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ORIGINAL

Metabolic syndrome in adolescents and its association with diet quality

Síndrome metabólica em adolescentes e sua associação com a qualidade da dieta

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ABSTRACT

Objective

Analyzing the prevalence of metabolic syndrome and its association with adolescent diet quality.

Methods

Cross-sectional research with 327 adolescents from public and private high schools of *Teresina, Piauí*. Socioeconomic, anthropometric, and food consumption data were analyzed to obtain the Brazilian Healthy Eating Index-Revised. Moreover, data related to metabolic syndrome (blood glucose, blood pressure, waist circumference, triglycerides, and high-density lipoprotein cholesterol) were also analyzed. Continuous variables were described by means, standard deviations, and 95% confidence intervals. To verify the association between dependent and explanatory variables, we calculated the adjusted odds ratio. The level of significance was set at $p<0.05$.

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Results

The prevalence of metabolic syndrome was 3.3%, with low high-density lipoprotein cholesterol concentration being the most frequent alteration (50.5%). The mean score on the Brazilian Healthy Eating Index-Revised was 55.4 points. The worst scores were obtained in whole cereals, dark-green and orange vegetables, oils, milk and dairy products, and whole fruits. In contrast, total cereals, meat, eggs, and legumes had scores close to the maximum stipulated. The lowest tertile of dark-green, orange, and leguminous vegetables showed risk for low high-density lipoprotein cholesterol, and the second tertile was protective against high blood glucose levels. As for the milk group, its lower intake increased the chances for high triglyceride and blood pressure levels.

Conclusion

Despite the low prevalence of metabolic syndrome, there were significant alterations in its components, associated with less consumption of important Brazilian Healthy Eating Index-Revised items.

Keywords: Adolescents. Food consumption. Metabolic syndrome.

RESUMO

Objetivo

Analisar a prevalência de síndrome metabólica e sua associação com a qualidade da dieta dos adolescentes.

Métodos

Pesquisa transversal realizada com 327 adolescentes do ensino médio da rede pública e particular de Teresina, Piauí. Obteve-se dados socioeconômicos, antropométricos, de consumo alimentar, para obtenção do Índice de Qualidade da Dieta Revisado, e relativos à síndrome metabólica (glicemia, pressão arterial, circunferência da cintura, triglicerídeos e colesterol de lipoproteína de alta densidade). As variáveis contínuas foram descritas por médias, desvios padrão e intervalos de confiança de 95%. Para verificar a associação entre as variáveis dependentes e as explanatórias, calculou-se o odds ratio ajustado. O nível de significância adotado foi de p<0,05.

Resultados

A prevalência de síndrome metabólica foi 3,3%, sendo a baixa concentração de colesterol de lipoproteína de alta densidade a alteração mais frequente (50,5%). A média de pontuação no Índice de Qualidade da Dieta Revisado foi 55,4 pontos. Piores escores foram obtidos em cereais integrais, vegetais verde-escuros e alaranjados, óleos, leites e derivados e frutas integrais. Em contrapartida, os cereais totais, e carnes, ovos e leguminosas tiveram pontuações próximas ao máximo estipulado. O menor tercil de vegetais verde-escuros, alaranjados e leguminosas demonstrou risco para baixo colesterol de lipoproteína de alta densidade e o segundo tercil foi protetor para níveis glicêmicos elevados. Quanto ao grupo do leite, seu menor consumo aumentou as chances para níveis elevados de triglicerídeos e de pressão arterial.

Conclusão

Apesar da baixa prevalência de síndrome metabólica, houve alterações relevantes em seus componentes, associadas ao menor consumo de importantes itens do Índice de Qualidade da Dieta Revisado.

Palavras-chave: *Adolescentes. Consumo alimentar. Síndrome metabólica.*

INTRODUCTION

Metabolic Syndrome (MS) is a complex disorder that affects not only adults but also adolescents, due to the increase in obesity [1,2]. This syndrome increases the risk of Type 2 Diabetes *Mellitus* (T2DM) and Cardiovascular Disease (CVD) [3]. In general, individuals with MS are asymptomatic and thus underdiagnosed [4].

In adolescence, risk factors for heart and metabolic diseases may be related to increased risk of Chronic Noncommunicable Diseases (CNCDs) in adulthood [5,6]. The Study of Cardiovascular Risks in Adolescents (ERICA, *Estudo dos Riscos Cardiovasculares em Adolescentes*) showed MS prevalence in only 2.6% of Brazilian schoolchildren, but a high proportion of adolescents had alterations in the components of the syndrome [7].

Metabolic Syndrome is associated with changes in lifestyle due to urbanization, including physical inactivity, smoking, and inadequate diet [8], the last aspect being one of the most important. In this sense, dietary patterns constitute an alternative approach to nutrient analysis alone, being considered gold standard in nutritional epidemiology. Dietary patterns show more adequately the eating behavior and its relationship with CNCDs. In addition, dietary indices check the adherence to nutritional recommendations [9,10].

Studies involving eating patterns in adolescence demonstrate poor quality of food in this population, with an increased consumption of calories from solid fats, alcohol, and sugar [11,12]. Moreover, an association between unhealthy eating patterns and metabolic changes in adolescents was demonstrated [13]. Given the current importance of MS and the scarcity of studies addressing the interaction between this disorder and the eating pattern in adolescence, this research aims to analyze the prevalence of MS in adolescents and its association with the quality diet and its components.

METHODS

This cross-sectional study is part of the research "*Saúde na Escola*: *Diagnóstico Situacional no Ensino Médio*" (Health at School: Situational Diagnosis in High School), approved by the Research Ethics Committee of the *Universidade Federal do Piauí* (UFPI, Federal University of *Piauí*) under opinion no.1,495,975. The sample included adolescents aged 14-19 years, from public and private schools in *Teresina* (PI). Parents and/or guardians authorized their participation in the research by signing the Free and Informed Consent Form, and the adolescents confirmed their acceptance by signing the Free and Clarified Assent Form. When the adolescent was aged ≥18 years, he/she signed his/her Free and Informed Consent Form.

Initially, we enumerated the 169 regular high schools in *Teresina* (PI). Next, the institutions were organized according to the type of management: public or private; the four geographic areas in which the city is divided; and the size: small (up to 115 students), medium (116-215 students), and large (more than 215 students), aiming to draw a public school and a private school of each size, for each geographic area. Thus, making a total of 24 schools (12 public and 12 private). As for the students, sampling was stratified probabilistic and proportional to the number of students according to the type of management, school size, grade, sex and age (in that order).

The minimum sample was calculated using the program Epi Info 6.04d (Centers for Disease Control and Prevention, Atlanta, USA), considering the total number of students from private and public high schools as 40,136 according to the School Census of 2014 [14]. A 95% confidence interval was used, with prevalence of 17.1% overweight [15], 5% degree of accuracy, design effect of 1.4 [16], and 5% level of significance [17]. Thus, the minimum sample size was 316 adolescents. Ten percent (10%) more students were drawn in each school, considering possible losses and using the same selection criteria, resulting in a sample of 348 adolescents.

Socioeconomic and demographic data were obtained through a semi-structured questionnaire prepared for the research and previously tested. The variables gender, age (14-16 and 17-19 years), maternal schooling (≤8 and >8 years of schooling) and family income (≤1, >1 to ≤2 and >2 minimum wages) were used.

Weight and height were obtained according to Cameron (1984) [18] and Jelliffe & Jelliffe (1989) [19]. To weigh the adolescents, we used a portable electronic scale (SECA®, model 803, Hamburg, Germany) with 100g accuracy. To verify stature, we used a stadiometer (SECA®, model Messband 206, Hamburg, Germany) with 0.1cm accuracy.

From these data, the Body Mass Index (BMI) was calculated and expressed in z-score according to the World Health Organization (WHO) [20]. For nutritional diagnosis, we considered low weight <Z-score -2; eutrophy between ≥Z-score -1 and ≤Z-score +1, overweight between >Z-score +1 and ≤Z-score +2; and obesity >Z-score +2.

Waist Circumference (WC) was obtained at the midpoint between the last rib and the iliac crest [21], with an inelastic tape measure (SECA®, model 201, Hamburg, Germany) with 0.1 cm accuracy. Weight, height and WC measurements were performed in triplicate and the average of these analyzes was used.

Lipid profile, blood glucose, and blood pressure

For biochemical analyses, 5mL of blood of adolescents were collected after a 12-hour fast. The material was packed in Vacuette® tubes without anticoagulant. High Density Lipoprotein-cholesterol (HDL-c), Triglyceride (TG), and blood glucose levels were determined by colorimetric enzymatic method (Modelo BioSystems 310, *Curitiba, Paraná*, Brazil) using Labtest® kits.

Blood pressure (BP) was measured according to the procedures of the 7th Brazilian Guideline of Arterial Hypertension [22], using a properly calibrated aneroid sphygmomanometer (Durashock Welch Allyn-Tycos®, model DS-44, New York, United States of America), and cuffs of appropriate size. The mean of two measurements was obtained: one initial measurement and the other after 5 minutes of rest [23]. If there was a difference greater than 5mmHg between Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) measurements, two additional measurements were performed and their mean value was considered [24].

Criteria of the International Diabetes Federation (IDF) were considered for the diagnosis of MS, performed according to the presence of altered WC (under 16 years of age: ≥90th percentile; ≥16 years of age: ≥90cm for men and ≥80cm for women) and two other alterations (blood glucose ≥100mg/dL; TG ≥150mg/dL; SBP ≥130mmHg or DBP ≥85mmHg; HDL-c <40mg/dL, for subjects <16 years of age, and HDL-c <40mg/dL for men or <50mg/dL for women, for subjects ≥16 years of age) [25,26].

Diet quality evaluation

Adolescent food intake was obtained through a 24-hour food recall (24hFR), using the multiple-step method [27]. A second 24hFR was performed in 40% of the population, after two months, for correction of intrapersonal variability [28]. To analyze calories, saturated fat, sodium, sugar, alcohol, and trans fats, we used the Nutrition Support Program - NutWin of the *Universidade Federal de São Paulo* (Federal University of *São Paulo*), version 1.6.0.7, and the Brazilian Food Composition Table [29]. Some foods/preparations that were not in NutWin were inserted.

The usual intake of nutrients and food groups was obtained through the Multiple Source Method, version 1.0.1 (Department of Epidemiology of the German Institute of Human Nutrition, Potsdam-Rehbrucke, Nuthetal, Brandenburg, Germany), aiming at eliminating intrapersonal variability [30].

For diet quality analysis, the Brazilian Healthy Eating Index-Revised (BHEI-R) was used [31], being a validated instrument [32] for evaluating compliance with nutritional recommendations. BHEI-R has 12 components: eight food groups and four nutrients and culinary ingredients, with scores ranging from zero to 5, 10 or 20 points. Minimum score is attributed to nonconsumption (components 1 to 9) or consumption above the recommended levels (components 10 to 12), and maximum score occurs when the recommended value is reached or exceeded. For intermediate intakes, scores were calculated proportionally to consumption. The total score ranges from 0 to 100 points. Chart 1 shows the BHEI-R components and their scores.

Thus, components 1 through 9 assess adequacy of intake. On the other hand, those 10 to 12 evaluate moderate consumption. In all cases higher scores indicate better quality (higher consumption for components 1 to 9 and lower consumption for items 10 to 12).

Statistical analysis

Statistical analysis was performed using the IBM®SPSS® for Windows®, version 22.0. Continuous variables were described by means, Standard Deviations (SD), and their respective 95% Confidence Intervals (95% CI). Total BHEI-R and its components were expressed as tertiles, with the exception of whole grains and meats, eggs and legumes in which a large proportion of individuals had zero or maximum scores, respectively. This prevented subsequent analysis.

The worst-quality diets were those of the first tercil of the BHEI-R. The same was considered for BHEI-R components, considering that for all of them, lower scores indicate poorer quality in relation to the food/nutrient. However, the third tertile included better diet quality (higher scores) and thus was used as reference in the statistical analysis.

Chart 1. Description of the components of the BHEI-R*.

Components	Minimum-Maximum Score	Criteria for minimum Score	Criteria for maximum Score
1 - Total fruit	0-5	No consumption	1.0 servings/1,000kcal
2 - Whole fruit[1]	0-5	No consumption	0.5 servings/1,000kcal
3 - Total vegetables[2]	0-5	No consumption	1.0 servings/1,000kcal
4 - Dark-green, orange and leguminous vegetables	0-5	No consumption	0.5 servings/1,000kcal
5 - Total cereals	0-5	No consumption	2.0 servings/1,000kcal
6 - Whole cereals	0-5	No consumption	1.0 servings/1,000kcal
7 - Milk and dairy products	0-10	No consumption	1.5 servings/1,000kcal
8 - Meat, eggs, and legumes	0-10	No consumption	1.0 servings/1,000kcal
9 - Oils[3]	0-10	No consumption	0.5 servings/1,000kcal
10 - Saturated fat	0-10	≥15% of TEI	≤7% of TEI
11 - Sodium	0-10	≥2,0g/1.000 kcal	≤0,75g/1.000 kcal
12 - SoFAAS	0-20	≥35% of TEI	≤10% of TEI
BHEI-R total	0-100		

Note: *Adapted from Previdelli *et al*. [31]. [1]Does not include juices; [2]Includes legumes only after the maximum score of meats has been reached; [3]Includes nonhydrogenated oils and fish, nut, and seed oils. BHEI-R: Brazilian Healthy Eating Index-Revised; TEI: Total Energy Intake; SoFAAS: Calories from Solid, trans, and Saturated Fats, Alcohol, and Added Sugar.

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Bivariate analysis was performed to verify the associations between diet quality, as well as its components, and MS and its factors. For this purpose, the Chi-Square Test, expressed in 2x2 tables, was used with a 95% CI. The variables that presented *p*-value <0.20 in the bivariate analysis were inserted in the multivariate model. To verify the association between dependent and explanatory variables, *Odds Ratio* (OR) adjusted for sex, age, and total income was calculated using binary logistic regression. The level of significance was set at *p*<0.05.

RESULTS

The sample consisted of 327 adolescents, since 21 participants did not complete all stages of the study because they did not respond completely to the questionnaire or were excluded by blood hemolysis. There was no exclusion of subjects due to implausibility in consumption after adjusting intrapersonal variability. Most of the adolescents were female, aged 14 to 16 years, had mothers with ≤8 years of schooling, family income ≤1 minimum wages, and eutrophy, considering body mass index/age. Students who were overweight and obese accounted for 16.8% of the sample. The prevalence of MS was 3.3% and the most frequent alteration was low High Density Lipoprotein-cholesterol (HDL-c) concentration (50.5%), as shown in Table 1.

Table 1. Sociodemographic, anthropometric, and MS-related characteristics of the participants. *Teresina* (PI), 2016.

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Variables	Participants	
	n	%
Sex		
Male	133	40.7
Female	194	59.3
Age (years)		
14 to 16	166	50.8
17 to19	161	49.2
Type of school		
Public	215	65.7
Private	112	34.3
Mother's schooling (years)		
≤8	199	60.9
>8	128	39.1
Family income (MW)		
≤1	136	41.6
>1 to ≤2	96	29.4
>2	95	29.0
Body Mass Index		
Low weight	8	2.5
Eutrophy	264	80.7
Overweight	41	12.5
Obesity	14	4.3
Metabolic Syndrome		
Presence	11	3.4
Absence	316	96.6

Table 1. Sociodemographic, anthropometric, and MS-related characteristics of the participants. *Teresina* (PI), 2016.

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Variables	Participants	
	n	%
WC (cm)		
Normal	288	88.1
Altered	39	11.9
TG (mg/dL)		
<150	313	95.7
≥150	14	4.3
HDL-c (mg/dL)		
<40 or M<40; F<50	165	50.5
≥40 or M≥40; F≥50	162	49.5
Blood Glucose (mg/dL)		
<100	266	81.4
≥100	61	18.6
SBP (mmHg)		
<130	310	94.8
≥130	17	5.2
DBP (mmHg)		
<85	298	91.1
≥85	29	8.9

Note: MW: Minimum Wage of the year 2016; TG: Triglycerides; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; MS: Metabolic Syndrome Diagnosed by International Diabetes Federation criteria.

Table 2. Adolescent diet quality assessed by BHEI-R. *Teresina* (PI), 2016.

BHEI-R components	Prevalence of minimum scores (%)	Prevalence of maximum scores (%)	Mean (points)	SD	95% CI
Total BHEI-R	0	0	55.43	6.99	54.66-56.19
Total fruits	0	10.70	2.53	1.48	2.37-2.69
Whole fruits[1]	0	14.37	1.65	1.71	1.46-1.84
Total vegetables[2]	0	0.30	2.53	0.88	2.44-2.63
Dark-green, orange, and leguminous vegetables	0.30	0.61	0.20	0.18	0.18-0.22
Total cereals	0	89.60	4.70	1.02	4.59-4.81
Whole cereals	98.16	0.30	0.06	0.49	0.01-0.11
Meat, eggs, and legumes	0	91.74	9.84	0.66	9.77-9.91
Milk and dairy products	0	0	2.82	1.37	2.67-2.97
Oils[3]	0	0	2.17	0.64	2.09-2.24
Saturated fat	0.30	14.06	7.03	2.18	6.79-7.27
Sodium	1.52	3.66	6.58	2.21	6.34-6.82
SoFAAS	0	4.28	14.43	3.12	14.09-14.77

Note: [1]Does not include juices; [2]Includes legumes only after the maximum score of meats has been reached; [3]Includes nonhydrogenated oils and fish, nut, and seed oils. BHEI-R: Brazilian Healthy Eating Index-Revised; SoFAAS calories from solid, trans, and saturated fats, alcohol, and added sugar; SD: Standard Deviation.

The mean score of the adolescents in BHEI-R was 55.4 points (95% CI: 54.7-56.2). Regarding the components of the index, the worst scores were obtained in whole cereals, dark-green and orange vegetables, oils, milk and dairy products, and whole fruits (Table 2). In contrast, total cereals, as well as meat, eggs, and legumes, had scores close to the stipulated maximum.

Table 3 presents the prevalence of adolescents in BHEI-R tertiles, in relation to MS and its components. The adjusted OR analysis (Table 4) showed that lower consumption of dark-green, orange, and leguminous vegetables (1st tertile) was significantly associated with low HDL-c concentration (OR: 2.00; CI: 1.13-3.54). On the other hand, the second tertile of this component was protective against increased blood glucose levels (OR: 0.39; CI: 0.18-0.83). The lower tertile scoring of milk and dairy products increased the chances of high TG (OR: 5.06; CI: 1.04-24.67) and of high BP levels (OR: 2.22; CI: 1.09-4.55).

Table 3. Prevalence of adolescents in diet quality tertiles according to MS components (IDF criteria). *Teresina* (PI), 2016.

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BHEI-R Components	Increased WC		Decrease HDL-c		Altered TG		Altered Blood Glucose		Increased BP		SM	
	n	%	n	%	n	%	n	%	n	%	n	%
Total BHEI-R												
3rd tertile	14	35.9	50	30.3	6	42.8	17	27.9	12	32.4	4	36.4
2nd tertile	11	28.2	57	34.5	3	21.5	18	29.5	12	32.4	3	27.2
1st tertile	14	35.9	58	35.2	5	35.7	26	42.6	13	35.2	4	36.4
Total fruits												
3rd tertile	9	23.1	51	30.9	4	28.6	16	26.2	7	18.9	3	27.2
2nd tertile	13	33.3	53	32.2	6	42.8	20	32.8	8	21.6	3	27.2
1st tertile	17	43.6	61	36.9	4	28.6	25	41.0	22	59.5	5	45.5
Whole fruits												
3rd tertile	13	33.3	55	33.3	7	50.0	15	24.6	11	29.7	5	45.5
2nd tertile	12	30.8	52	31.5	5	35.7	23	37.7	16	43.3	3	27.2
1st tertile	14	35.9	58	35.2	2	14.3	23	37.7	10	27.0	3	27.2
Total vegetables												
3rd tertile	12	30.8	61	36.9	4	28.6	20	32.8	12	32.4	5	45.5
2nd tertile	18	46.1	53	32.2	7	50.0	14	22.9	12	32.4	4	36.4
1st tertile	9	23.1	51	30.9	3	21.5	27	44.3	13	35.2	2	18.1
Dark-green, orange, and leguminous vegetables												
3rd tertile	7	18.0	53	32.2	3	21.5	12	19.7	12	32.4	4	36.4
2nd tertile	21	53.8	69	41.8	7	50.0	30	49.2	14	37.9	6	54.5
1st tertile	11	28.2	43	26.0	4	28.6	19	31.2	11	29.7	1	9.1
Milk and dairy products												
3rd tertile	15	38.4	51	30.9	9	64.2	29	47.5	13	35.2	5	45.5
2nd tertile	10	25.7	62	37.6	3	21.5	13	21.3	9	24.3	3	27.2
1st tertile	14	35.9	52	31.5	2	14.3	19	31.2	15	40.5	3	27.2

Table 3. Prevalence of adolescents in diet quality tertiles according to MS components (IDF criteria). *Teresina* (PI), 2016.

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BHEI-R Components	Increased WC		Decrease HDL-c		Altered TG		Altered Blood Glucose		Increased BP		SM	
	n	%	n	%	n	%	n	%	n	%	n	%
Oils												
3rd tertile	16	41.0	54	32.7	8	57.1	16	26.2	12	32.4	5	45.5
2nd tertile	14	35.9	57	34.5	4	28.6	23	37.7	12	32.4	4	36.4
1st tertile	9	23.1	54	32.7	2	14.3	22	36.1	13	35.2	2	18.1
Saturated fat												
3rd tertile	11	28.2	51	30.9	3	21.5	19	31.2	14	37.9	2	18.1
2nd tertile	14	35.9	51	30.9	6	42.8	18	29.5	9	24.3	4	36.4
1st tertile	14	35.9	63	38.2	5	35.7	24	39.3	14	37.9	5	45.5
SoFAAS												
3rd tertile	10	25.7	51	30.9	4	28.6	17	27.9	12	32.4	3	27.2
2nd tertile	12	30.8	52	31.5	4	28.6	19	31.2	11	29.7	2	18.1
1st tertile	17	43.6	62	37.6	6	42.8	25	41.0	14	37.9	6	54.5

Note: IDF: International Diabetes Federation; BHEI-R: Brazilian Healthy Eating Index-Revised; WC: Waist Circumference; HDL-c: High Density Lipoprotein; TG: Triglycerides; BP: Blood Pressure; MS: Metabolic Syndrome; SoFAAS Calories from Solid, Trans, and Saturated Fats, Alcohol, and Added Sugar.

Table 4. Risk analysis (odds ratio) for adolescent diet quality according to MS components, following IDF criteria. *Teresina* (PI), 2016.

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BHEI-R Components	Increased WC	Decrease HDL-c	Altered TG	Altered Blood Glucose	Increased BP	SM
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (IC95%)	OR (IC95%)
Total BHEI-R						
3rd tertile	1	1	1	1	1	1
2nd tertile	1.33 (0.57-3.11)	0.78 (0.46-1.34)	2.06 (0.49-8.52)	1.09 (0.52-2.20)	0.95 (0.39-2.28)	1.33 (0.29-6.12)
1st tertile	0.94 (0.42-2.12)	0.80 (0.46-1.40)	1.11 (0.32-3.88)	0.62 (0.31-1.25)	0.92 (0.38-2.22)	0.95 (0.22-4.03)
Total fruits						
3rd tertile	1	1	1	1	1	1
2nd tertile	0.74 (0.30-1.83)	1.19 (0.68-2.09)	0.72 (0.19-2.67)	0.93 (0.44-1.94)	1.05 (0.36-3.11)	1.16 (0.22-5.97)
1st tertile	0.52 (0.21-1.26)	1.06 (0.61-1.85)	0.85 (0.19-3.69)	0.98 (0.47-2.04)	0.47 (0.18-1.19)	0.69 (0.15-3.09)
Whole fruits						
3rd tertile	1	1	1	1	1	1
2nd tertile	1.04 (0.45-2.40)	1.04 (0.59-1.81)	1.38 (0.42- 4.53)	0.65 (0.31-1.36)	0.71 (0.30-1.69)	1.71 (0.39-7.46)
1st tertile	0.84 (0.36-1.93)	0.82 (0.47-1.42)	4.67 (0.90-24.22)	0.76 (0.36-1.61)	1.49 (0.58-3.81)	1.51 (0.33-6.79)

Table 4. Risk analysis (odds ratio) for adolescent diet quality according to MS components, following IDF criteria. *Teresina* (PI), 2016.
2 of 2

BHEI-R Components	Increased WC	Decrease HDL-c	Altered TG	Altered Blood Glucose	Increased BP	SM
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (IC95%)	OR (IC95%)
Total vegetables						
3rd tertile	1	1	1	1	1	1
2nd tertile	0.67 (0.30-1.49)	0.62 (0.37-1.05)	0.59 (0.17-2.12)	1.69 (0.80-3.59)	1.02 (0.43-2.41)	1.30 (0.34-5.03)
1st tertile	1.16 (0.46-2.95)	1.12 (0.64-1.98)	1.01 (0.21-4.76)	0.50 (0.25-1.00)	0.69 (0.29-1.65)	2.28 (0.42–12.22)
Dark-green, orange, and leguminous vegetables						
3rd tertile	1	1	1	1	1	1
2nd tertile	0.42 (0.17-1.04)	1.17 (0.67-2.04)	0.48 (0.12-1.93)	**0.39 (0.18-0.83)**	1.08 (0.46-2.57)	1.00 (0.27-3.76)
1st tertile	0.67 (0.24-1.84)	**2.00 (1.13-3.54)**	0.79 (0.17-3.72)	0.69 (0.31-1.55)	1.35 (0.55-3.30)	4.86 (0.52-42.27)
Milk and dairy products						
3rd tertile	1	1	1	1	1	1
2nd tertile	1.58 (0.67-3.76)	0.66 (0.38-1.13)	3.05 (0.79-11.71)	**2.73 (1.31-5.67)**	1.87 (0.73-4.78)	1.89 (0.43-8.17)
1st tertile	1.19 (0.53-2.66)	1.05 (0.60-1.82)	**5.06 (1.04-24.67)**	1.06 (0.46-2.45)	**2.22 (1.09-4.55)**	2.07 (0.47-9.13)
Oils						
3rd tertile	1	1	1	1	1	1
2nd tertile	1.33 (0.59-2.97)	1.11 (0.63-1.93)	2.48 (0.69-8.89)	1.03 (0.49-2.18)	1.79 (0.72-4.49)	1.53 (0.38-6.12)
1st tertile	2.09 (0.84-5.21)	1.13 (0.63-2.03)	5.07 (0.97-26.48)	1.13 (0.52-2.45)	1.67 (0.65-4.28)	2.55 (0.42-15.44)
Saturated fat						
3rd tertile	1	1	1	1	1	1
2nd tertile	0.74 (0.31-1.75)	0.76 (0.44-1.32)	0.47 (0.11-1.98)	0.76 (0.36-1.59)	1.15 (0.46-2.89)	0.46 (0.08-2.71)
1st tertile	0.72 (0.30-1.69)	0.71 (0.41-1.23)	0.43 (0.09-1.92)	0.54 (0.26-1.12)	0.63 (0.26-1.51)	0.34 (0.06-1.91)
SoFAAS						
3rd tertile	1	1	1	1	1	1
2nd tertile	1.19 (0.49-2.91)	1.03 (0.60-1.77)	0.95 (0.23-3.94)	1.22 (0.58-2.55)	0.95 (0.38-2.31)	0.63 (0.10-3.97)
1st tertile	1.68 (0.71-3.92)	1.39 (0.80-2.41)	1.70 (0.45-6.41)	1.91 (0.93-3.90)	1.53 (0.64-3.66)	1.90 (0.45-8.02)

Note: p<0.05 in bold. IDF: International Diabetes Federation; BHEI-R: Brazilian Healthy Eating Index-Revised; WC: Waist Circumference; HDL-c: High Density Lipoprotein; TG: Triglycerides; BP: Blood Pressure; MS: Metabolic Syndrome; SoFAAS Calories from Solid, Trans, and Saturated fats, Alcohol, and Added Sugar; OR: *Odds Ratio*; 95% CI: 95% Confidence Interval. Adjustment variables: sex, age, and total income.

DISCUSSION

The prevalence of MS in the present study was low and similar to that observed in Brazilian adolescents by ERICA (2.6%). Both studies used IDF parameters [7]. Reuter *et al.* (2018) [33] also obtained a low prevalence of MS in adolescents from *Rio Grande do Sul* State, by the criteria of Cook *et al*. [34] (1.9%) and IDF (2.1%). In *Piauí*, studies with adolescents from private schools demonstrated MS prevalence values close to those of this research, making up more than 3% of the sample, also considering the criteria of Cook *et al*. [34] and IDF [35]. The fact that MS is detected at early ages is a concern regardless of the prevalence verified.

Despite the small number of adolescents diagnosed with the syndrome in this research, there was a significant prevalence of alterations in its components, especially HDL-c, as demonstrated by other authors [7,34,36-38]. Atherogenesis begins in childhood, and low HDL-c concentration plays an important role in this process, especially with increased TG levels. This combination is associated to Low Density Lipoprotein-cholesterol (LDL-c) with greater atherogenic effect [39,40].

Regarding nutritional status, the prevalence of obesity was lower than that of ERICA (8.4%) [15], indicating a better anthropometric profile of adolescents in this study. On the other hand, this prevalence was close to the one verified in the 2008-2009 Household Budget Survey (*Pesquisa de Orçamentos Familiares* - POF) (4.9%) [41]. Furthermore, it is necessary to consider the percentage of overweight (12.5%), which at early ages also increases the risk of CVD and decreases quality of life. If there is no intervention, these negative effects may persist in adulthood, increasing morbidity, mortality, and costs to society by the increase in health spending [42].

Regarding BHEI-R, other studies also found low consumption of whole cereals, dark-green and orange vegetables, milk and dairy products, and whole fruits by adolescents [10,12,43], which reflected lower scores. Whole cereals and dark-green and orange vegetables had the two worst scores among the components. The 2008-2009 POF [41] pointed to low consumption of salads and vegetables by adolescents. Fruits and vegetables are among the main sources of dietary fiber for Brazilians; therefore, their adequate intake is essential, along with adequate intake of whole cereals, since fiber intake in Brazil falls short of recommendations [44].

In contrast to this study, Previdelli *et al.* [10] verified high scores for oils, probably because they considered frying oils, unlike the present research. It is noteworthy that the oil component aims to capture good sources of the food. As for milk and dairy products, low consumption by adolescents can occur due to the omission of breakfast, in which dairy products are common. In ERICA, a considerable percentage of adolescents reported never consuming breakfast (21.9%) [45].

There is a shortage of studies on diet quality of Brazilian adolescents by BHEI-R. Among these, Wendap *et al*. [43] obtained a mean BHEI-R score higher than that of this research (75.1 points), while Previdelli *et al*. [10] found a lower mean (47.1 points). In a population-based study, the mean BHEI-R of adolescents was closer to that of this research (52.4 points) [46]. Considering the maximum BHEI-R score of 100 points, the diet quality of the respondents was unsatisfactory.

In this study, one of the main results in the logistic regression analysis was that the 1st tertile of scoring of the component dark-green and orange vegetables, that is, the lower consumption of these low Glycemic Index (GI) foods, was associated with decreased HDL-c. In adults, Fontanelli *et al.* [47] found a positive association between Glycemic Index (GI) and Glycemic Load (GL) and low HDL-c concentration, which may occur via mechanisms related to hyperinsulinemia. The adolescents studied had high intake of total carbohydrates and low scores in whole cereals, with possible implications in the GL of meals.

Furthermore, the second tertile of scoring of the aforementioned component was protective against high blood glucose levels. The soluble fibers of salads, fruits, and vegetables have numerous benefits, providing better blood glucose levels and lower incidence of T2DM [48,49]. Moreover, dark-green and orange vegetables are sources of β-carotene, an important antioxidant (pro-vitamin A) [50]. The low consumption of antioxidant micronutrients is associated with lipid alterations and cardiometabolic risk in adolescents [51], being another indication for the insertion of dark-green and orange vegetables in the diet of adolescents, aiming to prevent MS.

In view of these associations, ingestion (especially of dark-green and orange vegetables) should be encouraged for early prevention of metabolic alterations. However, there are no specific recommendations regarding these vegetables in the 2006 and 2011 food guidelines of the Ministry of Health [52,53].

As for the lowest tertile of scores of milk and dairy products as a risk factor for high TG and BP, evidence demonstrates that dairy products may be beneficial in reducing serum lipids and improving insulin sensitivity, especially whey protein. Calcium from these foods promotes lipid oxidation and increased fecal fat excretion, and its peptides are associated with BP reduction. The dietary matrix of milk and dairy products (saturated fatty acids and minerals such as calcium, potassium, and magnesium) appears to decrease metabolic risk; however, the effects on MS are indeed controversial [48,54,55]. On the other hand, the second tertile of the group of milk and dairy products increased the risk of high blood glucose levels.

When studying the influence of the *Dietary Approaches to Stop Hypertension* (DASH) dietary pattern on the incidence of MS in children and adolescents, Asghari *et al*. [56] demonstrated that participants with better adherence to the DASH pattern had lower SBP and TG. The higher calcium intake provided by the DASH diet was one of the factors that influenced these positive effects [56].

Research with Brazilian adolescents [38,57] demonstrated an association between low intake of fruits and vegetables and MS. In the present study, the poor quality of diet and its components was not associated with MS, possibly due to the low prevalence of this event in the study population. However, important associations between BHEI-R aspects and MS components were determined mainly in relation to dark-green and orange vegetables and milk and dairy products.

Some BHEI-R components were not categorized into tertiles, due to the large proportion of individuals with maximum score (meat, eggs and legumes, and total cereals) or zero score (whole cereals). In these circumstances, OR analyses could not be performed; however, the condition of low intake of whole cereals by the adolescents studied is of concern.

One of the limitations of this study is the cross-sectional design, in which caution should be exercised in assessing causality. In addition, there are inherent limitations to the use of 24hFR, such as under-reporting or over-reporting of food intake, quantification problems, and memory errors. There is also a great variance in the intake of some nutrients among adolescents; however, to overcome these difficulties, intrapersonal variability was adjusted.

Considering the risk/protection factors for alterations in MS components, it is important to highlight the importance of intersectoral actions to improve adolescent eating behaviors, aiming at the primary prevention of cardiovascular and metabolic disorders. Moreover, this research may support future studies to better elucidate the role of the eating pattern in the etiology of MS components in adolescents.

CONCLUSION

There was a low prevalence of MS in contrast to a considerable prevalence of altered HDL-c. Adolescents had worse scores on whole cereals, dark-green and orange vegetables, oils, milk, and whole fruits; while higher scores were observed for total cereals, meat, eggs, and legumes. The lower consumption of dark-green and orange vegetables increased the risk of low HDL-c concentration. Lower scores in the group of milk and dairy products resulted in risk for high TG and BP.

CONTRIBUTORS

LCRS LUSTOSA participated in the collection of research data, statistical analysis, interpretation of the results and wrote the article. LM NASCIMENTO participated in the conception of the study, of the statistical analysis and interpretation of the results. LCC LAVÔR participated in the collection of data from research, analysis and interpretation of results. KRO GOMES and MDM MASCARENHAS participated in the study design, review, and approval of the article. KMG FROTA participated in the design of the study, statistical analysis, interpretation of results, revised and approved the final version of the article.

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