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Trabajo Original

Otros

Consumption of meat, eggs and dairy products is associated with aerobic and anaerobic performance in Brazilian athletes – A cross-sectional study

El consumo de carne, huevos y productos lácteos se asocia al rendimiento aeróbico y anaeróbico en los deportistas brasileños: un estudio transversal

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Abstract

Objective: to associate food consumption according to the groups that make up the food pyramid with the aerobic and anaerobic performance of Brazilian athletes.

Method: a cross-sectional study of 168 athletes with a mean age and BMI of 20.84 ± 7.74 years and 22.88 ± 3.1 kg/m², respectively.

Results: maximum power output was significantly associated with the meat and eggs groups ($\beta = 0.31$; $p < 0.05$). VO_{2max} exhibited a positive relationship with the fruit group ($\beta = 0.29$; $p < 0.05$). A significant inverse relation between VO_{2max} and the legumes group was observed ($\beta = -0.76$; $p < 0.05$). The meat and eggs group and the dairy products group had an inverse and significant association with VO_{2max} ($\beta = -0.43$; $p < 0.01$).

Conclusions: consumption of meat and eggs showed a positive association with anaerobic performance, whereas the same group and the dairy products group had a negative association with aerobic performance.

Key words:

Food groups. VO_{2max}. Diet. Food pyramid.

Resumen

Objectivo: asociar el consumo de alimentos según los grupos que componen la pirámide de alimentos con el rendimiento aeróbico y anaeróbico de deportistas brasileños.

Método: estudio transversal de 168 deportistas con una media de edad e IMC de 20,84 ± 7,74 años y 22,88 ± 3,1 kg/m², respectivamente.

Resultados: la potencia máxima se asoció significativamente con el consumo de los grupos de carne y huevos ($\beta = 0{,}31$; $p < 0{,}05$). El VO_{2max} mostró una relación positiva con el grupo de la fruta ($\beta = 0{,}29$; $p < 0{,}05$). Se observó una relación inversa significativa entre el VO_{2max} y el grupo de las leguminosas ($\beta = -0{,}76$; $p < 0{,}05$). El grupo de carnes y huevos y el grupo de productos lácteos tuvieron una asociación inversa y significativa con el VO_{2max} ($\beta = -0{,}43$; $p < 0{,}01$).

Conclusiones: el consumo de carne y huevos mostró una asociación positiva con el rendimiento anaeróbico, mientras que el mismo grupo y los productos lácteos se asociaron de forma negativa al rendimiento aeróbico.

Palabras clave:

Grupos de alimentos. VO_{2max}. Dieta. Pirámide alimenticia.

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INTRODUCTION

Proper diet to the amount of physical work should be the starting point for maximum performance for high-performance athletes (1). The adequacy of energy and nutrient consumption is essential to maintaining performance, body composition and health in these individuals (2,3). Nutrition, when well targeted, can reduce fatigue, allowing the athlete to train longer or to recover better between workouts; reduce or assist in recovery from injury; increase energy deposits for competition; and finally help the general health of the athlete (4).

Qualitative food consumption, that is, the consumption seen in portions of the various food groups can affect both the nutritional status and the dietary nutrient supply (5). One of the common behaviors among athletes is the partial or total restriction of certain food groups, resulting in a consumption below that recommended for some nutrients (6) responsible for the regulation of energy metabolism, glucose and oxidative and muscle contraction, thus affecting performance (3,7).

A number of studies involving athletes are concerned with the quantitative consumption of nutrients and their effects on physical performance (8-10), but as far as we know, there are no studies that use food consumption by food groups for this same purpose and population. In 2013, Radavelli-Bagatini et al. (11) showed the association of milk consumption and milk products with performance (gripstrength, timed up and go, slow timed up and go, and self-reported falls) in the elderly. A similar study with adolescents showed that fruit and vegetable consumption was positively associated with muscle strength and potency (12). The results of this type of research may point to both the performance and the health of the population studied, suggesting the adequacy of food consumption to maintain good performance and health maintenance (13,14).

Thus, the objective of this study was to evaluate the association between the intake of the foods in the Brazilian food pyramid groups and the physical aerobic and anaerobic performance of Brazilian athletes. The present study will allow the establishment of relationships among food groups and performance in terms of potency, fatigue index and oxygen volume (VO_2), and will make it possible in the future to establish dietary guidelines specifically formulated for athletes needs.

METHODS

PARTICIPANTS

This was a cross-sectional study carried out at the *Núcleo de Aptidão Física, Informática, Metabolismo, Esporte e Saúde* (Nafimes, Center for Physical Fitness, Informatics, Metabolism, Sports, and Health) from 2014 to 2016. The sample was composed of 168 athletes of both genders, who competed in fifteen different sports (athletics, cycling, bodybuilding, soccer, American football, futsal, Brazilian jiu-jitsu, judo, karate, kung fu, mixed martial arts (MMA), swimming, taekwondo, triathlon and volleyball).

Athletes were contacted directly via phone calls or e-mail, and through indications from coaches or sporting federations. Convenience sampling was used, i.e., the participant athletes were selected based on availability and accessibility after contacting sports federations, clubs and coaches. Individuals who trained with competitive objectives, participated in regional and international events, or had a weekly training load equal to or greater than 6 hours were considered athletes (15). Athletes who did not respond to two 24-hour recalls (R24h) were excluded. All athletes (adults and under 18) and those responsible for athletes under the age of 18 years were informed of the study objectives and signed an informed consent form. Demographic (age and sex) and training (type of sport, volume, training phase) information was obtained through a questionnaire. This investigation was conducted according to the Declaration of Helsinki and was approved by the local University Ethics Committee (no. 488.198).

BODY COMPOSITION

Body mass was measured to the nearest 0.1 kg using a calibrated electronic scale, and height was measured using a stadiometer to the nearest 0.1 cm. The participants wore light clothing without shoes. Body mass index (BMI) was calculated as the body mass in kilograms divided by the square of the height in meters.

DIETARY INTAKE

Food intake was assessed by the 24-hour dietary recall method applied on two non-consecutive days of the week, with the aid of a photographic record taken during an interview (16). The homemade measurements of the nutritional values of foods and supplementations were converted into grams and milliliters by the online software Virtual Nutri Plus (Keeple®, Rio de Janeiro, Brazil). Some foods were not found in the program database and therefore items were added from food tables (17). Participants who used dietary supplements were instructed to report the brand and quantity consumed in order to ensure a higher accuracy of the macronutrient values present in each product. For the determination of food portions, the criterion of the Brazilian food pyramid was used (18). Foods are distributed in the food pyramid within eight groups, and each food group has a portion with a certain amount of calories. In this way, the foods consumed were quantified as total calories and later transformed into portions according to their characteristics. For supplements, the source of the nutrient with the highest prevalence in these was used to identify which group they belonged to, and to account for the caloric equivalent of their respective group.

AEROBIC AND ANAEROBIC PERFORMANCE

Anaerobic performance (maximum power) was obtained by using the Running Anaerobic Sprint Test (RAST), consisting of maximum sprints of 35 meters with 10 seconds of recovery between each sprint. The time recording was performed by photocells at each effort to determine the power generated at each run (HIDROFIT model PTL-BM 2 SK-D, software Multisprint full version 3.5.7, Brazil) (19). The RAST results provide an estimate of the neuromuscular and energetic determinants of maximal anaerobic performance (19).

Power produced in each sprint was calculated by the formula (19):

$$\text{Power (watts)} = (\text{body mass x distance}^2)/\text{time}^3$$
$$\text{Maximum power (w.kg}^{-1}) = \text{highest power produced in the six races.}$$

The aerobic performance (VO_{2max}) was obtained by means of the 20-m shuttlerun test consisting of one-minute continuous run steps, with increased velocity during the test. It is requested that the individual run in an area of 20 meters marked in two points, maintaining the pace of running with a sound signal that is emitted. The test stops when the participant fails and cannot pass by a 20-meter point before the beep occurs twice in a row (20).

The maximum volume of expired oxygen was estimated in mL.kg^{-1}.min^{-1} using the equations proposed by Léger et al. (1988) (21), as described below:

- From 6 to 18 years: VO_{2max} (mL.kg^{-1}.min^{-1}) = 31.025 + (3.238 x speed in km.h^{-1} in the last completed stage) - (3.248 x age in years rounded down) + (0.1536 x speed in km.h^{-1} in the last stage completed x age in years rounded down).
- Over 18 years: VO_{2max} (mL.kg^{-1}.min^{-1}) = -27.4 + (6.0 x speed in km.h^{-1} in the last completed stage).

STATISTICAL ANALYSIS

The Kolmogorov-Smirnov test was used to verify data distribution. Descriptive statistics are presented as mean and standard deviation. Differences in general characteristics, eating habits, and average training time according to sex were determined using the Mann-Whitney U-test, and the Kruskal-Wallis test was performed to evaluate the other analyses. For all statistical analyses, significance was accepted at $p < 0.05$. The data were analyzed using the SPSS software, version 20.0 (SPSS, Inc., Chicago, IL, USA). Differences in general according to sex and modalities were determined using the Mann-Whitney U-test or Student's t-test for independent samples. The values of maximum power and VO_{2max} were separated into tertiles and compared using the Kruskal-Wallis test.

For verification of the crude relationship between consumption of food groups and personal and training characteristics (independent variables) and maximum power and VO_{2max} (dependent variables) a linear regression (bivariate analyses) was performed. A multiple regression analysis was conducted to further test whether food groups (independent variables) were related to performance parameters (dependent variables), after adjusting for potential covariates such as hours of training, sex, BMI, and food intake (total calorie consumption/kg, g/kg of protein, g/kg of carbohydrates, and g/kg of lipids). For all statistical analyses significance was accepted at $p < 0.05$. The data were analyzed using the statistical package "R", version 3.4.2 (New Zealand).

RESULTS

The main characteristics of the athletes are presented in table I. When compared to women, men showed higher values in the variables age (p = 0.000), weight (p = 0.000), height (p = 0.000), BMI (p = 0.000), training hours (p = 0.004), consumption (p = 0.000), maximum power (p = 0.000), and VO_{2max} (p = 0.000). Table II

Table I. Descriptive characteristics of athletes by sex

	Total (n = 168)	Male (n = 131)	Female (n = 37)
Age (years)	20.84 ± 7.74	22.1 ± 8.1*	16.4 ± 3.88
Weight (kg)	68.28 ± 13.48	72.57 ± 11.65*	53.08 ± 7
Height (m)	1.72 ± 0.09	1.76 ± 0.07*	1.6 ± 0.07
BMI (kg/m²)	22.88 ± 3.1	23.49 ± 3.05*	20.73 ± 2.27
Hours of training/week	18.45 ± 12.93	20.13 ± 13.86*	12.51 ± 5.98
Proteins (g/kg/d)	1.73 ± 0.89	1.79 ± 0.95	1.56 ± 0.63
Carbohydrates (g/kg/d)	5.27 ± 2.82	5.39 ± 2.99	4.88 ± 2.16
Lipids (g/kg/d)	1.3 ± 0.7	1.31 ± 0.75	1.32 ± 0.56
Kcal (kcal/kg/d)	40.29 ± 17.96	40.91 ± 18.93	38.12 ± 14.03
Cereals (portions/d)	5.96 ± 3.6	6.42 ± 3.78*	4.33 ± 2.20
Vegetables (portions/d)	1.55 ± 1.98	1.62 ± 2.16	1.30 ± 1.17
Fruits (portions/d)	5.98 ± 5.65	6.52 ± 6.06	4.11 ± 3.38
Legumes (portions/d)	1.66 ± 1.42	1.80 ± 1.50*	1.18 ± 1
Meat & eggs (portions/d)	3.85 ± 2.15	4.15 ± 2.27*	2.83 ± 1.21
Dairy products (portions/d)	1.52 ± 1.81	1.67 ± 1.97	1.00 ± 0.94
Oils (portions/d)	1.49 ± 2.05	1.59 ± 2.19	1.12 ± 1.43
Sugars (portions/d)	3.98 ± 5.38	4.21 ± 5.88	3.17 ± 2.9
Maximum power (w/kg)	7.41 ± 1.97	8.09 ± 1.54*	5.04 ± 1.42
VO_{2max} (mL O_2.kg^{-1}.min^{-1})	43.98 ± 6.93	45.62 ± 6.56*	38.2 ± 4.86

Values presented as mean ± standard deviation. BMI: body mass index; VO_{2max}: maximum oxygen consumption.

presents the characteristics of the athletes according to sports modalities.

Table III shows the values for the portions of food consumed according to their respective food groups, and the contribution of nutritional supplements to the adequacy of the groups according to the recommendations proposed in the food pyramid. There was no significant difference between the "with supplements" and "without supplements" diets for all the food groups analyzed.

When analyzing food intake by food groups regarding maximum power (Table IV), as was expected,t weight and height differed between groups (T1 < T2 < T3). Regarding hours of training and age, we noticed that participants in tertiles T2 and T3 presented higher scores when compared with T1. It can also be seen that the meats and eggs (T1 < T2 and T3) and legumes (T1 < T3) groups presented significant differences between their respective tertiles.

Table V shows the tertiles obtained for VO_{2max}. Height differed between groups (T1 < T2 < T3). Regarding hours of training, we noticed that participants in tertiles T1 and T2 presented lower scores when compared with T3. It has also been observed that in calorie intake the participants of tertiles T2 and T3 presented higher scores when compared with T1. As regards protein intake, T2 differed from T1 and T3 (T1 = T3 < T2).

Table VI shows the linear regression model between maximum power and food groups. Maximum power was significantly associated with consumption of foods in the meat and eggs groups in the last model, adjusted for other possible confounding variables (Model 06).

Table VII displays the linear regression model between aerobic performance and food groups. VO_{2max} exhibited a positive relationship with the fruit group ($\beta = 0.29$; $p < 0.05$). These relationships remained significant after adjustment for the covariables hours of training, sex, and BMI ($\beta = 0.19$; $p < 0.05$). A significant inverse relation between VO_{2max} and the legumes group was observed after adjusting for hours of training, gender, BMI, and consumption of kcal/kg of body weight ($\beta = -0.76$; $p < 0.05$). The group of meats and eggs and the group of dairy products had an inverse and significant association with VO_{2max} after adjusting for hours of training, gender, BMI, consumption of kcal/kg of body weight, carbohydrate intake (g/kg/d), protein intake (g/kg/d), and lipid intake (g/kg/d) ($\beta = -0.76$, $p < 0.05$; $\beta = -0.44$, $p < 0.05$; and $\beta = -0.43$, $p < 0.01$, respectively).

DISCUSSION

According to the findings of the present investigation, the highest consumption of meat, eggs and legumes was observed in the upper tertiles of potency, and fruits were ingested in greater quantity in the higher tertiles of VO_{2max}. After adjusting for confounding factors, meat and egg consumption was positively associated with anaerobic performance, whereas the same group and dairy products were negatively associated with aerobic performance.

To the authors' knowledge, to date, this is the first study to investigate the association between dietary intake and physical perfor-

Table II. Characteristics of participants of the study by modality

Modality	n	Age (years)	Weight (kg)	Height (m)	BMI (kg/m²)	Hours of training / week	Maximum power (w/kg)	VO_{2max} (mL O_2.kg^{-1}.min^{-1})
Athletics	15	26 ± 14.94	65.57 ± 12.08	1.71 ± 0.10	22.14 ± 2.07	18.1 ± 10.99	8.04 ± 2.14	37.32 ± 7.02
Cycling*	1	45	71	1.69	25	12	5.45	26.6
Bodybuilding	5	27 ± 3.57	88 ± 7.59	1.72 ± 0.05	29.86 ± 2.88	10.8 ± 7.82	6.92 ± 1.39	41 ± 5.37
Soccer	69	21 ± 4.62	72.99 ± 9.58	1.76 ± 0.08	23.38 ± 2.21	23.88 ± 15.63	8.61 ± 1.16*	46.01 ± 5.45
American football*	1	31	94	1.86	27	9	8.78	44.6
Futsal*	1	17	70	1.74	23	10	7.91	42.47
Brazilian jiu-jitsu	7	23 ± 3.59	79.44 ± 10.52	1.76 ± 0.04	25.59 ± 2.42	20.86 ± 14.96	7.69 ± 1.08	50.78 ± 9.7
Judo	13	20 ± 9.57	59.12 ± 15.99	1.63 ± 0.09	21.94 ± 4.10	16.24 ± 11.82	5.25 ± 1.55	44.64 ± 5.47
Karate	10	21 ± 8.56	60.69 ± 23.64	1.61 ± 0.13	22.78 ± 5.37	12.6 ± 4.09	5.4 ± 1.64	39.02 ± 3.93
Kung fu	3	20 ± 0.64	58.77 ± 5.20	1.67 ± 0.07	21.16 ± 0.80	10.67 ± 4.16	6.26 ± 1.52	45.6 ± 17.58
MMA	2	27 ± 2.25	65.1 ± 6.93	1.65 ± 0.04	23.9 ± 1.36	18.5 ± 12.02	9.46 ± 1.03	41.6 ± 0
Swimming	19	16 ± 2.22	62.33 ± 11.54	1.69 ± 0.10	21.68 ± 2.42	16.47 ± 5.74	6.07 ± 1.34	46.62 ± 5.25
Taekwondo*	1	32	74	1.73	25	16	9.18	41.6
Triathlon*	1	48	71	1.71	24	36	6.62	62.6
Volleyball	20	15 ± 1.38	60.43 ± 9.09	1.71 ± 0.09	20.5 ± 1.93	8.95 ± 2.29	6.46 ± 2.34	40.03 ± 4.26

*Values presented as mean ± standard deviation. *The mean value was not calculated because there was only one subject.*

Table III. Consumption of food groups according to modality and contribution of dietary supplements

Modality	With supplements					Without supplements				
	Cereals	Vegetables	Fruits	Legumes	Meat and eggs	Cereals	Vegetables	Fruits	Legumes	Meat and eggs
Athletics	4.57 ± 1.31	-	1.86 ± 2.18	-	-	4.46 ± 1.4	2.05 ± 4.21	1.86 ± 2.19	2.2 ± 1.53	3.17 ± 1.79
Cycling*	-	-	-	-	-	4.83	0.76	11.09	0.56	1.58
Bodybuilding	12.06 ± 3.47	-	-	-	-	10.89 ± 3.55	1.14 ± 1.01	1.60 ± 3.58	0.48 ± 0.78	7.9 ± 4.16
Soccer	6.06 ± 3.54	-	-	-	-	5.98 ± 3.56	1.41 ± 1.85	7.55 ± 5.96	2.1 ± 1.43	4.18 ± 2.27
American football*	-	-	-	-	-	5.03	0.73	8.78	0.39	5.16
Futsal*	-	-	-	-	-	4.94	0.27	3.60	0.0	11.08
Brazilian jiu-jitsu	4.79 ± 2.37	1.70 ± 2.35	-	-	-	4.79 ± 2.36	1.69 ± 2.35	10.58 ± 7.8	1.57 ± 0.68	3.06 ± 0.55
Judo	5.46 ± 5.02	-	-	0.89 ± 0.51	-	5.32 ± 4.96	1.46 ± 1.05	6.32 ± 6.8	0.89 ± 0.52	3.01 ± 0.99
Karate	-	1.13 ± 0.93	-	-	-	5.06 ± 2.52	1.13 ± 0.94	3.54 ± 2.82	1.43 ± 1.36	3.07 ± 1.79
Kung fu	6.11 ± 3.19	-	-	-	-	6.11 ± 3.2	1.33 ± 0.68	5.84 ± 5.08	1.67 ± 1.57	3.32 ± 0.94
MMA	10.75 ± 2.58	3.01 ± 3.63	-	-	-	10.69 ± 2.67	3.01 ± 3.64	2.69 ± 3.8	0.0	2.71 ± 1.92
Swimming	6.88 ± 4.28	-	-	-	3.98 ± 1.43	6.85 ± 4.27	1.91 ± 1.47	6.15 ± 4.8	1.52 ± 1.81	3.98 ± 1.44
Taekwondo*	2.09	-	-	-	-	1.95	0.82	0.0	2.39	5.64
Triathlon*	-	-	-	-	-	8.69	3.27	17.27	0.87	2.39
Volleyball	-	-	-	-	-	5.19 ± 2.81	1.62 ± 1.53	3.85 ± 3.93	1.22 ± 1.21	3.24 ± 1.31
Total average	5.96 ± 3.6	1.55 ± 1.98	5.98 ± 5.65	1.66 ± 1.42	3.85 ± 2.15	5.87 ± 3.55	1.55 ± 1.98	5.98 ± 5.65	1.66 ± 1.42	3.85 ± 2.15

**The mean was not calculated because there was only one subject. With supplement: column with the supplement consumption counted in the diet; Without supplement: column without supplement consumption counted in the diet; -: there was no supplement consumed.*

mance in a population of athletes. The novelty of the study precludes a direct comparison with the literature. Overall, a proper diet is a key factor for adaptation and improved physical performance.

Meats are the best food sources of proteins with high biological value (22,23), are a good source of micronutrients such as zinc, iron, and vitamin B_{12} (24), and have better bioavailability when compared to plant sources of these nutrients (25). In addition, albumin has a high biological value, and contains amino acids that aid in the synthesis of creatine (26) and in pH control, favoring greater resistance to fatigue (27-29) and possibly the best anaerobic performance observed in our study.

In aerobic performance the consumption of meat, eggs and dairy products was inversely associated with VO_{2max} after adjustment for different confounding factors. Moreover, the athletes in the present study consumed carbohydrates in amounts inferior to the national recommendations for athletes (1), and cereal portions in the lower limit proposed in the Brazilian food pyramid (18). This dietary profile is similar to that observed in an earlier study by our study group in another cohort of athletes (30), who consumed protein-rich diets neglecting carbohydrate intake and total calories. This possibly affected the aerobic performance of the athletes in our study, justifying the negative association obtained for the food groups of meat and eggs and dairy products, whose main nutrient is protein.

In the group of milk and dairy products 11 modalities were below the proposed recommendation (athletics, cycling, futsal, soccer, Brazilian jiu-jitsu, judo, karate, kung fu, MMA, swimming, and volleyball) and 4 modalities were above (bodybuilding, American football, taekwondo, and triathlon). The values corresponding to the group of sugars and sweets were: 2 modalities as recommended (American football, kung fu) and 13 above recommendations (athletics, cycling, bodybuilding, soccer, futsal, Brazilian jiu-jitsu, judo, karate, MMA, swimming, taekwondo, triathlon, and volleyball).

Regarding oils 03 modalities were below recommendations (athletics, MMA, and taekwondo), 07 were within recommendations (bodybuilding, soccer, Brazilian jiu-jitsu, judo, swimming, triathlon, and volleyball) and 05 were above the recommended values (cycling, soccer, futsal, karate, kung fu). When supplements were removed from the calculation of portions, the only food group that obtained a change in the classification as related to the food pyramid was that of dairy products, where the modality of bodybuilding entered the classification below recommended values.

The consumption of legumes was negatively associated with VO_{2max} in the Model 5 of adjustment. This inverse association was a significant one and could be based on the assumption that legumes have an antinutritional factor called phytic acid. Phytic acid may be related to reduced bioavailability and absorption of some micronutrients (31), especially calcium and zinc (32). Calcium is closely related to energy metabolism and muscle contraction (33), while zinc is required for the activity of more than 300 enzymes and, if consumed in low amounts, can alter the individual's eating behavior and compromise aerobic fitness (34).

In addition, legumes are important sources of protein in the diet of vegetarians (35). In the present study the foods that mostly represented the legume group were beans.

Table IV. Consumption of nutrients and portions of food groups according to tertiles of maximum power output for the athletes

Characteristic	Total	T1 (< 6.67)	T2 (6.67 to 8.45)	T3 (> 8.45)	p-value
n	168 (131 M, 37 F)	56	56	56	
Maximum power (w/kg)	7.42 ± 1.97	5.08 ± 1.09 a	7.69 ± 0.50 b	9.46 ± 0.68 c	< 0.0001
Hours of training/week	18.45 ± 12.93	13.28 ± 7.62 b	18.55 ± 12.27 a	23.52 ± 15.70 a	0.0014
Age (years)	21 ± 7.74	20.75 ± 11.46 b	20.41 ± 5.31 a	21.35 ± 4.68 a	0.0003
Weight (kg)	68.28 ± 13.49	61.16 ± 15.75 a	69.30 ± 11.47 b	74.36 ± 9.18 c	< 0.0001
Height (m)	1.72 ± 0.10	1.65 ± 0.097 a	1.73 ± 0.079 b	1.78 ± 0.068 c	< 0.0001
BMI (kg/m²)	23 ± 3.11	22.13 ± 3.89	23.03 ± 2.88	23.47 ± 2.21	0.0669
Kcal (kcal/kg/d)	40.3 ± 17.96	38.98 ± 14.74	44.57 ± 20.86	37.33 ± 17.25	0.056
Proteins (g/kg/d)	1.74 ± 0.89	1.82 ± 0.95	1.84 ± 1.07	1.54 ± 0.54	0.359
Carbohydrates (g/kg/d)	5.28 ± 2.83	4.96 ± 2.10	5.78 ± 2.90	5.08 ± 3.31	0.124
Lipids (g/kg/d)	1.31 ± 0.71	1.28 ± 0.55	1.42 ± 0.94	1.21 ± 0.54	0.657
Cereals (portions/d)	5.96 ± 3.6	5.35 ± 3.43	6.69 ± 4.12	5.56 ± 2.90	0.059
Fruits (portions/d)	5.98 ± 5.65	4.77 ± 4.72	6.81 ± 6.03	6.42 ± 5.96	0.138
Vegetables (portions/d)	1.55 ± 1.98	1.66 ± 2.43	1.42 ± 1.52	1.55 ± 1.91	0.895
Meat and eggs (portions/d)	3.85 ± 2.15	3.23 ± 2.04 b	4.37 ± 2.40 a	3.97 ± 1.84 a	0.003
Legumes (portions/d)	1.66 ± 1.42	1.46 ± 1.64 b	1.66 ± 1.45 ab	1.84 ± 1.11 a	0.008
Dairy products (portions/d)	1.52 ± 1.81	1.47 ± 1.68	1.21 ± 1.18	1.40 ± 2.05	0.556
Sugars (portions/d)	3.98 ± 5.38	2.98 ± 3.04	4.82 ± 5.55	4.14 ± 6.78	0.289
Oils (portions/d)	1.49 ± 2.05	1.23 ± 1.45	1.92 ± 2.95	1.24 ± 1.30	0.545

Values expressed as mean ± standard deviation. kg: kilograms; m: meters; kg/m²: kilograms divided by meters squared; g/kg/d: grams per kilogram of weight per day; w/kg: watts per kilogram of weight. Means followed by the same letter do not differ at the 5% level (p < 0.05) of significance by the Kruskal-Wallis test.

Table V. Consumption of food groups according to tertiles of VO_{2max} for the athletes

Characteristics	Total	T1 (< 41.6)	T2 (41.6 to 46.57)	T3 (> 46.57)	p-value
n	168 (131 M, 37 F)	56	56	56	-
VO_{2max} (mL O_2.kg^{-1}.min^{-1})	43.98 ± 6.93	36.72 ± 3.60 a	43.74 ± 1.32 b	51.48 ± 4.51 c	< 0.0001
Hours of training/week	18.45 ± 12.93	15.89 ± 11.50a	17.08 ± 11.85 a	22.37 ± 14.52 b	0.025
Age (years)	21 ± 7.74	21.43 ± 10.17 a	19.34 ± 5.49 a	21.74 ± 6.68 a	0.060
Weight (kg)	68.28 ± 13.49	65.84 ± 16.16 a	68.66 ± 12.99 a	70.33 ± 10.57 a	0.052
Height (m)	1.72 ± 0.10	1.69 ± 0.10 a	1.72 ± 0.09 b	1.75 ± 0.07 c	0.003
BMI (kg/m²)	23 ± 3.11	22.81 ± 3.87 a	23.05 ± 2.93 a	22.76 ± 2.39 a	0.771
Kcal (kcal/kg/d)	40.3 ± 17.96	36.85 ± 14.39 a	40.36 ± 13.43 b	43.67 ± 23.84 b	0.043
Proteins (g/kg/d)	1.74 ± 0.89	1.57 ± 0.92 a	1.83 ± 0.77 b	1.79 ± 0.96 ab	0.036
Carbohydrates (g/kg/d)	5.28 ± 2.83	4.74 ± 2.14	5.23 ± 2.50	5.84 ± 3.56	0.163
Lipids (g/kg/d)	1.31 ± 0.71	1.20 ± 0.50	1.34 ± 0.65	1.38 ± 0.90	0.514
Cereals (portions/d)	5.96 ± 3.6	5.43 ± 3.73	5.90 ± 3.01	6.27 ± 3.86	0.121
Fruits (portions/d)	5.98 ± 5.65	4.36 ± 4.85b	6.24 ± 5.30a	7.35 ± 6.39a	0.019
Vegetables (portions/d)	1.55 ± 1.98	1.38 ± 2.35	1.61 ± 1.86	1.64 ± 1.70	0.508
Meat and eggs (portions/d)	3.85 ± 2.15	3.46 ± 2.16	3.94 ± 1.88	4.16 ± 2.35	0.113
Legumes (portions/d)	1.66 ± 1.42	1.69 ± 1.63	1.45 ± 1.15	1.84 ± 1.44	0.207
Dairy products (portions/d)	1.52 ± 1.81	1.07 ± 1.57	1.60 ± 2.12	1.42 ± 1.15	0.117
Sugars (portions/d)	3.98 ± 5.38	3.33 ± 2.80	3.41 ± 4.37	5.20 ± 7.65	0.454
Oils (portions/d)	1.49 ± 2.05	1.24 ± 1.59	1.86 ± 2.79	1.29 ± 1.50	0.263

Values presented as mean ± standard deviation. m = meters; kg/m²: kilograms divided by meters squared; g/kg/d: grams per kilogram of weight per day; w/kg: watts per kilogram of weight. Means followed by the same letter do not differ from each other at the level of 5% (p < 0.05) of significance by the Kruskal-Wallis test.

Table VI. Value of beta (β) and p-value for maximum power output (w/kg) according to the food groups

Relative maximum power (w/kg)	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	β1	p-value	β2	p-value	β3	p-value	β4	p-value	β5	p-value	β6	p-value
Cereals	-0.0019	0.9660	-0.026	0.5471	-0.0584	0.1016	-0.05435	0.1294	0.0249	0.7127	-0.084	0.4551
Vegetables	-0.1019	0.1870	-0.092	0.2078	-0.1035	0.0804	-0.10928	0.0660	-0.0943	0.1168	0.0062	0.9607
Fruits	0.05308	0.0570	0.0343	0.2018	0.01537	0.4767	0.01466	0.4975	0.03076	0.2107	0.0603	0.1382
Legumes	0.16922	0.1370	0.1553	0.1497	0.0645	0.4611	0.04914	0.5791	0.07629	0.3998	-0.1269	0.3750
Meat and eggs	0.12745	0.1080	0.1284	0.0871	0.05238	0.3910	0.06373	0.3038	0.16515	0.0875	0.3168	0.0065
Dairy products	0.0852	0.3610	0.1392	0.1194	0.04628	0.5247	0.04645	0.5231	0.10837	0.2054	0.1720	0.0551
Oils	-0.0137	0.8550	0.0326	0.6492	-0.0143	0.8063	-0.02506	0.6717	0.0244	0.7239	-0.0842	0.4269
Sugars	0.0256	0.3750	0.0287	0.2934	0.01727	0.4345	0.01589	0.4727	0.07892	0.1224	0.0431	0.6133
R	0.21		0.38		0.66		0.66		0.66		0.68	

Simple linear regression (Model 1); coefficient adjusted for training hours (Model 2); coefficient adjusted for training hours and sex (Model 3); coefficient adjusted for training hours, sex, and BMI (Model 4); coefficient adjusted for training hours, sex, BMI, and consumption of kcal/kg of weight (Model 5); coefficient adjusted for carbohydrates (g/kg/d), proteins (g/kg/d) and lipids (g/kg/d) (Model 6).

Table VII. Value of beta (β) and p-value for VO_{2max} (w/kg) according to the food roups

VO_2 relative maximum (mL O_2.kg^{-1}.min$_{-1}$)	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	β1	p-value	β2	p-value	β3	p-value	β4	p-value	β5	p-value	β6	p-value
Cereals	0.11094	0.4949	0.05604	0.7271	-0.02170	0.8840	0.03349	0.8165	-0.18630	0.4980	-0.080	0.4551
Vegetables	0.11122	0.6833	0.13341	0.6180	0.10548	0.6690	0.02709	0.9097	-0.01410	0.9530	0.0062	0.9607
Fruits	0.29268	0.0032	0.24984	0.0113	0.20460	0.0250	0.19487	0.0267	0.15020	0.1320	0.0603	0.1382
Legumes	-0.22890	0.5695	-0.26010	0.5100	-0.48030	0.1910	-0.68900	0.0557	-0.76420	0.0380	-0.1269	0.3750
Meat and eggs	0.11754	0.6745	0.11986	0.6623	-0.06460	0.8000	0.08959	0.7202	-0.19140	0.6230	-0.4428	0.0191
Dairy products	0.11592	0.7257	0.23747	0.4681	0.01200	0.9690	0.01422	0.9614	-0.15730	0.6490	-0.4361	0.0023
Oils	-0.12450	0.6399	-0.02025	0.9387	-0.13410	0.5830	-0.28040	0.2416	-0.41740	0.1370	-0.0842	0.4269
Sugars	0.13615	0.1834	0.14313	0.1541	0.11540	0.2140	0.09658	0.2807	-0.07810	0.7050	0.0431	0.6133
R	0.17		0.26		0.45		0.51		0.51		0.52	

Simple linear regression (Model 1); coefficient adjusted for training hours (Model 2); coefficient adjusted for training hours and sex (Model 3); coefficient adjusted for training hours, sex, and BMI (Model 4); coefficient adjusted for training hours, sex, BMI, and consumption of kcal/kg of weight (Model 5); coefficient adjusted for carbohydrates (g/kg/d), proteins (g/kg/d) and lipids (g/kg/d) (Model 6).

After adjustment for macronutrients (carbohydrates, proteins, lipids), the association between legumes and VO_{2max} lost its significance, indicating the possibility that it is the macronutrients and not the legumes themselves that are responsible for the associations observed in our study.

On the other hand, the legumes group was significantly more consumed in the tertile of better anaerobic performance (T3) when compared to the tertile of low anaerobic performance (T1). This difference can be explained by the fact that legumes are considered a good source of protein (35) and this nutrient in turn is associated with anaerobic performance (36-38).

According to the Brazilian food pyramid, the T1 group (low performance) and the T3 group (high performance) presented the same classification of consumption for most of the food groups but with values of different consumed portions, suggesting that small changes in the diet can make a difference between athletes with a low performance and athletes with a high performance. In our study, supplements did not alter the adequacy of dietary intake, partially corroborating a study with Brazilian athletes (30).

For fruits, T1 was the only tertile where consumption was as recommended in the food pyramid; the other tertiles (T2 and T3) were above recommendations. Vegetables and dairy products were in all tertiles below recommendations. Regarding the groups of meats and eggs, legumes, and sugars all tertiles were above the issued recommendations.

Men consumed cereals in appropriate portions and fruit above the food pyramid's recommendations. Among female athletes, cereal intake was low and fruit intake was within the recommended range. Oils and fats were consumed in adequate amounts by both sexes

In general, the cereal and oil groups were within the recommendations (05 to 09 servings and 01 to 02 servings, respectively), while the fruit, meat, legume, and sugar groups were above the recommendations of the food pyramid as adapted to the Brazilian population (03 to 05 servings, 01 to 02 servings, 01 serving, and 01 to 02 servings, respectively). The vegetable and dairy groups (recommendation of 04 to 05 servings, and of 03 servings, respectively) were below the recommended values.

Of the 15 assessed modalities, 5 showed cereal consumption below the recommended amounts (athletics, cycling, futsal, Brazilian jiu-jitsu, and taekwondo), 8 were in accordance with the issued recommendations (soccer, American football, judo, karate, kung fu, swimming, and triathlon) and 2 were above the recommended values (bodybuilding and MMA). Regarding the consumption of fruits, 4 modalities presented consumption below the recommendations (athletics, bodybuilding, MMA, and taekwondo), 3 were within the recommended amounts (futsal, karate, and volleyball) and 8 were above the recommended values (cycling, soccer, American football, Brazilian jiu-jitsu, judo, kung fu, swimming, and triathlon). All modalities reported an intake of vegetables below the available recommendations. The meat group had only one modality within the recommendation (cycling) whereas the other modalities were above the recommended values. Seven modalities consumed legumes below the recommended amount (cycling, bodybuilding, American football, futsal, judo, MMA, and triathlon) and 8 consumed them above recommendations (athletics, soccer, Brazilian jiu-jitsu, karate, kung fu, taekwondo, swimming, and volleyball).

The present study does have limitations that should be acknowledged. This study used a cross-sectional design, which does not allow the establishment of cause-and-effect relationships. Our sample was comprised of predominantly male athletes, thus limiting the generalization of these results to women. Other limitation of this study was that we were unable to obtain a homogeneous distribution of athletes within each modality, so as to more accurately investigate the influence of this variable on eating habits. Despite these limitations, a strong point of our study is its sample size (168 athletes) and the adjustments for potential confounders in the association between intake of food groups and performance parameters. It should be noted that performances were separated into "aerobic" and "anaerobic" classes for didactic purposes, since both occur intermittently during exertion, albeit with predominance of one over the other.

The fact that this study is the only one to relate the various food groups to the physical performance of athletes denotes that there is still much to research. Future investigations considering sport modalities and modality-specific tests to measure aerobic and anaerobic fitness may help in the construction of this body of knowledge.

Through the information gathered in this study, nutritionists will have greater support when advising on the choice and quantity to be consumed for each food group, knowing the potential of each one of them. For example, the prescription of meat and eggs consumption may exert a positive or negative effect on physical performance depending on the sport practised by a given athlete. It is important to note that even with the controversial results regarding the performance of athletes with different dietary macronutrient profiles, it is important to have a balanced and cautious diet. Given the low bioavailability of certain nutrients found in plant sources, extra attention should be payed to the food and even the supplementation that is recommended for athletes whose diet is based on plant sources.

CONCLUSION

The consumption of meat and eggs showed a positive association with anaerobic performance, whereas the same group and dairy products had a negative association with aerobic performance. This type of result suggests that the same alimentary profile that assists a certain skill may harm another, so special attention on the part of the professionals involved is required when drafting a dietary plan. The consumption of the various food groups was shown to be one of the possible factors involved in an athlete's physical performance. In addition, our study researched a scarcely explored subject, thus highlighting the need for further research in this field.

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