sports athletes have low body fat and high lean mass, but MMA athletes may have higher body fat than other combat sports athletes (Schick et al., 2010), especially if there is no close combat (i.e. out of competitive season). In addition, our results showed a higher body fat percentage than in previous studies (Marinho et al., 2016), and amateur athletes had a slightly higher body fat compared to professional athletes. It is worth mentioning that the athletes were out of the competitive period, which may imply a lack of concern with body composition, especially in amateur athletes who probably do not have the same number of fights throughout the year as professional athletes. Another factor that could have generated an impact may be related to the culture related to the lack of concern with the nutritional aspect, even due to technical lack of knowledge, since, in many cases, athletes do not have the assistance of a nutritionist, as they are assisted by masters and coaches (Artioli et al., 2016).

In addition, age was significantly different between the groups with older adults in the amateur group, which may be related to an increase in body fat percentage due to physiological consequences of aging (e.g., lower testosterone levels), both by age and training over the years (McArdle et al., 2016). It is worth mentioning that the analyzed body mass range was large and can be represented in at least six MMA weight categories, including the heaviest, where the concern with body weight is relatively low, given the large weight limits allowed. Body mass is an important variable in the context of MMA, as fight categories are organized by body mass. Thus, the nutritional profile becomes a central point in the body composition of MMA athletes.

The energy balance (energy intake - energy expenditure) was negative between both groups, which proposes the possibility of a condition known as low energy availability in these athletes. Energy availability, determined by the balance between dietary caloric intake and the expenditure on exercise, is calculated using the formula: Energy availability = Energy intake (kcal) − Exercise energy expenditure (kcal)/ Fat-Free Mass (FFM) (kg). An energy availability range below 30kcal/kg FFM/ day (125kJ/kg FFM/day) is considered the lower limit for low energy availability to manifest (Mountjoy et al., 2018). Low energy availability is a common problem in sport, particularly when the athlete is led to believe that body weight could influence sports performance or when there are weight divisions, leading to a syndrome called relative energy deficiency in Sport (RED-S), initially detected mainly in female athletes, which is expressed as impaired physiological functioning caused by relative energy deficiency and includes, but is not limited to, impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health. In 2018, the International Olympic Committee consensus on RED-S was revised and began to also recognize as relevant the low energy availability in male athletes, even placing weight class combat sports as risk sports (Mountjoy et al., 2018).

For the best performance to occur, energy intake must be proportional to energy expenditure, consequently, the quality and quantity of macronutrients are of paramount importance. Although several studies show the role and importance of macronutrient intake among combat sports athletes (Cho, 2014), currently, low consumption and amount of carbohydrates are still observed, a fact that is similar to our findings. Although the amateur and professional groups report lower values than those established, it is important to mention that none of the athletes had a marked fight during the study period, which may coincide with the low need for carbohydrate consumption. This behavior seems to be common even among athletes from other studies. (Anyżewska et al., 2018; Coswig et al., 2019). Although the current literature recommends the consumption of up to 10g/kg/day during competitive periods, until now, in MMA, there is still a lack of studies that demonstrate agreement with the positions (Burke et al., 2001; Thomas et al., 2016) or even that you have verified a minimum quantity outside the competitive period. Another important point to low carbohydrate consumption may be related to the adjustment process resulting from training with low carbohydrates, which could cause metabolic adaptation and consequently a perception of not needing more carbohydrates.

Regarding protein consumption between amateur and professional, consumption was similar and adequate (Anyżewska et al., 2018). Athletes had protein intakes within the recommended range (1.5-2.0 g/kg/BM) (Kerksick et al., 2018; Thomas et al., 2016). According to the ACSM/ADA/DC position, protein consumption values for endurance events are 1.2 to 1.4g/kg/day, and for strength and power exercises, 1.6 to 1.7g/kg/day. For the International Society of Sports Nutrition (ISSN 2018), there is a suggested range of recommendations between 1.2 and 2.0g/kg/day, and values above 1.6g/kg/day do not provide additional advantages for lean mass gains (Kerksick et al., 2018).

Lipid intake among amateur and professional athletes was shown to be in the recommended range (0.5 to 1.0 g/kg/day; total energy intake 15 to 30%) (Kerksick et al., 2018). So far, there is a lack of studies that have investigated the ingestion of lipids in the practice of MMA. In a study conducted by Artioli et al. (2009) male athletes are reported to consume more fat (34.8%; 1.7 ± 1.2g/kg) than female athletes (25.4%; 1.4 ± 0.7g/kg). These values are very close to those reported in male athletes from Poland (0.9 ± 0.4g/kg) (Anyżewska et al., 2018). A possible explanation for these results may be associated with the fact that athletes choose foods rich in fat and, consequently, even reduce their carbohydrate intake. As it is an intermittent, high-intensity contact sport, MMA, as a result of its efforts, generates an increase in the formation of reactive species that lead to an inflammatory state. However, this state can be reduced when lipids such as EPA (eicosapentaenoic acid) and/or DHA (docosahexaenoic acid) are ingested (Simopoulos, 2007).

Our study demonstrates that the consumption of vitamins and micronutrients was inadequate and insufficient by both groups according to the dietary reference intakes guidelines. It was observed between amateur and professional, insufficient values in calcium intake. These values are similar to those presented by (Anyżewska et al., 2018; Cócaro et al., 2012). The role of calcium in food is fundamental both in early adolescence for bone development (Cócaro et al., 2012), and in the life of a combat athlete due to the imminent risk of injury, therefore, insufficient values should be investigated. Evans et al. (2008) demonstrated that after four months of training, it is possible to have an increase in the biochemical indicators of calcium turnover between men and women. This growth in levels demonstrates the fundamental role of food consumption during a nutritional program so that the functions involved in the process of bone formation, and contractile or muscle activity are highly dependent on calcium.

Currently, there is no consensus on recommended values for vitamin D sufficiency, insufficiency, and deficiency. Although widely used, cut-off points have been discussed by the scientific community as they may be outdated, and because they are conservative, but what draws the most attention is the focus given mainly on the role of vitamin D on bone health (Owens et al., 2018). In general terms, this consensus recommends 25(OH)D levels between 20 and 60 ng/mL as normal for the general population while individuals with levels below 20 ng/mL are reported as deficient (Moreira et al., 2020). This statement identifies the potential benefits of maintaining 25(OH)D levels > 30 ng/mL in specific conditions while values above 100 ng/mL are considered toxic and potentially fatal (Moreira et al., 2020). The amateur and professional athletes demonstrate a low consumption of vitamin D as in other studies (Anyżewska et al., 2018). Adequate values of vitamin D are associated with good bone health, and the immune system, therefore, insufficient values may interfere with sports performance (Larson-Meyer & Willis, 2010).

Our results should be interpreted with caution and have limitations. The main one is related to the transversal design. Carrying out evaluations and monitoring of teams of athletes in the baseline, pre-competitive, and in-competition phases, in addition to the post-competitive period, would provide greater ecological validity and results with greater capacity for generalization, for other athletes and teams in the same conditions. Another limitation refers to the complexity of obtaining a calendar of fights with the date and time for preparing the routines involved among amateur athletes. This would allow to observe if there are changes in the food pattern as a result of a calendar. What makes it recurrent among athletes, is the possible restrictive conduct of food consumption to always be ready to fight, because, in the absence of a competitive calendar, the athlete can be called at any moment and this may have affected the record food, resulting in inferior nutritional control in the face of sport's needs.

5. Conclusion

The results of this study suggest that the hypothesis that competitive level would affect the anthropometric and food consumption profiles was not confirmed. Both groups demonstrated negative energy balance and an inability to reach the suggested levels of macronutrient intake. Thus, it is recommended that both MMA groups receive attention regarding nutritional strategies. In conclusion, data suggests that an adjustment in food consumption seems to occur, and this seems to influence the anthropometric profile, regardless of the athlete's level.

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