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Food consumption among adolescents and biological and adiposity outcomes

Consumo alimentar entre adolescentes e desfechos biológicos e de adiposidade

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KEYWORDS
Nutrients
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ABSTRACT

Objective: to investigate the association between macronutrient consumption and biological and adiposity indicators in adolescents. **Methods:** A total of 77 adolescents were evaluated in relation to anthropometric measurements, sexual maturation, body composition, sociodemographic variables, and food composition. **Results:** the percentage of lipids in relation to total energy intake was positively related to age (β = 1.33; 95% CI = 0.37 to 2.28), and inversely related to sexual maturation (β = -2.44; 95% CI =-4.68 to – 0.20). Girls had a higher consumption of lipids than boys (β= 4.59; 95% CI = 0.62 to 8.57). Age was positively associated with the consumption of saturated (β = 0.62; 95% CI =0,30 to 0,94) and monounsaturated fatty acids (β=0.48; 95% CI = 0.16 to 0.79). Sexual maturation was inversely associated with the consumption of saturated (β=-1.7; 95% CI = -2.46 to -0.95), monounsaturated (β = -1.59; 95% CI = -2.34 to -0.84), and trans fatty acids (β = -0.32; 95% CI = -0.34 to -0.00). Fat mass showed a positive association with the consumption of saturated (β = 0.18; 95%CI = 0.03 to 0.32) and monounsaturated fatty acids (β = 0.23; 95% CI =0.091 to 0.38). **Conclusion:** The consumption of lipids was positively related to age and inversely related to sexual maturation; fat mass was positively associated with the consumption of saturated and monounsaturated fatty acids. The findings of this study reinforce the concern regarding a high-fat diet among adolescents, especially older girls.

PALAVRAS-CHAVE
Nutrientes
Adolescentes
Consumo alimentar
Avaliação nutricional
Maturação

RESUMO

Objetivo: investigar a associação entre consumo de macronutrientes, indicadores biológicos e de adiposidade em adolescentes. **Métodos:** foram avaliados 77 adolescentes em relação às medidas antropométricas, maturação sexual, composição corporal, sociodemográficas e composição alimentar. **Resultados:** O percentual de lipídios em relação à ingestão energética total foi positivamente relacionado à idade (β = 1,33; IC95% 0,37 a 2,28) e inversamente relacionado à maturação sexual (β = -2,44; IC95% -4,68 a –0,20). As meninas apresentaram maior consumo desses lipídios quando comparadas aos meninos (β= 4,59; IC95% 0,62 a 8,57). A idade associou-se positivamente ao consumo de ácidos graxos saturados (β = 0,62; IC95% 0,30 a 0,94) e monoinsaturados (β = 0,48; IC95% 0,16 a 0,79). A

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maturação sexual foi inversamente associada ao consumo de ácidos graxos saturados (β=-1,7; IC95% -2,46 a -0,95), monoinsaturados (β = -1,59; IC95% -2,34 a -0,84) e trans (β = -0,32; IC95% -0,34 a -0,00). A massa gorda apresentou associação positiva com o consumo de ácidos graxos saturados (β = 0,18; IC95% 0,03 a 0,32) e monoinsaturados (β = 0,23; IC95% 0,091 a 0,38). **Conclusão**: O consumo de lipídios esteve positivamente relacionado com a idade e inversamente relacionado com a maturação sexual; a massa gorda foi positiva associada ao consumo de ácidos graxos saturados e monoinsaturados. Os achados desta pesquisa reforçam a preocupação quanto a uma alimentação hiper lipídica entre adolescentes, especialmente entre as meninas com maior idade.

INTRODUCTION

Adolescence is marked by broad and complex biopsychosocial development, combined with a phase of adjustment to the social environment, in which opportunities arise to adopt habits and practices that can extend into adulthood. This period also includes the pubertal phase, where bodily changes are more intense and growth is rapid; therefore, nutrition is a substantial factor in reaching the body's full potential[1].

Inadequate and unbalanced nutrition in terms of energy, carbohydrates, proteins, lipids, and micronutrients can have undesirable effects and compromise the growth, development, sexual maturation, and bone health of adolescents[2].

Al-Jawaldeh et al.[3] highlighted inadequate eating habits among children and adolescents, characterized by low consumption of fruits, vegetables, and dairy products, high intake of sugary drinks, frequent consumption of sweets and snacks, high intake of saturated fats, and inadequate consumption of several micronutrients. Regarding the dietary pattern, there is a decrease in the consumption of basic foods and an increase in the frequency of consumption of highly processed products, with a high total and saturated fat, sugar, and sodium content[4].

Given the above and considering the importance of food and nutrition in adolescents' health, the objective of the current study was to investigate the association between macronutrient consumption, and indicators of adiposity and biological variables among adolescents.

METHODS

This is a cross-sectional study conducted in the teaching clinic of a university hospital that serves adolescents with nursing consultations, located in the city of Recife, Pernambuco, in the Northeast Region of Brazil. The place of care for these individuals stands out as a reference center for outpatient and hospital care for women and adolescents in the state of Pernambuco. Nursing consultation aims to monitor the growth and development of adolescents without morbidities. Scheduling occurs on demand and/or from referrals made by health professionals from establishments linked to the Unified Health System (SUS) of the state of Pernambuco.

The population comprised adolescents aged between 10 and 19 years, according to the criteria of the World Health Organization[5]. This was a convenience sample with the intention of capturing all adolescents who attended during the data collection period, with an average of four per week. Individuals who attended nursing consultations during the collection period were included. Patients with previously diagnosed physical, intellectual, neurological, or degenerative illnesses and pregnant women were excluded from the study because of their inability to participate in the research procedures.

In the nursing care routine, the adolescents received a first consultation, guided by protocols from the Brazilian Ministry of Health[6], to identify health needs and perform a complete physical examination and anthropometric assessment, as well as pubertal development. After approximately 15–21 days, the adolescents returned to verify the effectiveness of the care plan established by the nurse. At this time, the need for referrals to the multidisciplinary health team was also studied.

Considering the adolescent care flowchart carried out by the nurse, data collection occurred at two moments, respecting the outpatient clinic routine, between August 2019 and June 2022. In the first meeting, sociodemographic data (date of birth, sex, and family income), family history, and clinical data (weight, height, waist circumference, body composition) were collected in addition to dietary records from the previous 24 h. Information about sexual maturation that appeared in the adolescent's medical records was also recorded. In the second meeting, another dietary record of the previous 24 h was applied.

The study was approved by the Research Ethics Committee of the University of Pernambuco, Brazil (CAAE 02697318.3.0000.5207; CONEP decision nº 3.363.452). All adolescents under the age of 18 who agreed to participate in the study signed the Assent Form (AF) and their guardians signed the Free and Informed Consent Form (ICF). Participants aged 18 or over signed only the ICF.

Anthropometry

Height and body weight were measured by a trained nutritionist according to the Jellife method[7]. The body mass index was calculated using the standard formula [weight (kg)/height^2 (m)]. The assessment of nutritional status was assessed according to the z-Score distribution[8], using the WHO Anthro Plus software (version 1.0.4) considering the adolescent'ssex, date of birth, and age at the time of assessment[9]. For the current study, overweight and obese adolescents were allocated to a group called "excess weight", and the remainder were allocated to the "eutrophic group".

Waist circumference was assessed with the adolescent standing, with the abdomen relaxed and arms alongside the body, using an inextensible measuring tape. To evaluate the circumference, the measuring tape was applied firmly around the waist at the height of the narrowest part of the trunk, i.e., at the smallest curvature located between the iliac crest and the last rib, and the reading was taken during expiration[10]. The cut-off points established to evaluate waist circumference were established by Freedman et al.[10].

Adolescent body composition was determined using Bioelectrical Impedance (BIA 1010, SANNY, São Paulo, Brazil), which provides specific equations for the studied population; the formulas aimed at children and adolescents are those of Kushner et al.[11] and Houtkooper et al.[12]. Body fat percentage was assessed as recommended by McCarthy[13].

Sexual maturation

Pubertal development was assessed during the nursing consultation, according to the Tanner criteria[14]. In the current study, only the volume and appearance of the breasts were used for girls and the characteristics of the external genitalia for boys, avoiding biases related to racial and maturational factors and pubic hair removal present in the assessment of body hair.

Food intake

The average of the two recalls from the previous 24 h was used to assess food consumption. The adolescents, togetherwith their guardians, reported the foods consumed at all meals to a nutritionist, specifying the location, brand of food, time, preparation details, and home measurements[15]. To standardize and avoid errors in information regarding food consumption, strategies such as household utensils and photo albums with portions of food and drinks were used. Food composition analysis was performed using Diet Pro 5i software, and the adequacy of food consumption was assessed according to the recommendations of the Institute of Medicine[16] and WHO/FAO[17].

Statistical analysis

The normality of the data distribution was verified using the Kolmogorov-Smirnov test, histogram inspection, and analysis of asymmetries. Having confirmed the normality of distribution of the pending variables, the values are presented as mean and standard deviation, minimum and maximum.

Linear regression analyses were performed using the Enter method to verify the existence of an association between age, sex, sexual maturation, nutritional status, anthropometric parameters, body composition, and per capita family income with dependent variables related to the composition of the diet. Data are expressed as regression coefficients (β), with a 95% confidence interval and adjusted coefficient of determination (r^2). All analyses were performed using the Statistical Package for the Social Sciences (SPSS, Inc. Chicago, IL, version 25.0), with a significance level of $p < 0.05$.

RESULTS

In total, 133 adolescents were evaluated; of these, 77 (57.89%) returned for the second consultation and completed the two 24-h recalls, composing the final sample. The mean age of the participants was 13.9 ± 2.4 years, and the mean per capita family income was 362.3 ± 243.8 reais. Other parameters related to waist circumference and body composition are described in Table 1. Among the 77 adolescents, 55.80% were female and 58.44% were in stages 1, 2 and 3 of sexual maturation, considered intermediate (pre-pubertal or pubescent). The prevalence of excess weight was 39%, and the assessment of waist circumference showed that 19.50% of adolescents were at risk for metabolic diseases (Table 1).

Table 2 describes the consumption of macronutrients and lipid fractions in relation to total energy, in addition to cholesterol consumption in grams. Total energy consumption had a mean value of 2,217.96 (± 726.51) kcal.

The linear regression results related to the percentages of macronutrients and omegas are presented in Table 3. The percentage of lipids in relation to total energy intake was positively related to age (β = 1.33; 95% CI = 0.37 to 2.28), and inversely related to sexual maturation (β = -2.44; 95% CI = -4.68 to -0.20); girls had higher lipid consumption than boys (β= 4.59; 95% CI = 0.62 to 8.57). There were no significant associations between the independent variables and the percentage of consumption of carbohydrates, proteins, and omegas 3 and 6. The explanatory power of the variables varied between 0.04 (carbohydrates) and 0.28 (lipids).

When lipid fractions were analyzed (Table 4), age was positively associated with the percentage of saturated fatty acids (SFA) (β = 0.62; 95% CI =0.30 to 0.94), and Monounsaturated Fatty Acid (MFA) (β=0.48; 95% CI = 0.16 to 0.79). Sexual maturation, in turn, was inversely associated with the percentage of SFA (β=-1.7; 95% CI = -2.46 to -0.95), MFA (β = -1.59; 95% CI = -2.34 to -0.84), and Trans Fatty Acid (TFA) (β = -0.32; 95% CI = -0.34 to -0.00). Fat mass was positively associated with the percentage of SFA (β = 0.18; 95% CI = 0.03 to 0.32) and MFA consumption (β = 0.23; 95% CI = 0.091 to 0.38). There were no significant associations between the variables analyzed and the percentage of Polyunsaturated Fatty Acid (PFA) and cholesterol. The explanatory power of the lipid fractions varied between 0.07 (cholesterol) and 0.40 (SFA).

DISCUSSION

It is important to consider the complex interplay of biological, environmental, and socioeconomic factors when studying nutritional or health outcomes. The average per capita income found in the study was less than half the minimum wage (R$606.00)[18], including families in the low-income classification. The economic profile of the family nucleus can compromise purchasing power and food choices, resulting in insufficient consumption of fresh or minimally processed foods[19].

In the current research, it was observed that 39% of adolescents presented with excess weight, according to BMI. A high prevalence of excess abdominal weight was also evidenced among the adolescents studied (19.5%), which raises a warning due to its strong influence on greater cardiometabolic risks[20].

Table 1 – Characteristics of adolescents regarding age, income, anthropometric variables, and sexual maturation, Recife, Pernambuco, Brazil (N = 77)

Variables	Mean ± SD	Minimum - Maximum
Age (y)	13.87 ± 2.40	10.16 – 18.65
Per capita income (R$)	362.29 ± 243.79	43.30 – 1700
Waist circumference (cm)	75.14 ± 11.83	59.00 – 119.50
Fat mass (kg)	18.14 ± 9.98	5.52 – 47.37
Lean mass (kg)	37.28 ± 9.24	23.03 -71.29
	Frequency	
	n	%
Sex		
Boys	34	44.20
Girls	43	55.80
Sexual Maturation		
Stage 1	5	6.49
Stage 2	10	12.99
Stage 3	19	24.67
Stage 4	16	20.78
Stage 5	17	22.08
Not evaluated	10	12.99
Nutritional status		
Normal weight	47	61.00
Excess weight	30	39.00
Waist circumference		
No risk factor for metabolic diseases	62	80.50
With risk factor for metabolic disease	15	19.50

SD, standard deviation.

Table 2 – Percentage of macronutrient intake according to total caloric intake and cholesterol in adolescents aged 10 to 19 years, Recife, Pernambuco, Brazil

Variables	Mean ± SD	Minimum maximum
Carbohydrates (%)	54.11 ± 16.57	34.76 – 181.95
Protein (%)	14.39 ± 3.56	6.96 – 23.45
Lipids (%)	34.09 ± 6.53	18.08 – 47.97
Saturated Fatty Acid (%)	9.08 ± 2.41	4.09 – 15.80
Monounsaturated Fatty acid (%)	9.21 ± 2.34	4.30 – 14.81
Polyunsaturated Fatty Acid (%)	8.03 ± 2.55	2.93 – 14.72
Trans Fatty Acid (%)	1.56 ± 0.84	0.09 – 3.96
Omega 3 (%)	0.58 ± 0.22	0.12 – 1.22
Omega 6 (%)	6.85 ± 2.28	2.57 – 13.46
Cholesterol (g)	329.33 ± 209.62	56.24 – 1020.20

SD, standard deviation.

Table 3 – Linear regression coefficient for the association between the percentage of macronutrients and omega 3 and omega 6 in relation to total energy consumption with age, sex, income, sexual maturation, and indicators of adiposity in adolescents aged 10 to 19 years. Recife, Pernambuco, Brazil

Variables	Carbohydrates (%) *			Protein (%) *			Lipids (%) *			Omega 3 (%)*			Omega 6 (%)*		
	β	CI (95%)	R²	β	CI (95%)	R²	β	CI (95%)	R²	β	CI (95%)	R²	β	CI (95%)	R²
Years of age	0.55	-2.24 to 3.35		0.19	-0.40 to 0.79		**1.33**	**0.37 to 2.28**		0.03	-0.01 to 0.06		0.3	-0.07 to 0.66	
Sex #	0.46	-11.20 to 12.11		-0.81	-3.29 to 1.67		**4.59**	**0.62 to 8.57**		0.03	-0.13 to 0.18		0.72	-0.78 to 2.23	
SM ##	-1.55	-8.13 to 5.02		-0.41	-1.81 to 0.99		**-2.44**	**-4.68 to -0.20**		-0.02	-0.10 to 0.07		-0.42	-1.26 to 0.43	
NS ###	5.70	-9.68 to 21.08	0.04	1.16	-2.11 to 4.44	0.06	4.63	-0.62 to 9.88	0.28	0.18	-0.02 to 0.37	0.11	1.84	-0.15 to 3.83	0.15
WC (cm)	-0.71	-1.79 to 0.37		-0.14	-0.37 to 0.09		-0.14	-0.51 to 0.23		-0.01	-0.02 to 0.01		-0.05	-0.18 to 0.09	
FM (kg)	0.47	-0.80 to 1.74		0.15	‘-0.12 to 0.42		0.17	-0.26 to 0.61		0	-0.14 to 0.02		0.03	-0.13 to 0.19	
LM (kg)	0.36	-0.39 to 1.11		0.03	-0.13 to 0.19		0.06	-0.19 to 0.32		0	-0.01 to 0.01		-0.04	-0.13 to 0.06	

SM=Sexual Maturation, NS=Nutritional Status; WC=Waist Circumference; FM=Fat Mass; LM=Lean Mass. # Boys reference. ## Stage 1 reference. ### Eutrophic reference. * Adjusted by per capita income.

Table 4 – Linear regression coefficient for the association between the percentage of saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, and trans fatty acids in relation to total energy and cholesterol intake with age, sex, income, sexual maturation, and indicators of adiposity in teenagers aged 10 to 19 years. Recife, Pernambuco, Brazil

Variables	SFA (%)*			MFA (%)*			PFA (%)*			TFA (%)*			Cholesterol		
	β	CI (95%)	R²	β	CI (95%)	R²	β	CI (95%)	R²	β	CI (95%)	R²	β	CI (95%)	R²
Years of age	**0.62**	**0.30 to 0.94**		**0.48**	**0.16 to 0.79**		0.24	-0.16 to 0.63		0.05	-0.08 to 0.18		25.97	-8.78 to 60.75	
Sex #	1.12	-0.22 to 2.45		0.68	-0.64 to 2.01		0.71	-0.96 to 2.37		-0.2	-0.75 to 0.36		57.18	-87.85 to 202.21	
SM ##	**-1.7**	**-2.46 to – 0.95**		**-1.59**	**-2.34 to -0.84**		-0.23	-1.17 to 0.71		**-0.32**	**-0.34 to – 0.00**		-31.54	-113.35 to 50.27	
NS ###	-0.88	-2.65 to 0.88	0.4	-1.2	-2.95 to 0.55	0.38	2.07	-0.13 to 4.27	0.17	-0.42	-1.16 to 0.32	0.15	40.97	-150.42 to 232.36	0.07
WC (cm)	-0.04	-0.16 to 0.09		-0.05	-0.18 to 0.07		-0.06	-0.22 to 0.09		-0.03	-0.08 to 0.03		6.84	-6.59 to 20.26	
FM (kg)	**0.18**	**0.03 to 0.32**		**0.23**	**0.091 to 0.38**		0.07	-0.11 to 0.25		0.05	-0.01 to 0.11		-9.93	-25.70 to 5.83	
LM (kg)	-0.02	-0.11 to 0.06		0	-0.09 to 0.08		-0.04	-0.15 to 0.07		-0.01	-0.04 to 0.03		1.85	-7.47 to 11.61	

SFA=Saturated Fatty Acid; MFA=Monounsaturated Fatty Acid; PFA=Polyunsaturated Fatty Acid, and TFA=Trans Fatty Acid; SM=Sexual Maturation; NS=Nutritional Status; WC=Waist Circumference; FM=Fat Mass; LM=Lean Mass. # Boys reference. ## Stage 1 reference. ### Eutrophic reference. In bold, when significant. *Adjusted by per capita income.

According to Jaime et al.[21], the epidemiological transition faced worldwide is associated with changes in the population's dietary patterns, including adolescents. This condition is characterized by excessive energy consumption and a decrease in the intake of fresh foods, favoring higher rates of chronic non-communicable diseases.

When analyzing macronutrient consumption, Alfaris et al.[22] found adequate protein intake in Saudi Arabia, unlike the findings of Wever et al.[23], who reported that Venezuelan adolescents did not reach the minimum intake of this nutrient.These divergent findings can be explained by cultural and socioeconomic differences.

The results of the 2008/09 Family Budget Survey in Brazil identified that adolescents had a lipid intake above the recommended level [24], which characterizes a high caloric demand, considering that fat is the largest contributor among macronutrients to energy supply. The literature describes that this population has a high consumption of total and saturated fats, whereas there is a decrease in the consumption of unsaturated fats[23].

Regarding trans fats, it was observed that the intake of this group is well above that recommended in adolescents[24]. This high consumption is possibly related to a greater intake of ultra-processed products, which are characterized by high levels of saturated and trans fats, sugars, and sodium, thus making it an unfavorable scenario for health promotion[22].

In the current study, it was observed that the percentage of lipids in relation to total energy consumption was positively associated with age. Therefore, a high-calorie and high-fat diet has been associated with cardiovascular diseases among adolescents because these practices are recurrent in this age group[20]. Lima et al.[25] found that greater consumption of ultra-processed foods was also associated with older adolescents (17-19 years old), whereas Barbalho et al. identified that younger adolescents (10-14 years) are approximately five times more likely to present excess weight[26].

Furthermore, it was observed in this study that girls consumed more lipids than boys. When evaluating the eating patterns of adolescents, Arruda Neta et al. observed that the female sex was inversely associated with a traditional diet consistingof basic items such as rice, beans, and meat, which has a protective effect on adiposity and LDL levels (low density lipoproteins)[27]. The imposition of beauty standards and body dissatisfaction experienced by adolescents can aid understanding of these findings as they consider psychological aspects present in these individuals who tend to easily internalize the thin body ideal conveyed by the media, making them more susceptible to inappropriate eating habits[28]. All these findings indicate greater vulnerability among girls, leading to a greater risk of developing excess weight, both in body and abdominal measurements[25,26].

Concomitantly, in the present study, an inverse association was identified between sexual maturation and SFA, TFA, and MFA, demonstrating that the lower the pubertal stage, the greater the consumption of these lipid fractions. Duan et al.[29] showed that female adolescents who had the habit of consuming fast food had menarche earlier than girls who did not have this habit. These authors also argued that menarche at an early age can favor the onset of type 2 diabetes mellitus and cardiovascular disorders, among others.

Regarding the food consumption of adolescents, it was observed that the consumption of trans fatty acids and cholesterol is above the recommended level, while the consumption of omega 3 is below the IOM[16] and WHO/FAO recommendations[17], reaffirming what is demonstrated in the literature[23]. The presence of inadequate omega-3 consumption raises concerns, especially regarding the inadequate omega-3/omega-6 ratio, which could increase the occurrence of chronic diseases, such as inflammation and atherosclerosis[29].

Fat mass was also associated with the consumption of SFA and MFA among the adolescents evaluated. This result can be analyzed according to the high energy value consumed, which results from the metabolization of excessive consumption of lipids and their fractions. Barbalho et al.[30] corroborated these results, reporting that adolescents who inappropriately consume foods with high energy density are twice as likely to develop excess weight.

As a limitation, the current study has a cross-sectional approach, which makes it impossible to attribute causality in relation to the variables analyzed. Due to the need for information reported by adolescents to assess macronutrient consumption, memory bias may be present, although this aspect was carefully monitored to minimize bias through illustrations of portions, homemade measuring utensils, and nutritionists trained to apply and evaluate the instrument used (24-hour recall). Another limitation is the use of Bioelectrical Impedance to evaluate body composition. We recognize that the absence of physical activity measures may also be a limitation of our study, which prevents us from verifying its role as an independent factor or as a potential moderator of the associations analyzed. However, logistical and financial reasons prevented us from including objective measures of physical activity, which should be considered in future research.

The results of this study may aid in the development of strategies and actions that contribute to health policies to promote healthy eating among adolescents; in addition to helping to prevent and reduce diseases associated with poor diet. Prospective studies are needed to better investigate how dietary intake of macronutrients can relate to different indicators among adolescents, as well as to assess genetic predisposition to greater food consumption.

CONCLUSIONS

A high prevalence of overweight and abdominal obesity was found among adolescents, converging with the global scenario. Age was positively associated with lipid consumption. Girls had higher lipid consumption than boys. In the evaluation of lipid fractions, age was associated with the consumption of SFA, whereas sexual maturation was inversely associated with the consumption of SFA, MFA, and TFA. Fat mass was positively associated

with the consumption of SFA and MFA, indicating that the high consumption of these lipid fractions may favor adiposity in adolescents.

The findings of the current research reinforce the concern regarding a high-fat diet among adolescents, especially older girls, as this practice favors the development of diseases and chronic conditions in the short and long term. It is essential that public actions include adolescents to promote approaches that develop the empowerment, self-care, and autonomy of these subjects in relation to adequate and healthy eating.

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