Association between eating patterns and body mass index in a sample of children and adolescents in Northeastern Brazil

Associação entre padrões alimentares e índice de massa corporal em amostra de crianças e adolescentes do Nordeste brasileiro

Asociación entre patrones de alimentación e índice de masa corporal en una muestra de niños y adolescentes en el noreste de Brasil

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Abstract

The aim of this study was to assess the relationship between eating patterns and body mass index (BMI) in children and adolescents. This is a cross-sectional study of 1,247 male and female students, aged between 6 and 12, from public elementary schools in São Francisco do Conde, Bahia State, Brasil. BMI was used to analyze the children's nutritional status. Food consumption frequencies, in addition to demographic and socioeconomic information, were collected for each participant. Dietary patterns were identified through a factor analysis. The prevalence of overweight and obesity was 17.3% (10.2% overweight and 7.1% obese). Two eating patterns, "obesogenic" and "prudent", were identified. The former is characterized by sweets and sugars, typical Brazilian dishes, pastries, fast food, oils, milk, cereals, cakes, and sauces, and was positively associated with increased BMI (ßi = 0.244; p = 0.018). An "obesogenic" dietary pattern was associated with increased BMI.

Feeding Behavior; Body Mass Index; Adolescent; Child

Resumo

O objetivo deste estudo foi identificar a associação entre padrões alimentares e índice de massa corporal (IMC) em crianças e adolescentes. Estudo transversal realizado em amostra de 1.247 estudantes entre 6 a 12 anos, de ambos os sexos, matriculados na rede pública de ensino de São Francisco do Conde, Bahia, Brasil. Para avaliar o estado nutricional foi utilizado o IMC. Informações de frequência de consumo alimentar, além das demográficas e socioeconômicas foram obtidas para cada participante. Os padrões alimentares foram obtidos a partir de análise fatorial. A prevalência de excesso ponderal foi de 17,3% (10,2% de sobrepeso e 7,1% de obesidade). Foram encontrados dois padrões alimentares: padrão "obesogênico" e "prudente". O primeiro, caracterizado pelo consumo de doces, pratos típicos brasileiros, pastelarias, fast food, *óleos, leite, cereais, bolos e molhos, esteve positivamente associado ao aumento do IMC (ßi = 0,244; p = 0,018). Os resultados apontaram associação do padrão obesogênico com aumento do IMC.*

Comportamento Alimentar; Índice de Massa Corporal; Adoslecente; Criança

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Introduction

Obesity is a chronic, multifactorial disease characterized by the accumulation of fat tissue either locally or throughout the body as a result of the positive difference between energy consumption and expenditure [1]. Excess weight in childhood and adolescence has been associated with adverse short-term and long-term health effects. These effects include an increased risk of cardiovascular disease and factors related to metabolic abnormalities, such as dyslipidemia, glucose intolerance and an increased likelihood of being obese as an adult [2]. Other symptoms such as sleep apnea [3,4] as well as psychological and social repercussions have been reported in the literature [5].

Overweight and obesity are becoming the major nutritional problems in the modern world and are rapidly increasing in many developed and developing countries [6]. In the United States, the prevalence of obesity among 6- to 11-year-old children has increased over the last 30 years from 7% to 20%, and among 12- to 19-year-old adolescents, the prevalence has increased from 5% to 18% [7]. In Brazil, national surveys conducted over the past few decades have also shown an increase in overweight and obesity among Brazilian children and adolescents, suggesting an epidemic trend. The *Household Budget Survey* (HBS) conducted in 2008/2009 estimated that 30% of children between 5 and 9 years of age and approximately 20% of 10- to 18-year-olds had excess weight [8].

Genetic, physiological, psychosocial and metabolic factors may be associated with excess weight. However, the factors that explain the increase in the number of obese children appear to be specifically related to lifestyle changes [9,10]. According to the literature, an obesity epidemic in youth appears to be the result of changes in modern society. One of the most commonly mentioned changes is the increased availability of highly energy-dense manufactured foods, especially those rich in saturated fat and simple carbohydrates, at the expense of plant-based foods, combined with few opportunities for physical activity [11]. These changes, mainly imposed by the new "lifestyle" experienced in the last few decades, have increased the risk factors associated with non-transmissible chronic diseases [12].

Most studies use food, alone or associated with micronutrient ingestion to study the association between diet and chronic disease; nutrients and foods are not consumed in isolation but in combination. As a result, the World Health Organization (WHO) [13] has suggested that assessments of food intake in population-based studies on nutrition should be based on eating patterns. Dietary patterns can summarize the combined and potentially synergistic effects of a repertoire of foods contributing to usual dietary intake in a defined population. Several nutritional epidemiology researchers have investigated the link between eating patterns and excess weight and have found a positive correlation between inadequate eating patterns and higher body mass index gain in children and adolescents [14,15,16,17]. However, this relationship was not observed in other studies [18,19,20]. Overall, studies on the relationship between eating patterns and weight status during this phase of life are not consensual.

In order to support and strengthen the knowledge in this field, this study sought to explore the relationship between eating patterns and weight status, based on an exploratory factor analysis, with the main component estimation method used to measure eating patterns. Our hypothesis is that a higher adherence to dietary patterns that are characterized by foods that are energy-dense, high in fat and low in fiber predispose young people to an increased body mass index. These results may contribute to the creation and implementation of strategies for promoting healthy eating and better health in children and adolescents.

Methods

Study design/population/sample

A cross-sectional design was used to study 6- to 12-year old children living in São Francisco do Conde, a municipality located in the metropolitan region of Salvador, Northeast Brazil. This municipality has 33,183 inhabitants and a high urbanization rate (80.2%). Economically, the municipality has the third highest development index in the state of Bahia, and the city council is the largest local employer. However, this region experiences challenges in certain areas, including its social development index (30th), level of education (139th) and health indicators (178th) [21].

We used data from the São Francisco do Conde Municipal Education Department for the year 2010 to calculate the sample size. Of 3,734 registered students, 2,649 were from rural areas and 1,085 were from urban areas. Considering the prevalence of respiratory allergies and overweight of 25% [22,23], a sample size calculation with a 3% error and a 95% level of confidence resulted in samples of 531 and 775 students in urban and rural areas, respectively. However, these students were distributed across 22 schools in the county school system. Thus, to minimize travel costs and time for subject recruitment, we chose (not at random) to include in our study all students from schools that had at least 150 or more students. Therefore, only nine schools attended this requirement. All students aged 6-12 years in each school were eligible for the study. In addition to this, we added 15% to the total sample size to account for students who chose not to participate in the study, resulting in a total of 1,500 students being enrolled in the study.

Response variable: body mass index

- **Anthropometric data**

Each participant's weight was obtained using a Master portable digital scale, and height was measured using a Leicester Height Measure portable stadiometer (Seca, Hamburg, Germany). The weight of the uniform (100g) was subtracted during the analysis. To assess anthropometric status, tables from the WHO [24] with percentile values of body mass index [BMI = weight (kg)/ height (m)^2] according to age and sex were used as reference. For classification to an anthropometric status, we used the WHO 2006 [25] proposal: underweight (< 3rd percentile); normal weight (≥ 3rd percentile and < 85th percentile, reference category); overweight (≥ 85th percentile and < 97th percentile) and obese (≥ 97th percentile). The overweight and obese categories were aggregated. Therefore, children with excess BMI were situated on or above the 85th percentile.

Principal independent variable

- **Eating patterns**

The items of the quantitative food frequency questionnaire (FFQ) were included based on a study developed by Borges et al. [26]. The FFQ was validated recently by Mascarenhas [27]. The average energy and nutrient values from the FFQ were compared with those from a three-day food record through the paired t test and Pearson correlation coefficients. The Pearson correlation coefficients, after being adjusted and corrected for variability, ranged from 0.27 to 0.99 [carbohydrates (0.41), proteins (0.62), lipids (0.44), zinc (0.99), magnesium (0.45), calcium (0.33), fiber (0.27) iron (0.40)]. This questionnaire was applied to the students' parents or guardians by trained nutritionists and nutrition students in meetings together with the students. Information missing in the parents' or guardians' answers was completed by the students.

The FFQ contained 97 food items. This questionnaire evaluated the quantity of foods and nutrients consumed during the preceding 6 month period. The portions or home-cooking measurements reported were converted into grams or milliliters. To minimize possible sources of error (memory bias) in the food consumption information, an album with drawings of foods and utensils of different dimensions was used, and, in addition, standard liquid measurements were presented to the mothers at the time of the interview.

For the analysis, the foods were grouped into 22 food clusters according to the coded nutritional content, including: sugars and sweets; typical Brazilian dishes (*feijoada*: a stew of black beans with beef and pork; *feijão-tropeiro*: a dish made with beans, cassava flour, sausage, garlic, onion, bacon and eggs; *acarajé*: a dish made from peeled black-eyed peas, formed into balls, and deep fried in palm oil); soft drinks; pastries; fast food; oils; milk; beef; chicken; fish; eggs; processed meat products; breads; cereals (rice, cassava flour, and pasta); cakes; roots; baked beans, legumes; fruits; leafy vegetables; sauces; and artificial sweeteners.

Frequencies of consuming foods or food types were summarized in one unique value for each student using the method described by Neumann et al. [28]. To do so, foods were initially codified according to individual consumption frequencies: never = 0; from 1 to 3 times a month = 1; once a week = 2: 2 to 3 times a week = 3; 4 to 7 times a week = 4. Then codified frequencies corresponding to foods actually consumed by the individual were summed in each food type group, resulting in the numerator of the summary measure. The denominator has been defined as the maximum number of foods that the individual could eat in each food type group, multiplied by 4.

As an example, for a particular individual, the sum of codified frequencies for the sugars and sweets group was 20. In this food type group, the denominator would be 40 (the maximum consumption is 10 food products, a number that was multiplied by 4). In this way, the score of sweets consumption for this particular individual was 20/40 = 0,5. This is how summary measures were obtained for each individual belonging to the sample.

The food intake registered by the FFQ was converted into energy and nutrients by the Virtual Nutri program [29]. The daily intake frequency was calculated based on the weekly and monthly intake frequency of each food. The values, multiplied by the concentration of nutrients in the food, resulted in the daily intake value [30,31].

Confounding variables

- **Physical activity level**

Physical activity levels were measured by applying the short version of the *International Physical Activity Questionnaire* (IPAQ) in an interview [32]. Guedes et al. [32] has demonstrated the reproducibility and validity of the questionnaire. The student's parents or guardians were asked about the time and the frequency of moderate and intense activities and walking during the previous week. Information missing in the parents' or guardians' answers were completed by the students. For this study, the final results were divided into two groups using a cutoff of 300 minutes/week of moderate or intense activity. The children with ≥ 300 minutes of activity per week were considered active (reference category), and the children with < 300 minutes/week were classified as insufficiently active [33].

- **Sedentary behavior**

In addition, a questionnaire about the average time that the children spend watching television, playing video games, playing or surfing on a computer on a typical weekday and on a typical weekend day was applied [34]. Time spent was summed into the total screen time. We chose to record the total time spent on this activity for the entire week. In this study, the results were divided into two categories using the median as a cutoff. Thus, this variable was dichotomized as non-sedentary (< 3.35 hours/day; reference category) or sedentary (≥ 3.35 hours/day).

- **Sexual maturation**

Evaluation of the stage of sexual maturity was based on breast and pubic hair characteristics in girls and genitals and pubic hair in boys. Based on this staging, adolescents were grouped according to categories described by Marshall & Tanner [35,36] into pre-pubescent (reference category) and pubescent. The identification of these stages was made by means of self-description that was supported by drawings provided by the interviewers.

Other variables

The other variables included in the study were gender (male, female – reference category), age (< 10 years old, ≥ 10 years old – reference category). Questions concerning socioeconomic characteristics were answered by the student's parents or guardians: caregiver education (≤ 4th grade, > 4th grade – reference category), family income (1.5 times the Brazilian minimum wage, ≥ 1.5 times the Brazilian minimum wage – reference category) and household location (urban, rural – reference category). The economic classification was defined using the *Brazilian Economic Classification Criteria* [37], which includes the possession of domestic goods and the education level of the head of the family. The families were divided into the following economic categories (starting with the greatest purchasing power): A1, A2, B1, B2, C1, C2, D and E. Only the categories B2 reference category, C2, D and E were found.

Data processing

The data processing and database construction were performed using Epi Info, version 6.04 (Centers for Disease Control and Prevention, Atlanta, USA). The data were entered in duplicate after the questionnaires were revised, and coding errors made in the fields were corrected. Simple frequencies were verified and analyses were conducted to determine the consistency between the questions and the answers to clean up the database.

Statistical analysis

In the first instance, descriptive analyses were performed to characterize the study population using proportions for the categorical data. Before proceeding to the exploratory factor analysis and to assure that this method is adequate in order to explain the maximum variation in food intakes, the Kaiser-Mayer-Olkin (KMO) coefficient and Bartlett's test of sphericity were used. To assess the degree of inter correlations between variables we adopted a value greater than 0.60 for the KMO [38]. Factor analysis with principal component estimation method followed by an orthogonal rotation (varimax) was used for the exploratory factor structure (pattern) analysis. To identify the number of principal components to be retained, the following criteria were used: The criterion of eigenvalues exceeding 1, the scree plot (which is a graphical presentation of eigenvalues) and the interpretability of each component. The derived factors were labeled on the basis of data and a review of the literature. The factor score for each pattern was calculated by summing intakes of food groups weighted by their factor loadings, and each participant received a factor score for each identified pattern. Food groups with factor loadings greater than 0.40 and communality over 0.20 were retained in the patterns identified [38].

All component scores were approximately normally distributed and Spearman's correlations coefficients were calculated to measure the association between pattern scores and nutrient intakes. Additionally, partial correlation coefficients were calculated, adjusting for energy intake, and thus represented the association between dietary patterns and relative nutrient intake.

Multiple linear regression analysis was used to evaluate the associations between food consumption factor scores and body mass index. The models were adjusted for gender, age, sexual development, sedentarism, physical activity level, household location, economic conditions and for energy consumption. The effects of the dietary patterns were also adjusted for each other since rotations can introduce correlations between them, although principal components are uncorrelated. Confounding variables were chosen based on current knowledge drawn from the literature review. We tested the data for interactions between dietary patterns and gender in the regression analysis.

The statistical tests were two-tailed with a 5% level of significance. The statistical analyses were performed using SPSS, version 17.0 (SPSS Inc., Chicago, USA).

Ethics

Ethical approval was provided by the Ethics Research Committee of the School of Nutrition at the Federal University of Bahia, Brazil. The study was conducted in accordance with the *Declaration of Helsinki*, as revised in 2000. Written and informed consent detailing all procedures to be carried out was signed by a parent or legal guardian of each participant.

Results

Of the students initially selected (1,500 students), 193 (12.8%) did not participate in the study (because they refused, because their families moved to another city or because they were transferred to another school). Ultimately, a total of 1,307 students of both genders between 6 and 12 years old participated in the study. A total of 1,247 students had complete data for FFQ which was included in the analyses. There were no statistically significant differences between the original sample and the sample used in this study in terms of socioeconomic, anthropomorphic and demographic characteristics (data not shown).

There were higher percentages of male students (53.1%) and students 10 years old or older (50.2%). The other characteristics are shown in Table 1. The prevalence of weight excess was 17.3% (10.2% overweight and 7.1% obese).

Table 1

Characteristics of the study population from São Francisco do Conde, Bahia State, Brazil, 2010.

Variable	n	%
Age (years) *		
< 10	609	49.8
≥ 10	614	50.2
Gender		
Male	662	53.1
Female	585	46.9
Caregiver education *		
Illiterate	49	4.2
Elementary school-cycle I	306	25.9
Elementary school-cycle II	302	25.6
Middle school and above	523	44.3
Family income (minimum wage **) *		
≥ 1.5	506	42.3
< 1.5	691	57.7
Economic classification *		
Class B	661	56.3
Classes C, D, E	514	43.7
Household location		
Urban	434	34.8
Rural	813	65.2
Puberty *		
Pre-pubescent	953	76.4
Pubescent	294	23.6
Sedentarism *		
Sedentary	311	25.1
Non-sedentary	926	74.9
Physical activity level *		
Active	985	79.2
Inactive	258	20.8

* Different totals because of no available data;
** Value in 2010: BRL 510.00, equivalent to US$ 290.70.

Both the KMO index (0.864) and Bartlett's test ($\chi^2 = 4335{,}619$; $p < 0.001$) indicated that the correlation among the variables was sufficiently strong for a factor analysis. To reduce bias as a result of multiple testing and to better identify common dietary patterns, only the dietary patterns with an eigenvalue of > 1.5 were extracted. This cut-off was made on the basis of the scree plots, which indicated a clear break after the second factor (i.e. dietary pattern) with an eigenvalue of 1.6.

The factor analysis revealed two eating patterns that were responsible for 47.89% of the total variance. These eating patterns were designated "obesogenic" and "prudent". The factor loadings of the eating patterns for each component are shown in Table 2. The first component was positively correlated with the intake of sugars, typical Brazilian dishes, pastries, fast food, oils, milk, cereals, cakes and sauces. The second component was positively correlated with roots, legumes, fruits and leafy vegetables. Some foods and food groups were not included in the analyses because of the low communalities ($h^2 < 0.20$) (i.e. the proportion of variance of each variable that could be explained by the factors): soft drinks, beef, chicken, fish, eggs, processed meat products, bread, baked beans, and artificial sweeteners.

Table 3 presents the correlations between the dietary patterns score and estimated nutrient intake, both absolute and energy-adjusted. Positive correlations (Spearman coefficient) were observed between "obesogenic" dietary pattern and intakes of total fat (r = 0.52), polyunsaturated fatty acids (PUFA) (r = 0.41), monounsaturated fatty acid (MUFA) (r = 0.495), saturated fatty acid (SFA) (r = 0.436) points that were attenuated but not removed by energy adjustment. The majority of correlations with protein, fiber and micronutrients were reversed after energy adjustment. The micronutrients rather than the macronutrients were more strongly correlated with the 'prudent' dietary pattern. Energy adjustment did not greatly attenuate the correlations between this pattern and fiber or most micronutrients. However, correlations with some macronutrients were reversed; notably total fat, PUFA, MUFA and SFA.

Table 4 shows the regression coefficients (βi) from the multiple linear regression analysis for each food consumption factor scores and the body mass index values. There was a significant positive association between "obesogenic" dietary pattern and body mass index. This relationship was statistically significant even after adjusting for age, gender, sexual development, sedentarism, physical activity, economic variable (ABEP), household location and total energy intake (βi = 0.244; p = 0.018).

There was no association between body mass index and the food consumption score for the students with the "prudent" dietary pattern, even after the appropriate adjustments have been made.

There was no interaction between gender and dietary patterns ("prudent" dietary pattern p = 0.373, "obesogenic" dietary pattern p = 0.507).

Discussion

In this study, the influence of eating patterns on body mass index was investigated in a population of 6- to 12 year-old children living in the city of São Francisco do Conde. The prevalence of excess weight found here (17.3%) is higher than the one found in other studies in Salvador [39], or in studies conducted in Corumbá in Mato Grosso do Sul State (6.5% obese; 6.2% overweight) [40] and

Table 2

Distribution of the factor loadings for the food consumption patterns of 6- to 12-year-old children and adolescents enrolled in the public school system of São Francisco do Conde, Bahia State, Brazil, 2010.

Foods and food groups	"Obesogenic" pattern	"Prudent" pattern	h_2
Sugars	**0.697**	0.085	0.498
Typical Brazilian dishes	**0.601**	0.115	0.378
Pastries	**0.586**	0.113	0.351
Fast food	**0.767**	0.012	0.590
Oils	**0.619**	0.265	0.457
Milk	**0.656**	0.165	0.470
Cereals (rice, cassava flour, and pasta)	**0.424**	0.319	0.326
Cakes and filled cookies	0.531	0.017	0.290
Roots and tubers	0.253	**0.641**	0.460
Legumes	0.052	**0.825**	0.684
Fruits	0.463	**0.503**	0.449
Leafy vegetables	0.073	**0.747**	0.568
Sauces	**0.640**	0.100	0.423
Eigenvalues	4.090	1.658	
% Variance explained	30.25	17.63	
% Variance accumulated	47.89		

Table 3

Correlation coefficients between dietary pattern scores and corresponding absolute nutrient intakes and partial correlation coefficients between dietary pattern scores and nutrient intakes adjusting for energy intake. Children and adolescents enrolled in the public school system of São Francisco do Conde, Bahia State, Brazil, 2010.

Nutrient	"Obesogenic" pattern		"Prudent" pattern	
	Absolute	Adjusted	Absolute	Adjusted
Energy	0.491 *	-	0.224 *	
Carbohydrate	0.459 *	-0.023	0.219 *	0.007 *
Total fat	0.523 *	0.083 *	0.193 *	-0.118 *
PUFA	0.411 *	0.086 *	0.167 *	-0.020
MUFA	0.495 *	0.121 *	0.148 *	-0.062 *
SFA	0.436 *	0.132 *	0.128 *	-0.115 *
Protein	0.432 *	-0.143 *	0.273 *	0.123 *
Fiber	0.305 *	-0.120 *	0.309 *	0.257 *
Fe	0.420 *	-0.009	0.195 *	0.114 *
Zn	0.358 *	-0.005	0.174 *	0.090 *
Vitamin B6	0.327 *	-0.029	0.344 *	0.321 *
Vitamin B12	0.120 *	-0.011	0.352 *	0.327 *
Niacin	0.351 *	-0.052	0.197 *	0.120 *
Folate	0.348 *	-0.057 *	0.304 *	0.276 *
Retinol	0.219 *	-0.001	0.566 *	0.557 *
Na	0.417 *	-0.041	0.088 *	-0.082 *
Ca	0.360 *	-0.069 *	0.181 *	0.094 *

Ca: calcium; Fe: iron; MUFA: monounsaturated fatty acid; Na: sodium; PUFA: polyunsaturated fatty acids; SFA: saturated fatty acid; Zn: zinc.
* $p < 0.001$.

Belo Horizonte, Minas Gerais State (3.1% obese; 8.4% overweight) [41]. However, the prevalence is lower than the one found in studies conducted in Fortaleza in Ceará State (19.5% obese and overweight) [42], and Santos in São Paulo State (18% obese; 15.7% overweight) [43].

With factor analysis, two food consumption patterns were identified: (1) the "obesogenic" pattern composed of sweets and sugars, typical Brazilian dishes, pastries, fast food, oils, milk, cereals, cakes, and sauces; and (2) the "prudent" pattern composed of roots, legumes, fruits, and leafy vegetables. From the results we can observe that the "obesogenic" pattern shows an increase in the average BMI. Thus, this pattern has a negative effect on the healthy growth of children and adolescents, especially because it includes foods with fat, saturated fat and simple carbohydrates. While it is difficult to make direct comparisons among dietary pattern studies, findings from our study were similar to those found in other studies on Brazilian population food consumption patterns [44,45]; these studies have shown increased consumption of manufactured products, insufficient consumption of fruits and vegetables, and increased amounts of overall fat and saturated fat in the diet.

The WHO has suggested that epidemiologic nutritional analyses of population food consumption should be based on eating patterns rather than on nutrient intake [13]. In order to evaluate the association between diet and diseases, particularly for chronic diseases, the use of dietary patterns has several advantages compared with methods focusing on nutrients and food alone. Indeed, this approach reduces the chance of finding spurious associations between exposure (dietary) and outcome (chronic diseases), and it incorporates both the complex interactions between nutrients (synergistic or antagonistic) and their correlations, which can modify bioavailability.

After necessary adjustments, the results of the multiple linear regression show a significant positive association between the "obesogenic" food consumption pattern and BMI. Cross sectional studies that analyze the relationship

Table 4

Multiple linear regression for evaluating the relationship between eating patterns and body mass index in 6- to 12-year-old children and adolescents enrolled in the public school system of São Francisco do Conde, Bahia State, Brazil, 2010.

	"Obesogenic" pattern		"Prudent" pattern	
	β *	p-value	β *	p-value
Model 0	0.232	0.008	0.003	0.977
Model 1	0.229	0.007	-0.003	0.976
Model 2	0.242	0.005	-0.006	0.941
Model 3	0.231	0.009	-0.009	0.913
Model 4	0.244	0.018	-0.025	0.776

Model 0: effects of the dietary patterns adjusted for each other since; Model 1: Model 0 + adjusted by gender, age, sexual maturation; Model 2: adjusted by gender, age, sexual maturation, sedentarism and physical activity; Model 3: adjusted by gender, age, sexual maturation, sedentarism, physical activity and economic classification; Model 4: adjusted by gender, age, sexual maturation, sedentarism, physical activity, economic classification, household location and energy intake.
* Regression coefficient.

between eating patterns and overweight/obesity, especially in youth, showed that junk food eating patterns, characterized by high intake of sweets such as chocolates, ice cream, foods with added sugar, fried foods (French fries, hamburgers, "empanados", popcorn, bacon), sodas and alcoholic drinks, were related to excess weight in Korean [46,47] and Spanish [48] youth populations. However, this association was not found in studies of Scottish [19] and American adolescents [20]. Therefore, our results corroborated the previous findings, showing that dietary patterns that are high in energy-dense, high-fat and low-fiber foods predispose young people to overweight later. Ambrosini [49] points out in his revision paper that studies reporting positive associations between this type of dietary pattern and later obesity risk were of consistently higher quality than those reporting null associations.

Inadequate eating habits may have a large effect on the occurrence of overweight/obesity, especially in children and adolescents. It is possible that the effect of fatty foods on the BMI gain is due to their high energy density, associated with low nutrient contents. In addition, the flavor of these foods may lead to weight gain by promoting excessive consumption. Some studies have also shown that the power of satiety of fats is lower compared to carbohydrates and proteins, making it more difficult to adjust compensation after a meal rich in fat, which is directly related to excessive energy consumption [50].

Clear positive correlations, which were fairly robust to energy adjustment, were evident between the scores on the "obesogenic" pattern and fats intake. Furthermore, intakes of almost all of the micronutrients as well as fiber and protein were negatively correlated with this pattern after energy adjustment. Surprisingly an inverse relationship was seen with carbohydrate, although it was not significant. In total, this result is not surprising given that high scores on the "obesogenic" pattern are associated with a high consumption of high-fat and nutrient-poor processed foods. This pattern, characterized by an elevated intake of fat, is likely to contribute to the increasing prevalence of childhood obesity and the fact that the correlations of this pattern with energy were strong and those with micronutrients were reversed after energy adjustment suggests that it is a marker for an energy-dense, nutrient-poor diet. The "prudent" pattern showed positive relationships with fiber and many micronutrients that were robust to energy adjustment. This result was again not unexpected given that higher pattern scores are related to higher intakes of nutrient-dense foods such as fruit, vegetables and leafy vegetables. The results observed in the current study were consistent with results obtained Cribb et al. [51] and Patel et al. [52], which found a "processed" pattern that was positively associated with fats and sugar, as well as "health conscious" and "traditional" patterns that both showed positive linear relationships with most nutrients. Results from the current study and others investigating dietary patterns and nutrient intakes have the potential to inform new public health initiatives, as this method of examining dietary patterns as a whole can be more useful than focusing on single foods and/or nutrients. It is evident from the results presented here that the "obesogenic processed" pattern is the least ideal in terms of nutrient intake.

Limitations of the study

There are several limitations to this study: as a cross-sectional study, it is unable to determine causal relationships because it does not account for the temporal progression from exposure to effect. Many studies are still limited to cross-sectional designs, which only allows for the investigation of association between variables. However, several randomized controlled intervention studies lead to the conclusion that changes towards healthy eating habits positively affect weight loss in all age groups [53]. It is important to highlight that semi-quantitative FFQ was validated only for adolescents. Furthermore, the nutritional intakes of children estimated via this questionnaire might not represent their true intakes and may depend on recall bias and social desirability [54], however, it is an appropriate instrument for ranking dietary intakes. Moreover, misclassification of the children's dietary intake, resulting from administration of the FFQ to the student's mothers, might happen especially considering foods eaten away from home. Thus, according to Drewnouski [55], these dietary data may reflect the mother's dietary image rather than the real diet of the child. This approach was still necessary, given that cognitive skills required to estimate and recall usual intakes, as well as the knowledge of how foods are prepared, are limited in elementary school children [56]. The limitation resulting from interviewing parents or guardians rather than the students was mitigated by applying the interviews in the presence of the students, asking them to complement or correct any missing or incomplete information. In addition, data driven by factor analysis depends on subjective or arbitrary decisions, for example, when grouping the food items or labeling the factors [57]. Also, the decision about how many factors to retain and which correlation matrix rotation method to use in the factor analysis could represent limitations of this study, which may contribute to the inconsistency and considerably limit the ability to generalize the results. However, these decisions were made taking the aims of the study and the interpretability of the data into account, as recommended by Hearty & Gibney [58].

Conclusion

Despite the limitations, the results of this study support the hypothesis that the "obesogenic" pattern composed of sweets and sugars, typical Brazilian dishes, pastries, fast food, oils, milk, cereals, cakes, and sauces are correlated with increased body mass index, after adjusting for confounders. Improving diet quality may reduce the risk of obesity in young people.

Resumen

El objetivo de este estudio fue identificar la asociación entre patrones dietéticos e índice de masa corporal (IMC) en niños y adolescentes. Se trata de un estudio transversal, realizado en muestra de 1.247 estudiantes entre 6 a 12 años de edad, de ambos los sexos, inscritos en la red pública de enseñanza de São Francisco do Conde, Bahía, Brasil. Para evaluar el estado nutricional se utilizó el IMC. La información sobre la frecuencia de consumo alimentario, además de la demográfica y socioeconómica, se consiguió con cada participante. Los patrones dietéticos fueron obtenidos a partir del análisis factorial. La prevalencia de exceso ponderal fue de 17,3% [10,2% de sobrepeso y 7,1% de obesidad]. Fueron encontrados dos patrones dietéticos: "obesogénico" y "prudente". El primero, caracterizado por el consumo de azúcares, platos típicos brasileños, pastelerías, fast food, aceites, leche, cereales, pasteles y salsas estuvo asociado al aumento del IMC (βi = 0,244; p = 0,018). Los resultados apuntaron asociación del patrón dietético "obesogénico" y aumento del IMC.

Conducta Alimentaria; Índice de Masa Corporal; Adoslecente; Niño

Contributors

N. H. A. Santos participated in the interpretation of results and writing of the manuscript. R. L. Fiaccone designed the work and reviewed the manuscript. M. L. Barreto participated in the interpretation of results and revision of the manuscript. L. A. Silva participated in the field work and reviewed the manuscript. R. C. R. Silva participated in the study design, data collection, interpretation of results, and writing of the manuscript.

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Conflicts of interest

The authors declare no conflict of interest.

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