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ANTHROPOMETRIC, METABOLIC AND HEMODYNAMIC INDICATORS AS PREDICTORS OF METABOLIC SYNDROME IN ADOLESCENTS

Indicadores antropométricos, metabólicos e hemodinâmicos como preditores da síndrome metabólica em adolescentes

Indicadores antropométricos, metabólicos y hemodinámicos como predictores del Síndrome metabólico en adolescentes

Thais Norberta Bezerra de Moura (OrcID)
Maranhão State Health Force (Força Estadual de Saúde do Maranhão - FESMA) - São Francisco do Maranhão (MA) - Brazil

Jéssica Denise Vieira Leal (OrcID)
Federal University of Piauí (Universidade Federal do Piauí - UFPI) - Picos (PI) - Brazil

Gisely Silva Sousa (OrcID)
Federal University of Piauí (Universidade Federal do Piauí - UFPI) - Picos (PI) - Brazil

Regianne Kellyne Carneiro de Sousa (OrcID)
Federal University of Piauí (Universidade Federal do Piauí - UFPI) - Picos (PI) - Brazil

Edina Araújo Rodrigues Oliveira (OrcID)
Federal University of Piauí (Universidade Federal do Piauí - UFPI) - Picos (PI) - Brazil

Luisa Helena de Oliveira Lima (OrcID)
Federal University of Piauí (Universidade Federal do Piauí - UFPI) - Picos (PI) - Brazil

ABSTRACT

Objective: To predict metabolic syndrome in adolescents using anthropometric, metabolic and hemodynamic indicators based on analysis of sensitivity and specificity. **Methods:** Cross-sectional study carried out from July 2015 to March 2016 with 186 adolescents from eight private schools in the municipality of Picos, Piauí, Brazil. The data were individually collected using a form adapted with information on anthropometric, metabolic and blood pressure measures in a room reserved for such within the premises of the schools. After a 12-hour overnight fast, venous blood was collected for further biochemical analysis. The T-test was used for comparison of means in independent samples with significance level of $p < 0.05$. Cut-off scores were selected based on the receiver operating characteristic (ROC) curves using the values with sensitivity and specificity closest to each other and not below 60%. **Results:** There was a predominance of women (61.8%; n= 114), age between 15 and 19 years (57.5%; n=106) and syndrome in 2.7% (n=5) of the sample. When the area under the curve (AUC) was analyzed, conicity index (AUC=0.83), high-density lipoprotein (AUC= 0.88), systolic blood pressure (AUC=0.86) and mean arterial pressure (AUC=0.84) were found to be significant predictors of the syndrome in the total sample. **Conclusion:** The indicators analyzed proved to be predictors of metabolic syndrome, particularly conicity index, high-density lipoprotein, systolic blood pressure and mean arterial pressure.

Descriptors: Metabolic Syndrome; Anthropometry; Adolescent; Dyslipidemia; Blood Pressure; Abdominal Obesity.

RESUMO

Objetivo: *Predizer a síndrome metabólica em adolescentes a partir de indicadores antropométricos, metabólicos e hemodinâmicos por análise de sensibilidade e especificidade.* ***Métodos:*** *Estudo transversal, realizado entre julho de 2015 e março de 2016, com 186 adolescentes de oito escolas particulares do município de Picos, Piauí, Brasil. Coletaram-se os dados por meio de um formulário adaptado com informações sobre medidas antropométricas, metabólicas e pressão arterial nas dependências das escolas de forma individual em sala reservada para tal. Após um jejum noturno de 12 horas, realizou-se uma coleta de sangue venoso para posterior análise bioquímica. Utilizou-se o teste T para amostras independentes para comparação de médias dos*

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indicadores com nível de significância de p < 0,05. Para seleção dos pontos de corte, adotaram-se as curvas receiver operating characteristic (ROC), utilizando-se os valores com sensibilidade e especificidade mais próximos entre si e não inferiores a 60%. ***Resultados:*** *Houve prevalência do sexo feminino (61,8%; n= 114), idade entre 15 a 19 anos (57,5%; n=106) e da síndrome em 2,7% (n=5) da amostra. Quando analisada a área sob a curva (AUC) ROC, encontraram-se como preditores significativos da síndrome na amostra total o índice de conicidade (AUC = 0,83), a lipoproteína de alta densidade (AUC = 0,88), a pressão arterial sistólica (AUC = 0,86) e a pressão arterial média (AUC = 0,84).* ***Conclusão:*** *Os indicadores investigados demonstraram-se preditores da síndrome metabólica, merecendo destaque o índice de conicidade, a lipoproteína de alta densidade, a pressão arterial sistólica e a pressão arterial média.*

Descritores: *Síndrome Metabólica; Antropometria; Adolescente; Dislipidemias; Pressão Arterial; Obesidade Abdominal.*

RESUMEN

Objetivo: *Predecir el síndrome metabólico en adolescentes a partir de los indicadores antropométricos, metabólicos y hemodinámicos por el análisis de sensibilidad y especificidad.* ***Métodos:*** *Estudio transversal realizado entre julio de 2015 y marzo de 2016 con 186 adolescentes de ocho escuelas privadas del municipio de Picos, Piauí, Brasil. Se recogieron los datos a través de un formulario adaptado con informaciones sobre las medidas antropométricas, metabólicas y presión arterial en las escuelas de manera individual en clase reservada para ello. Después de un ayuno nocturno de 12 horas se realizó una colecta de sangre venosa para posterior análisis bioquímico. Se utilizó el test T para muestras independientes para la comparación de medias de los indicadores con el nivel de significación de p < 0,05. Para la elección de los puntos de corte, se adoptaron las curvas receiver operating characteristic (ROC), utilizándose los valores con sensibilidad y especificidad más cercanos entre si y no inferiores al 60%.* ***Resultados:*** *Hubo prevalencia para el sexo femenino (61,8%; n= 114), edad entre 15 y 19 años (57,5%; n=106) y del síndrome en el 2,7% (n=5) de la muestra. Se han encontrado como predictores significativos para el síndrome en la muestra total el índice de conicidad (AUC = 0,83), la lipoproteina de baja densidad (AUC = 0,88), la presión arterial sistólica (AUC = 0,86) y la presión arterial media (AUC = 0,84) a partir del análisis del área bajo la curva (AUC) ROC.* ***Conclusión:*** *Los indicadores investigados se han demostrado predictores del síndrome metabólico con especial importancia para el índice de conicidad, la lipoproteina de alta densidad, la presión arterial sistólica y la presión arterial media.*

Descriptores: *Síndrome Metabólico; Antropometría; Adolescente; Dislipidemias; Presión Arterial; Obesidad Abdominal.*

INTRODUCTION

Adolescence is the period of life in between childhood and adulthood. In this period, the individual experiences a growth spurt for weight and height, the development of secondary sex characteristics, menarche marking the beginning of the reproductive cycle in women, and complex transformations in the process of cognitive development that will influence the discovery of new intrapersonal, interpersonal and environmental relationships[1].

This period is critical for the development of personal skills and the acquisition of decision-making skills. Therefore, it is important to develop strategies targeted at the health of adolescents with a focus on reducing preventable diseases and strengthening ties in order to develop their autonomy to maintain health and quality of life[1].

The metabolic syndrome (MS) is an aggregation of cardiometabolic problems and is considered a complex disorder represented by a set of cardiovascular risk factors usually related to fat deposition and insulin resistance[2].

The syndrome implies an association of risk factors capable of predisposing the individual to the development of cardiovascular diseases and type 2 diabetes mellitus, thus representing a serious public health problem nowadays, with a significant impact on morbidity and mortality of the population[3] and accounting for 7% of global deaths[4].

The risk factors for the syndrome are the aggregation of excess weight or central adiposity, hypertension, high triglyceride levels, low HDL (High Density Lipoprotein) and glucose intolerance[5]. Its prevalence rate in Brazil is 2.6% in adolescents and its mainly caused by physical inactivity and inadequate diet, thus demonstrating the need for interventions to improve such situation and tackle this public health problem in adolescence[6].

Considering that the early onset of MS components increases the risks of disease in adult life, the identification of simple and low cost noninvasive anthropometric measurement methods that correlate with these factors in healthy adolescents is of great use for the prevention of noncommunicable diseases in current and future life[7].

Thus, there is a need to explore health promotion strategies to broaden the health-disease process horizon. The dissemination of information and knowledge leads the human being to a critical reflection on reality, thus favoring the experience of healthy attitudes and behaviors that can guarantee the optimization of self-care actions[8].

Given that, the objective of this study was to predict metabolic syndrome in adolescents using anthropometric, metabolic and hemodynamic indicators based on analysis of sensitivity and specificity.

METHODS

A cross-sectional study was carried out between July 2015 and March 2016 with 186 adolescents from eight private schools in the city of Picos, Piauí. Picos is a city in South Central Piauí, which is located 321 km away from the capital, Teresina. The city had an estimated population of 78,002 people in 2018, with a land area of 577,304 km²[9].

The study sample was obtained from a sample calculation using the formula for cross-sectional studies with finite population, which involves: sample size, confidence coefficient, population size, absolute sampling error, complementary percentage and proportion of occurrence of the phenomenon under study[10].

Parameters were 95% confidence coefficient (1.96), sampling error of 3%, population of 2250 adolescents (10 to 19 years old) (N=2250) regularly enrolled in urban schools, and MS prevalence rate of 5% (p=0.05)[11].

The sample was randomly selected by means of a random sampling software (True Random Generator®) in which all adolescents had the same chance of being selected as long as they met the inclusion criteria (age between 10 and 19 years and regular enrollment and attendance to classes) and exclusion criteria (previous cardiopathy, adopted children, failure to fast for 12 hours).

The adolescents were selected with a probability proportional to the number of students enrolled in each participating school. The study was carried out in private schools because previous research has shown[12] that cardiometabolic risk factors (excess body weight and sedentary lifestyle) are even more pronounced among adolescents of high socioeconomic status. Therefore, health promotion and disease prevention actions and early detection of these changes should be targeted at this population group.

Data were individually collected on school premises in a room reserved for that purpose on a single day. Blood samples were not collected on the same day as it required previous fasting.

This study included anthropometric indicators (body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHtR), conicity index (CI) and neck circumference (NC), metabolic indicators (triglycerides (TG), total cholesterol (TC), Low Density Lipoproteins (LDL)-cholesterol, High Density Lipoproteins (HDL)-cholesterol, insulin and homeostatic model assessment (HOMA)) and hemodynamic indicators (systolic, diastolic and mean arterial pressure).

Weight and height were measured using a G-Tec® scale with digital display and a Seca® stadiometer, respectively. BMI was calculated using the formula: peso (kilogram-Kg) / height^2 (meter-m). WC and NC were measured using an inelastic flexible measuring tape of 150 centimeters (cm) accurate to one decimal place. WC was measured with the individual standing upright on a flat and smooth surface with abdomen relaxed, arms along the body and feet together. The measuring tape was placed around the narrowest part of the trunk between the last rib and the iliac crest. NC was measured at mid-neck height[13]. Measurements were performed three times and the arithmetic mean of the values obtained was used in the study. WHtR was measured as the quotient of WC (cm) divided by height (cm)[14]. The conicity index (CI)[15] was calculated using an equation that involves: waist circumference, body weight and height.

Blood pressure was measured using the classic auscultatory method and an instrument tested for the study. Blood pressure measurement followed the procedures recommended by the VII Brazilian Guidelines on Hypertension (2016)[16]. Appropriately sized cuffs were used for children and adolescents and we developed a protocol to measure blood pressure which considered the means of two measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP) measured in the adolescent after 5 minutes of rest. If the difference between the first and second measurements of the SBP or DBP was greater than 5 millimeters of mercury (mmHg), a third measurement was taken and the mean between the second and third measurements was calculated[17]. Mean arterial pressure (MAP) was also calculated as it represents SBP and DBP in a single variable based on the following formula: MAP = [(SBP-DBP/3) + DBP][18].

Venous blood was collected on school premises for further biochemical analysis after a 12-hour overnight fast. The samples were stored into vacuum tubes with separator gel and without anticoagulants[19]. TG and blood glucose were measured by enzymatic colorimetric kit processed in Autohumalyzer A5 (Human-2004)[19]. Insulin was measured using an Automated Chemiluminescence System ACS-180 (Ciba-Corning Diagnostic Corp. 1995, USA)[20].

The diagnosis of MS in the study sample was confirmed based on the occurrence of three or more of the following criteria: obesity (WC ≥ 90th percentile for sex and age), dyslipidemia (TG > 130 mg/dl, HDL-cholesterol < 40 mg/dl), high blood pressure (blood pressure ≥ 90th percentile for sex, age and height) and impaired fasting glucose (glucose ≥ 110 mg/dl)(21).

The analyses were categorized by age group and sex. Age group was divided into early adolescence (10 to 14 years of age) and late adolescence (15 to 19 years of age)(22), and sex was divided into men and women.

Initially, the independent samples t-test was used to compare the means of the indicators among adolescents with and without MS, with a significance level set at p<0.05. All the indicators that presented a significant relationship (p<0.05) were selected.

In order to select cut-off points, the analysis was performed using the receiver operating characteristic (ROC) curves technique(23). The values with sensitivity and specificity closest to each other and not below 60% were used(23). The statistical significance of each analysis was checked using the area under the ROC curve (AUC) and a 95% confidence interval (95%CI). In this study, the indicator was considered a good predictor when it presented an area under the ROC curve greater than 0.50. The statistical analysis of the data was performed using the Statistical Package for the Social Sciences (SPSS) version 20.0.

Parents/legal guardians gave written informed consent authorizing the participation of the adolescents. In addition, adolescents also gave written informed consent. The results of the tests were given to the adolescents with written guidelines on the implementation of healthy life habits were provided. The adolescents who presented changes in the parameters analyzed were referred to the primary health care center that covers the region where they live. The research project was approved by the Research Ethics Committee of the Federal University of Piauí (*Universidade Federal do Piauí*) under Approval No. 353.372.

RESULTS

The study was carried out with adolescents from the Piauí semi-arid region. There was predominance of women (61.8%, n=114) and individuals aged 15 to 19 years (57.5%, n=106). MS was found in 2.7% (n=5) of the sample as depicted in Table I.

Table I - Characterization of adolescents aged 10 to 19 years in private schools. Picos, Piauí, Brazil, 2015.

Variables	n	%
Sex		
Men	71	38.2
Women	115	61.8
Age (in years)		
10-14	79	42.5
15-19	107	57.5
Metabolic syndrome		
Yes	5	2.7
No	181	97.3

n: Absolute number; %: Percentage

The results regarding MS and the anthropometric, metabolic and hemodynamic indicators of adolescents are shown in Table II. WC, TC, HDL-cholesterol, insulin, HOMA index, SBP and MAP were found to be significantly correlated with the presence of MS.

The areas under the ROC curve and their respective CI related to the anthropometric, metabolic and hemodynamic indicators of MS are described in Table III.

Regarding the total sample, BMI, WC, WHtR, TC, LDL, insulin and HOMA index did not demonstrate a significant discriminatory power to detect MS (LL-CI < 0.50). On the other hand, the analysis of the area under the ROC curve showed that the anthropometric indicator CI proved to be a significant predictor of MS (AUC = 0.83). In addition, the metabolic indicator HDL (AUC = 0.88) and the hemodynamic indicators SBP (AUC = 0.86) and MAP (AUC = 0.84) were found to have significant discriminatory power to predict MS (LL-CI ≥ 0.50).

The results regarding MS and the anthropometric, metabolic and hemodynamic indicators of adolescents are shown in Table II. WC, TC, HDL-cholesterol, insulin, HOMA index, SBP and MAP were found to be significantly correlated with the presence of MS.

Table II - Metabolic syndrome and anthropometric, metabolic and hemodynamic indicators in adolescents in private schools. Picos, Piauí, Brazil, 2015.

Indicators	Metabolic syndrome			
	Total sample	Yes	No	p-value*
Anthropometric, mean (standard deviation)				
BMI†	20.94 (3.52)	23.95 (7.30)	20.86 (3.36)	0.399
Waist circumference	69.66 (10.02)	79.88 (12.99)	69.38 (9.82)	0.021‡
Waist-to-height ratio	0.43 (0.06)	0.47 (0.07)	0.43 (0.05)	0.099
Conicity index	11.02 (1.14)	11.67 (0.16)	11.00 (1.15)	0.198
Neck circumference	31.40 (4.42)	31.00 (11.54)	31.41 (4.13)	0.939
Metabolic, mean (standard deviation)				
Triglycerides	82.37 (44.88)	95.38 (38.63)	82.01 (45.08)	0.513
Glucose	72.49 (9.93)	76.44 (23.99)	72.38 (9.39)	0.725
Total cholesterol	154.02 (30.16)	123.06 (20.84)	154.87 (29.96)	0.020‡
HDL§	48.25 (8.53)	37.62 (3.15)	48.54 (8.44)	0.004‡
LDL‖	89.18 (27.28)	66.36 (17.39)	89.81 (27.27)	0.058
Insulin	16.04 (15.19)	36.56 (36.32)	15.47 (13.99)	0.002‡
HOMA¶	2.84 (3.01)	8.28 (10.65)	2.69 (2.44)	0.001**
Hemodynamic, mean (standard deviation)				
Systolic blood pressure	108.51 (10.65)	124.60 (11.48)	108.07 (10.30)	0.001**
DBP††	69.93 (8.77)	76.40 (10.04)	69.75 (8.69)	0.095
Mean arterial pressure	82.79 (8.12)	92.46 (5.63)	82.52 (8.02)	0.007‡‡

*p-value; †BMI: Body mass index; ‡Student t-test; §HDL: High Density Lipoprotein; ‖LDL: Low Density Lipoprotein; ¶HOMA: Homeostatic model assessment; **$p \leq 0.001$; ††DBP: Diastolic blood pressure; ‡‡$p < 0.05$

Table III - Area under the ROC* curve and 95%CI† for anthropometric, metabolic and hemodynamic indicators and MS in the sample. Picos, Piauí, Brazil, 2015.

Metabolic syndrome	Area under the ROC* curve (95%CI)† total sample
Anthropometric	
BMI‡	-
Waist circumference	0.73 (0.43-1.00)
Waist-to-height ratio	-
Conicity index	0.83 (0.76-0.90)§
Metabolic	
Total cholesterol	0.18 (0.15-0.35)
LDL‖	0.22 (0.06-0.39)
HDL¶	0.88 (0.82-0.94)§
Insulin	0.69 (0.44-0.94)
HOMA**	0.66 (0.40-0.92)
Hemodynamic	
Systolic blood pressure	0.86 (0.70-1.00)§
Diastolic blood pressure	-
Mean arterial pressure	0.84 (0.74-0.95)

*ROC: Receiver Operating Characteristic; †95%CI: 95% confidence interval; ‡BMI: Body mass index; §: Area under the ROC curve showing discriminatory power to detect metabolic syndrome (LL-CI ≥ 0.50); ‖LDL: Low Density Lipoprotein; ¶HDL: High Density Lipoprotein; **HOMA: Homeostatic model assessment; %:Percentage

Among male adolescents aged 10 to 14 years, only MAP (AUC = 0.81; CI=0.74-0.95) was a good predictor of MS. Among students aged 15 to 19 years, SBP (AUC = 0.96, CI=0.90-1.00) and MAP (AUC = 0.96, CI=0.90-1.00) had a significant discriminatory power to predict MS (AUC and LL-CI ≥ 0.50).

The points with the highest sensitivity and specificity in the total sample were: 11.56 cm for CI, 39.05 mg/dl for HDL, 121.5 mmHg for SBP and 89.0 mmHg for MAP. The cut-off points for female adolescents aged 15 to 19 years were: 27.10 kg/m^2 for BMI, 0.53 cm for WHtR and 124 mmHg for SBP (Table IV).

As shown in Table V, cut-off points for MAP was 89.0 mmHg among male adolescents aged 10 to 14 years and 94.66 mmHg among male adolescents aged 15 to 19 years.

Table IV - Cut-off points, sensitivity and specificity of anthropometric, metabolic and hemodynamic indicators to predict metabolic syndrome (MS) in the sample. Picos, Piauí, Brazil, 2015.

MS	CP- total sample	S (%) total sample	Sp (%) total sample	CP- 15 to 19 years	S (%) 15 to 19 years	Sp (%) 15 to 19 years
Anthropometric						
BMI*	NP†	-	-	27.10	100.0	98.5
WHtR	NP†	-	-	0.53	100.0	100.0
Conicity index	11.56	80.0	81.2	NP†	-	-
Metabolic						
HDL‡	39.05	100.0	82.9	NP†	-	-
Hemodynamic						
SBP	121.5	80.0	88.4	124.0	100.0	98.5
MAP	89.0	80.0	79.6	NP†	-	-

MS: Metabolic syndrome; CP: Cut-off point; S: Sensitivity; Sp: Specificity; *BMI: Body mass index; WHtR: Waist-to-height ratio; †NP: Nonpredictive; ‡HDL: High Density Lipoprotein; SBP: Systolic blood pressure; MAP: Mean arterial pressure; %: percentage

Table V - Cut-off points, sensitivity and specificity of anthropometric, metabolic and hemodynamic indicators to predict metabolic syndrome (MS) in students in private schools. Picos, Piauí, Brazil, 2015.

MS	CP-10 to 14 years	S (%) 10 to 14 years	Sp (%) 10 to 14 years	CP-15 to 19 years	S (%) 15 to 19 years	Sp (%) 15 to 19 years
Anthropometric	NP*	-	-	NP*	-	-
Metabolic	NP*	-	-	NP*	-	-
Hemodynamic						
DBP	NP*	-	-	81.5	100.0	92.1
MAP	89.0	100.0	79.3	94.66	100.0	92.1

MS: Metabolic syndrome; CP: Cut-off point; S: Sensitivity; Sp: Specificity; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; *NP: Nonpredictive; %: Percentage

DISCUSSION

The prevalence rate of metabolic syndrome in the study population was 2.7% (n=5). This result is similar to that found in the Study of Cardiovascular Risks in Adolescents (*Estudo de Riscos Cardiovasculares em Adolescentes – ERICA*), the first Brazilian school-based study on the issue that found a prevalence rate of 2.6%, which is slightly higher than that found in Teresina, Piauí (1.9%)[24]. However, in other studies, prevalence rates ranged from 4.1%[9,22] to 14.1%[24]. In a study carried out in Guatemala with 302 children/adolescents, MS prevalence rate was 2.0%; however, at least one component of MS was found in approximately 54% of the participants[25]. In a study carried out in Korea with 1554 adolescents aged 10 to 19 years, MS prevalence rates were 2.3% in the total sample, 2.8% in overweight adolescents and 23.7% in obese adolescents[26].

The heterogeneity of definitions and cutoff points for the components of MS may explain, at least in part, the different prevalence rates reported in the literature. Nevertheless, it is acknowledged that these rates have been increasing in both developed and developing countries[27]. In addition, MS prevalence rates increase significantly ($p<0.05$) among overweight and/or obese adolescents, with prevalence rates ranging from 11.3% to 31.8% across the Brazilian municipalities and 21.3% of Brazilian obese adolescents presenting MS[24]. The findings of the present study corroborate such information as BMI was found to be a good predictor of MS among female adolescents aged 15 to 19 years.

The analysis of sensitivity and specificity using ROC curves not only allows the identification of the best cutoff point, but also provides the area under the curve, which demonstrates the discriminatory power of an indicator for a given outcome[28].

Studies have shown that WC is a good indicator of visceral abdominal fat and cardiovascular risk factors in adolescents, and it may be a simple tool to identify MS[13].

In the present study, both the CI in the total sample and the WHtR in female students aged 15 to 19 years exhibited good sensitivity and specificity for the prediction of MS with cut-off points of 11.56 cm and 0.53 cm, respectively. It was also observed in the present study that adolescents with MS had lower mean HDL and higher mean TC, insulin and HOMA index, and only HDL was a good predictor for screening MS in the total sample.

The increase in HDL reduces cholesterol concentration circulating in the blood and peripheral tissues. In addition, it has antioxidant, anti-inflammatory and anticoagulant properties and promotes endothelial protection. In contrast, low levels of HDL also increase the risk for the development of cardiovascular diseases[29].

The low levels of HDL in the present study can be explained by the nutritional transition process experienced in Brazil, where most foods consumed are highly processed and high energy foods. Adolescents exhibit a high consumption of stuffed biscuits, sausage, hot dogs, mortadella, sandwiches and salted snacks and a low consumption of fruits and vegetables[30].

With regard to the hemodynamic indicators in the present study, SBP and MAP were good predictors of MS in the total sample. After categorization by sex and age, SBP was a predictor in female students aged 15 to 19 years, MAP was a predictor in male adolescents of both age groups, and DBP was a predictor in students aged 15 to 19 years.

Similar results were found in a study carried out with children and adolescents in Guabiruba, Santa Catarina[31], where students with MS presented high levels of systolic BP and diastolic BP in comparison with those without MS ($p<0.0001$). In the ERICA study[24], the prevalence rate of high BP was 8.2% among the adolescents analyzed. In addition, 57.6% of the adolescents with MS had high BP, which confirms BP as an important component to be analyzed during adolescence.

Considering that systemic arterial hypertension (SAH) in adulthood can originate in childhood and adolescence, preventive strategies, particularly those related to the identification of the various cardiovascular risk factors associated with hypertension in this age group, should be adopted early in an attempt to reduce the late complications of this disease[29].

Given that, it should be noted that health promotion actions delivered by health professionals, particularly by those working in primary health care, should be primarily focused on health promotion and encourage healthy habits and environments. Such actions should be developed to assist children and adolescents in order to provide them with conditions conducive to their healthy and full development[32].

The measurement of blood pressure is a limitation of the present study. Although it was measured in duplicate and followed all the recommendations included in guidelines on hypertension, BP was measured in a single moment. Therefore, further studies should be carried out to measure BP in three alternate days according to recommendations.

CONCLUSION

Anthropometric, metabolic and hemodynamic indicators were predictors of metabolic syndrome, mainly conicity index, high density lipoprotein, systolic blood pressure and mean arterial pressure.

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CONTRIBUTIONS

Thais Norberta Bezerra de Moura contributed to the study design and project, analysis and interpretation of data, drafting the manuscript and critical review of intellectual content. **Jéssica Denise Vieira Leal, Gisely Silva Sousa and Regianne Kellyne Carneiro de Sousa** contributed to the analysis and interpretation of data and drafting the manuscript. **Edina Araújo Rodrigues Oliveira** contributed to the analysis and interpretation of data, drafting the manuscript and critical review of intellectual content. **Luisa Helena de Oliveira Lima** contributed to the study design and project, analysis and interpretation of data, drafting the manuscript, critical review of intellectual content and approval of the final version for publication.

REFERENCES

1. Ribeiro AC, Padoin SMM, Paula CC, Terra MG. The daily living of adolescentes with HIV/Aids: impersonality and tendency to fear. Text Context Nursing [Internet]. 2013 [accessed on 2018 Sep 15];22(3):680-6. Available from: http://www.scielo.br/pdf/tce/v22n3/en_v22n3a14.pdf

2. Pereira AMVB, Gomes I, Schwanke CHA. Metabolic syndrome in elderly assisted in tertiary health care in Curitiba, Paraná, Brazil: prevalence and association with health, functional capacity, life style, and sociodemographic factors. Sci Med [Internet]. 2016 [accessed on 2018 Sep 08];26(3):1-9. Available from: http://revistaseletronicas.pucrs.br/ojs/index.php/scientiamedica/article/view/23444/14874

3. Leitão MP, Martins IS. Prevalence and factors associated with metabolic syndrome in users of primary healthcare units in São Paulo - SP. Rev Assoc Med Bras [Internet]. 2012 [accessed on 2018 Aug 15];58(1):60-9. Available from: http://www.scielo.br/pdf/ramb/v58n1/v58n1a16.pdf.

4. Araújo MFM, Freitas RWJF, Lima ACS, Pereira DCR, Zanetti ML, Damasceno MMC. Relation between sleep quality and metabolic syndrome among university students. Texto & Contexto Enferm [Internet]. 2015 [accessed on 2018 Sep 08];24(2):505-12. Available from: www.scielo.br/pdf/tce/v24n2/pt_0104-0707-tce-24-02-00505.pdf

5. Silva ARV. Risk factors for metabolic syndrome in adolescents [editorial]. Rev Enferm UFPI [Internet]. 2014 [accessed on 2018 Aug 15];3(2):1-3. Available from: http://www.ojs.ufpi.br/index.php/reufpi

6. Barreto AC Neto, Andrade MIS, Lima VLM, Diniz AS. Peso corporal e escores de consumo alimentar em adolescentes no nordeste brasileiro. Rev Paul Pediatr [Internet]. 2015 [accessed on 2018 Sep 08];33(3):318-25. Available from: http://www.scielo.br/pdf/rpp/v33n3/0103-0582-rpp-33-03-0318.pdf

7. Faria FR, Faria ER, Faria FR, Paula HAA, Franceschini SCC, Priore SE. Association between metabolic syndrome and anthropometric and body composition indicators in adolescents. Rev Assoc Bras Nutrição [Internet]. 2014 [accessed on 2018 Sep 08];6(1):13-20. Available from: https://www.rasbran.com.br/rasbran/article/view/163/123

8. Faial LCM, Silva RMCRA, Pereira ER, Refrande SM, Souza LMC, Faial CSG. The school as an environment for health promotion during adolescence: literature review. Rev Pró-UniverSUS [Internet]. 2016 [accessed on 2018 Sep 15];7(2):22-9. Available from: http://editora.universidadedevassouras.edu.br/index.php/RPU/article/view/344/525

9. Instituto Brasileiro de Geografia e Estatística, Diretoria de Pesquisas, Coordenação de População e Indicadores Sociais. Estimativas da população residente com data de referência 2017. [Internet]. 2017 [accessed on 2018 Sep 08]. Available from: https://www.ibge.gov.br/estatisticas-novoportal/por-cidade-estado-estatisticas.html?t=destaques&c=2208007

10. Miot HA. Sample size in clinical and experimental trials. J Vasc Bras [Internet]. 2011 [accessed on 2018 Aug 15];10(4):275-8. Available from: http://www.scielo.br/pdf/jvb/v10n4/en_v10n4a01

11. Marcarini M, Mendes GK. Metabolic syndrome and its relationship with the nutritional status inadolescents – variability of diagnostic criteria. Scientia Medica [Internet]. 2013 [accessed on 2018 Aug 16];23(2):108-18. Available from: http://revistaseletronicas.pucrs.br/ojs/index.php/scientiamedica/article/view/12819/9661

12. Ferreira RW, Rombaldi AJ, Ricardo LIC, Hallal PC, Azevedo MR. Prevalence of sedentary behavior and its correlates among primary and secondary school students. Rev Paul Pediatr [Internet]. 2016 [accessed on 2018 Aug 16];34(1):56-63. Available from: http://www.scielo.br/pdf/rpp/v34n1/0103-0582-rpp-34-01-0056.pdf

13. Ferreira MG, Valente JG, Gonçalves-Silva RMV, Sichieri R. Accuracy of waist circumference and waist-to-hip ratio as predictors of dyslipidemia in a cross-sectional study among blood donors in Cuiabá, Mato Grosso State, Brazil. Cad Saúde Pública [Internet]. 2006 [accessed on 2018 Aug 16];22(2):307-14. Available from: http://www.scielo.br/pdf/csp/v22n2/08.pdf

14. Pereira PF, Serrano HMS, Carvalho GQ, Lamounier JA, Peluzio MCC, Franceschini SCC, et al. Waist and waist-to-height ratio: useful to identify the metabolic risk of female adolescents? Rev Paul Pediatr [Internet]. 2011 [accessed on 2018 Aug 16];29(3):372-7. Available from: http://www.scielo.br/pdf/rpp/v29n3/en_a11v29n3.pdf

15. Pitanga FJG, Lessa I. Sensitivity and specificity of the conicity index as a coronary risk predictor among adults in Salvador, Brazil. Rev Bras Epidemiol [Internet]. 2004 [accessed on 2018 Aug 16];7(3):259-69. Available from: http://www.scielo.br/pdf/rbepid/v7n3/04.pdf

16. Malachias MVB, Souza WKSB, Plavnik FL, Rodrigues CIS, Brandão AA, Neves MFT, et al. 7th Brazilian Guideline of Arterial Hypertension. Arq Bras Cardiol [Internet]. 2016 [accessed on 2018 Aug 16];107(3 Suppl 3):1-83. Available from: http://www.scielo.br/pdf/abc/v107n3s3/0066-782X-abc-107-03-s3-0000.pdf

17. Molina MCB, Faria CP, Montero MP, Cade NV, Mill JG. Cardiovascular risk factors in 7-to-10-year-old children in Vitória, Espírito Santo State, Brazil. Cad Saúde Pública [Internet]. 2010 [accessed on 2018 Aug 16];26(5):909-17. Available from: http://www.scielo.br/pdf/csp/v26n5/13.pdf

18. Silva JLN, Silva FL Júnior, Ferreira AP, Simões HG. Characterization and influence of indicators of central obesity, fitness cardiorespiratory and level of physical activity on blood pressure of school. Rev Andal Med Deporte [Internet]. 2017 [accessed on 2018 Aug 16];10(1):25–30. Available from: www.elsevier.es/pt-revista-revista-andaluza-medicina-del-deporte-284-pdf-S1888754616300089-S300

19. Brito BB, Leal JDV, Formiga LMF, Frota KMG, Silva ARV, Lima LHO. Cardiovascular diseases: risk factors in adolescents. Cogitare Enferm [Internet]. 2016 [accessed on 2018 Aug 16];21(2):1-8. Available from: http://www.saude.ufpr.br/portal/revistacogitare/wp-content/uploads/sites/28/2016/10/41848-177492-1-PB.pdf

20. Gauche R, Gadelha AB, Paiva FML, Oliveira PFA, Lima RM. Strength, muscle quality and markers of cardiometabolic risk in older women. Rev Bras Cineantropom Desempenho Hum [Internet]. 2015 [accessed on 2018 Aug 16];17(2):186-94. Available from: https://periodicos.ufsc.br/index.php/rbcdh/article/download/1980-0037.2015v17n2p186/28728

21. Cook S, Weitzman M, Auinger P, Nguyen M, Dietz WH. Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health and Nutrition Examination Survey, 1988-1994. Arch Pediatr Adolesc Med [Internet]. 2003 [accessed on 2018 Aug 16];157(8):821-7. Available from: https://jamanetwork.com/journals/jamapediatrics/fullarticle/481403

22. Unicef. Fase inicial e fase final da adolescência [Internet]. 2011 [accessed on 2018 Sep 15]. Available from: http://www.unicef.org/brazil/sowc2011/foco1.html

23. Erdreich LS, Lee ET. Use of relative operating characteristic analysis in epidemiology: method for dealing with subjective judgement. Am J Epidemiol [Internet]. 1981 [accessed on 2018 Aug 16];114(5):649-62. Available from: https://doi.org/10.1093/oxfordjournals.aje.a113236

24. Kuschnir MCC, Bloch KV, Szklo M, Klein CH, Barufaldi LA, Abreu GA, et al. ERICA: prevalence of metabolic syndrome in Brazilian adolescents. Rev Saúde Pública [Internet]. 2016 [accessed on 2018 Aug 16];50(Suppl 1):11s. Available from: http://www.scielo.br/pdf/rsp/v50s1/0034-8910-rsp-S01518-87872016050006701.pdf

25. Pontes LM, Amorim RJM, Lira PIC. Components of metabolic syndrome and associated factors in adolescents: a case-control study. Rev AMRIGS [Internet]. 2016 [accessed on 2018 Aug 16];60(2):121-8. Available from: http://www.amrigs.org.br/revista/60-02/10_1598_Revista%20AMRIGS.PDF

26. Mbowe O, Diaz A, Wallace J, Mazariegos M, Jolly P. Prevalence of metabolic syndrome and associated cardiovascular risk factors in Guatemalan school children. Matern Child Health J [Internet]. 2014 [accessed on 2018 Aug 16];18(7):1619-27. Available from: http://europepmc.org/articles/PMC4055521

27. Park SH, Park JH, Kang JW, Park HY, Park J, Shin KJ. Prevalence of the metabolic syndrome and abnormal lipid levels among Korean adolescents. J Paediatr Child Health [Internet]. 2013 [accessed on 2018 Aug 16];49(7):582-7. Available from: https://doi.org/10.1111/jpc.12284

28. Ribeiro-Silva RC, Florence TCM, Conceição-Machado MEP, Fernandes GB, Couto RD. Anthropometric indicators for prediction of metabolic syndrome in children and adolescents: a population-based study. Rev Bras Saude Mater Infant [Internet]. 2014 [accessed on 2018 Aug 16];14(2):173-81. Available from: http://www.scielo.br/pdf/rbsmi/v14n2/1519-3829-rbsmi-14-02-0173.pdf

29. Özer S, Yılmaz R, Özlem KN, Sönmezgöz E, Karaaslan E, Altuntaş B, et al. Higher hdl levels are a preventive factor for metabolic syndrome in obese Turkish children. Nutr Hosp [Internet]. 2014 [accessed on 2018 Aug 16];31(1):307-12. Available from: https://www.researchgate.net/publication/270655893/download

30. Pereira PF, Faria FR, Faria ER, Hermsdorff HHM, Peluzio MCG, Franceschini SCC, et al. Anthropometric indices to identify metabolic syndrome and hypertriglyceridemic waist phenotype: a comparison between the three stages of adolescence. Rev Paul Pediatr [Internet]. 2015 [accessed on 2018 Aug 16];33(2):194-203. Available from: http://www.scielo.br/pdf/rpp/v33n2/0103-0582-rpp-33-02-00194.pdf

31. Rosini N, Moura SAZO, Rosini RD, Machado MJ, Silva EL. Metabolic syndrome and importance of associated variables in children and adolescents in Guabiruba - SC, Brazil. Arq Bras Cardiol [Internet]. 2015 [accessed on 2018 Aug 16];105(1):37-44. Available from: http://www.scielo.br/pdf/abc/v105n1/0066-782X-abc-20150040.pdf

32. Lima LHO. Promoção da saúde na infância e adolescência: perspectivas e desafios. In: Silva ARV, Oliveira AKS, Lima LHO, Machado ALG. Interlocuções entre vivências coletivas na promoção da saúde [Internet]. Teresina: EDUFPI; 2018 [accessed on 2018 Sep 08]. p. 27-30. Available from: http://saudecoletivapicos.com.br/media/livros/Interloc.pdf

Mailing address:
Thais Norberta Bezerra de Moura
Força Estadual de Saúde do Maranhão - FESMA
Av. Borborema, Quadra-16, 25
Bairro: Calhau
CEP: 65071-360 - São Luís - MA - Brasil
E-mail: thaisinha_moura@hotmail.com