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Body mass index, waist circumference, and arterial hypertension in students

Índice de massa corporal, circunferência da cintura e hipertensão arterial em estudantes

Índice de masa corporal, circunferencia de la cintura y hipertensión arterial en estudiantes

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ABSTRACT

Objective: to investigate what is the best anthropometric predictor of arterial hypertension among private school students. **Method:** this was a cross-sectional study with 286 students between the ages of 10 and 14 from two private schools in the city of Paranavaí, Paraná, Brazil. The following variables were analyzed: body mass index, waist circumference and blood pressure. Statistical analysis was conducted with Pearson's partial correlation test and multivariate logistic regression, with $p<0.05$. **Results:** both anthropometric indicators displayed weak correlation with systolic and diastolic levels, with coefficients (r) ranging from 0.27 to 0.36 ($p< 0.001$). Multivariate analysis showed that the only anthropometric indicator associated with arterial hypertension was waist circumference (OR = 2.3; 95% CI: 1.1-4.5), regardless of age or gender. **Conclusion:** in this age group, waist circumference appeared to be a better predictor for arterial hypertension than body mass index.

Key words: Anthropometry; Arterial Pressure; Adolescent Health.

RESUMO

Objetivo: investigar qual o melhor preditor antropométrico de hipertensão arterial em alunos de escolas privadas. **Método:** estudo transversal, com amostra composta por 286 alunos com idade de 10 a 14 anos de duas escolas privadas de Paranavaí-Paraná. As variáveis analisadas foram: índice de massa corporal, circunferência de cintura e pressão arterial. Na análise estatística foram utilizados os testes de correlação parcial de Pearson e a regressão logística multivariada, considerando-se $p<0,05$. **Resultados:** os dois indicadores antropométricos demonstraram fracas correlações com os níveis sistólicos e diastólicos, com coeficientes (r) variando de 0,27 à 0,36 ($p< 0,001$). Na análise multivariada, o único indicador antropométrico associado ao risco de hipertensão arterial foi a circunferência de cintura (OR = 2,3; IC 95%: 1,1-4,5) independente da idade e gênero. **Conclusão:** nesta faixa etária, a circunferência de cintura parece ser melhor do que índice de massa corporal como preditor de hipertensão arterial.

Descritores: Antropometria; Pressão Arterial; Saúde do Adolescente.

RESUMEN

Objetivo: investigar cuál es el mejor predictor antropométrico de la hipertensión arterial en los alumnos de escuelas particulares. **Métodos:** estudio transversal con muestra compuestas por 286 alumnos con edad de 10 a 14 años de dos escuelas privadas de Paranavaí-Paraná. Las variables analizadas fueron: índice de masa corporal, circunferencia de la cintura y la presión arterial

sistólica y diastólica. En el análisis de estadísticas fueron utilizadas las pruebas de correlación parcial de pearson y regresión logística multivariada considerándose $p<0.05$. **Resultados:** los dos indicadores antropométricos han mostrado débiles correlaciones con los niveles sistólicos y diastólicos, con Coeficientes (r) variando de 0,27 a 0,36 ($p<0,001$). En el análisis multivariado el único indicador antropométrico asociado al riesgo de hipertensión arterial fue la circunferencia de la cintura (OR = 2,3; IC 95%: 1,1- 4,5) independiente de la edad y el género. **Conclusión:** en este grupo de edad, la circunferencia de la cintura parece ser mejor de que el índice de masa corporal como predictor de la hipertensión arterial.
Palabras clave: Antropometría; Presión Arterial; Salud del Adolescente.

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INTRODUCTION

Obesity has become a great global health problem over the last decades. Recent data have demonstrated a substantial increase in overweight and obese children and adolescents in the last twenty years. Increased food consumption and lack of physical activity, factors associated with obesity, contribute to at least 300,000 deaths per year in the United States[1].

One of the main causes of death in the world among adults are cardiovascular diseases, usually progressive and with their roots in the early years of life. Childhood and adolescence are important phases in this process, as they are marked by biological changes in the human body. Furthermore, adolescents begin to adopt patterns and independent behaviors which influence the risks for such diseases[2].

Among the numerous diseases of this type, one of the most prevalent among the general population is systemic arterial hypertension, characterized by high and sustained levels of blood pressure. Moreover, hypertension is no longer exclusive to adults, as obese children and adolescents can potentially develop such altered hemodynamics[3].

It is known that alterations such as obesity and excessive central fat precede increased blood pressure in children and adolescents. For this reason, researchers have investigated the predictive capacity of anthropometric qualities, in the context of using simple, practical and low-cost methods, to assess risk factors for cardiovascular diseases among this age group[4].

Detecting risk indicators among the youth population is essential for monitoring individuals who present greater chances of developing altered blood pressure in adulthood[5].

OBJECTIVE

This study aimed to investigate what is the best anthropometric predictor for arterial hypertension among private school students in the city of Paranavaí, Paraná, Brazil.

METHOD

This was a cross-sectional study conducted between July and August 2013. The sample consisted of students between the 6th and 9th grades, aged 10 to 14, at two private schools in Paranavaí, Paraná, Brazil. The classes were selected through systematized random allocation in two steps: 1) by using the lottery method, one class from each year from both schools were drawn; and 2) students from the selected classes were invited to participate and received an explanation on the nature of the study.

Sample size calculation was obtained by considering the total number of students in the studied population (n = 417), an outcome prevalence of 50% (arterial hypertension) with a 95% confidence interval and 5% sampling error. Based on these parameters, we aimed to collect data from 200 students. Assessments were conducted only with students who agreed to participate in the study and who presented the Free and Informed Consent Form signed by their parents or legal guardians (n = 298). Of these, 12 were excluded because: 1) they did not fall in the 10 to 14 age group; and 2) they did not participate in all the assessments. The final sample comprised 286 children and adolescents; 149 boys and 137 girls. The margin of sampling error calculated *post hoc* was 3.3% to 3.4%, a result below the level established *a priori* (5%).

The assessments were carried out during school hours by trained evaluators and with calibrated instruments. Height was measured using a wall stadiometer (Wisoâ, Brazil) with 0.1 cm resolution, and body mass with a digital scale (G-Tech) with 100-gram resolution and 150 kg maximum capacity. Participants wore only their school uniform, with or without objects in their pockets. Body mass index (kg/m2) was used to categorize the students as eutrophic or overweight[6]. Data from students with low weight (0.3%; n = 1) were included in the eutrophic category.

Waist circumference was measured using a flexible and non-elastic tape measure (Gullikâ, Brazil), with 0.1 cm resolution, applied immediately above the iliac crest. To classify abdominal obesity (central), we established $P \geq 75°$ as the cutoff point for all ethnicities[7].

Blood pressure was measured according to the techniques recommended by the Brazilian Society of Cardiology[8], using a mercury sphygmomanometer (Wan Medâ, Brazil). Measurements were collected at three points, with a minimum two-minute interval between them. For data analysis we used the mean value of the two last measurements. Values of systolic or diastolic blood pressure equal to or greater than the 90º percentile or 120 mmHg and/or 80 mmHg were considered high[9].

For statistical analysis, the Kolmogorov-Smirnov test was used to identify the normality of the data and the existence of outliers was verified using box plots. Outliers were included in the analyses because they corresponded to data from overweight students, which were of interest to this study.

Student's t-test was used to compare the anthropometric and hemodynamic characteristics between genders; Levene's test was used to test for equality of variances between the investigated groups.

Pearson's test for partial correlations was used to analyze the relation between body mass index (BMI) and waist circumference (WC), and of both measures with regards to systolic blood pressure (SBP) and diastolic blood pressure (DBP), adjusted for gender and age.

Exploratory data analysis demonstrated a non-linear relationship between *x* and *y*, from a determined point of its distribution, demonstrating a logistic S-curve. Thus, binomial multivariate regression was conducted to determine the odds ratio (OR) and the respective confidence intervals (95%) used to analyze the independent association between arterial hypertension (dependent variable) and BMI and WC (independent variables). All the studied variables were categorized, and inclusion criterion of the independent variables in the multivariate models was an association level of $p \leq 0.20$ with the dependent variable, according to the chi-square test.

Analyses were conducted using the Statistical Package for the Social Sciences (SPSS) software, version 20.0, with $p < 0.05$. The research proposal was approved by the research ethics committee of Maringá State University, under resolution number 353.552 and in accordance with the Declaration of Helsinki.

RESULTS

The mean values for BMI, height and WC were higher among boys than in girls ($p \leq 0.05$). In terms of age, mean BMI, SBP and DBP values were equal between the two groups (Table 1).

Table 1 - Age and anthropometric characteristics of private school students in Paranavaí, Paraná, Brazil, 2013

	Mean ± SD		
Variables	**Male (n = 149)**	**Female (n = 137)**	p-value
Age (years)	12.3 ± 1.23	12.0 ± 1.14	0.245
Mass (kg)	53.0 ± 11.70	48.4 ± 11.84	0.031*
Height (cm)	1.58 ± 0.10	1.54 ± 0.08	0.043*
BMI (kg/m2)	21.23 ± 3.61	20.3 ± 3.86	0.296
WC (cm)	75.3 ± 10.92	69.6 ± 9.51	0.004*
SBP (mmHg)	110.9 ± 17.4	108.4 ± 14.6	0.581
DBP (mmHg)	64.2 ± 8.47	61.0 ± 8.43	0.728

*SD, standard deviation; BMI, body mass index, WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure. *Significant values for p ≤ 0.05.*

Table 2 - Pearson's partial correlation (r) for the studied variables adjusted for age and gender among private school students in Paranavaí, Paraná, Brazil, 2013

Variables	IMC	PAS	PAD	C.C
IMC	-	0.27*	0.29*	0.84*
PAS	0.27*	-	0.51*	0.36*
PAD	0.29*	0.51*	-	0.36*
C.C	0.84*	0.36*	0.36*	-

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; WC, waist circumference.

**Significant correlations at p ≤ 0.001.*

Table 3 - Odds Ratio for risk of high blood pressure adjusted for age and gender among private school students in Paranavaí, Paraná, Brazil, 2013

Variables		Adjusted odds ratio (95% CI)
Gender	Male	1
	Female	1.1 (0.6 - 2.0)
Age	10 years	1
	11 years	0.7 (0.2 - 1.9)
	12 years	1.1 (0.4 - 3.2)
	13 years	1.8 (0.7 - 5.0)
	14 years	1.5 (0.5 - 4.4)
BMI	Eutrophic	1
	Overweight	1.8 (0.9 - 3.6)
WC	< 75°	1
	≥ 75°	2.3 (1.1 - 4.5)*

BMI, body mass index; WC, waist circumference; CI, confidence interval.

**Significant association at p ≤ 0.05.*

Table 2 presents an analysis of the relationship among the studied variables and shows that the anthropometric measurements presented weak correlations with SBP and DBP, with coefficients ranging between 0.27 and 0.36. However, two anthropometric indicators (BMI and WC) presented strong correlation ($r = 0.84$ $p < 0.001$), indicating collinearity between them.

Multivariate analysis showed that the model with the greater predictive validity included BMI, WC, gender and age, (Hosmer and Lemeshow goodness of fit index for the model = 0.974), with the capacity of explaining 73.1% of adequate blood pressure cases. The only variable that was positively associated with higher blood pressure levels was waist circumference ($p = 0.020$), indicating that students with measurements above the cutoff point (≥75°) were 2.3 more likely

(130% greater chance) to present high blood pressure (95% CI: 1.1-4.5), when compared to those with adequate measurements. Gender, age and BMI were not associated with risk for high blood pressure (Table 3).

DISCUSSION

The frequency of high blood pressure among children and adolescents has increased worldwide[5]. In particular, overweight individuals have presented higher proportions of hypertensive measurements and cardiovascular risks[10-11].

Studies have attempted to identify the best anthropometric indicator for high blood pressure among children and adolescents, but the results have been conflicting[1,4,12–14]. The present study aimed to highlight such divergences, analyzing the relationship between blood pressure with two anthropometric indicators of obesity (BMI and WC), which are easy to use among this population.

The results showed weak correlations between both anthropometric parameters and SBP and DBP, a finding that corroborates those of previous studies[4,9]. The magnitude of these correlations may have been compromised due to the multifactorial characteristic of high blood pressure, influenced by environmental factors or by the logistic behavior of the data. It is worth noting that blood pressure measurements were taken at only one point (during school hours), representing a possible classification bias and a limitation of this study.

Another important finding was the positive association of waist circumference as an anthropometric indicator independently associated with arterial hypertension. The students classified with central obesity ($P \geq 75°$) were 130% more likely ($OR = 2.3$) to have high blood pressure in comparison with students who were not diagnosed with abdominal obesity.

Some studies have pointed to obesity as a risk factor for increased blood pressure in children and adolescents, however, the best anthropometric parameter is still contradictory; some studies showed WC as the best predictor[5,15], while others indicated BMI as having a higher association among this age group[13,16]. In the present research, there was a strong correlation between BMI and WC ($r = 0.84$; $p < 0.001$). This finding could explain the existing conflict in the literature, as among this population, it is possible that high BMI values are directly related to excess body fat. This is because the lean-fat proportion among this age group is not very expressive, especially among prepubescents and pubescents. An analysis of the students' sexual maturation could have provided more details on the issue, but due to bureaucratic problems and school procedures, we were not able to conduct such an analysis.

The use of Brazilian criteria and cutoff points to classify BMI[6] conferred greater reliability to analyses of this variable in this study, as they were more precise in determining high blood pressure among boys and girls aged 10 to 17 in comparison to international references[17].

Notwithstanding, the lack of regression-based association between high blood pressure and BMI in the present study does not dismiss its importance in predicting arterial hypertension among children and adolescents, as it was correlated with systolic and diastolic levels. This finding suggests that it is a potential indicator of arterial hypertension. A possible explanation for such lack of association may be the period in which the students were exposed to excess weight, which was not enough to provoke hemodynamic alterations.

On the other hand, the association found between blood pressure and waist circumference may have been negatively influenced, distorting the estimates of the risk for high blood pressure, due to the use of international criteria. Such criteria are not sensitive and specific enough to identify high blood pressure among Brazilian children and adolescents due to the strong miscegenation of this population, which requires specific critical values[18]. In this sense, Brazilian cutoff points for this age group must be validated in order to confer greater reliability to studies with students.

CONCLUSIONS

Conducting appropriate routine blood pressure measurements at school is hindered by lack of adequate equipment and, in particular, lack of trained evaluators to perform the technique. Anthropometric indicators are simple and yet reliable options for hypertension risk stratification. In this research, waist circumference was the best predictor for high blood pressure among the students, regardless of BMI, gender and age. However, further studies with this population that include stages of puberty must be conducted, as different maturation classifications can interfere in data interpretation.

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