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A comparison between overweight cutoff points for detection of high blood pressure in adolescents

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Abstract

Objectives: To evaluate the accuracy of three different cutoff points for the detection of high blood pressure in adolescents, given the strong relationship between overweight and high blood pressure levels.

Methods: A total of 1,021 adolescents of both sexes were enrolled in the study, selected at random from public and private schools in Londrina, Brazil. Their body weight was measured using a digital balance, and their height with a portable stadiometer with a maximum extension of 2 meters. Arterial blood pressure was measured using an automatic apparatus. The capacity of body mass index to detect high blood pressure was gauged using ROC curves and their parameters (sensitivity, specificity, and area under the curve).

Results: The cutoff points proposed in a Brazilian standard exhibited greater accuracy (males: 0.636±0.038; females: 0.585±0.043) than the cutoff points proposed in an international (males: 0.594±0.040; females: 0.570±0.044) and a North-American standard (males: 0.612±0.039; females: 0.578±0.044).

Conclusions: The Brazilian proposal offered greatest accuracy for indicating high blood pressure levels.

J Pediatr (Rio J). 2009;85(4):353-358: Blood pressure, body mass index, adolescents.

Introduction

All over the world, cardiovascular disease are the greatest cause of death among the general population. These diseases have countless risk factors and arterial hypertension is one of the most important. Arterial hypertension is defined as high blood pressure levels that remain above the limits considered normal when at rest,[1] and it is a condition that has been affecting a growing proportion of the adult population, increasing their risk of cardiovascular problems.

Furthermore, high blood pressure levels are being reported in the younger population too,[2-4] causing major epidemiological concern. Studies have demonstrated that high blood pressure (HBP) in the young is associated with overweight. Along the same lines, several different studies with pediatric populations have indicated a positive linear relationship between arterial blood pressure levels and body mass index (BMI),[2,5-7] making BMI a highly valuable tool for the detection of individuals at greater risk. However, the accuracy of BMI for detecting excess body fat in children and adolescents is directly related to the cutoff point adopted.[8,9]

To this end, Cole et al.[10] proposed critical values, or the LMS curves method (*lambda*, *mu,* and *sigma*), based

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This study was carried out at Universidade Estadual de Londrina (UEL), Londrina, PR, Brazil.

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on surveys carried out in six countries, one of which was Brazil. In contrast, Must et al.[11] published values (percentiles) developed from data originating solely from the North American population. Recently, Conde & Monteiro[12] suggested new values for detecting overweight (using the LMS method), based solely on Brazilian data.

To date, the accuracy of these cutoff points for detecting indicators of cardiovascular health risk in pediatric populations, as is the case with HBP, has not been investigated within Brazil. This information is significant when choosing cutoff points both in clinical environments and for use in population studies, aiming at developing prevention strategies.

Therefore, the objective of this study was to evaluate the accuracy of three tables of critical BMI values for the detection of HBP in Brazilian adolescents of both sexes.

Methods

This study was carried out in the city of Londrina, Brazil, and recruited adolescents aged from 10 to 17 years, all enrolled at primary and secondary schools. Adolescents were excluded from the sample if they were pregnant, had taken caffeine within 30 minutes of the evaluation or if they took pharmaceuticals with chronotropic or inotropic effects. According to the Municipal Education Department, the city of Londrina had 70,632 schoolchildren enrolled in the 5th to 8th grades of state and private schools (data from 2007). These data were subdivided according to six geographical areas of the city: North, South, East, West, and central regions and the peripheral ring.

Of the total number of children studying in the city of Londrina's public schools, 46.3% studied in the central region, while 9.2% were enrolled at schools in the South region, and 18.1, 13.4, 11 and 2% were enrolled at schools in the North, East and West regions and the peripheral ring respectively. With relation to the number of children enrolled in the 5th to 8th grades of private schools, 37.1% studied in the central region, and 22.3, 15.1, 8.1, 14.2 and 3.2% studied in the North, South, East and West regions and the peripheral ring, respectively (data provided by the IV Regional Education Center of Londrina). One public and one private school were chosen at random from each region. If any of the chosen schools had not met the proportionality criteria, a second school would have been chosen to make up the numbers (this procedure was not invoked since all of the schools chosen did meet the necessary proportionality).

We assumed an HBP prevalence of 10%, as described in the literature,[2] and an acceptable error of 3% and a 95% confidence interval. On this basis, the initial sample size obtained was 382 subjects. However, data was collected considering the classes chosen at random in their entirety (clusters) and, as a result of this, a design effect sample correction factor of 2.0 was necessary, resulting in a total of 764 subjects. In order to allow for possible losses, a further 20% was added to this figure, leading to a final number of 916 subjects. During data collection, a total of 1144 subjects were assessed. Of these, 123 were absent on a data collection day or refused to undergo assessments (10.7%). Thus, 1,021 subjects took part in all phases of the study and the minimum sample size was achieved.

All of the adolescents assessed provided a Free and Informed Consent Form signed by their parents or guardians authorizing their participation in the study. The study was approved by the Research Ethics Committee at the Universidade Estadual de Londrina (UEL) (protocol nº 0281.0.268.000-07), Londrina, Brazil.

All of the anthropometric measurements were carried out at the schools. Body mass was measured using an electronic balance made by Plenna with accuracy of 0.1 kg and maximum capacity of 150 kg. The children were weighed barefoot, standing in the center of the balance plate, wearing light clothing. Height was measured using a portable stadiometer accurate to 0.1 cm and with a maximum extension of 2 m. The movable part of the stadiometer was lowered until it touched the vertex and the subjects' hair was compressed.[13]

Body mass index was calculated on the basis of these results for mass and height, using the following equation: BMI = body mass (kg) / height (m)^2. The children were then classified on the basis of their BMI into one of two nutritional states: 1) healthy weight or 2) overweight/obesity, according to the three different criteria under investigation: a) Cole et al.;[10] b) Conde & Monteiro;[12] and c) Must et al.[11] The 85th percentile of the table published by Must et al.,[11] was used as the cutoff for overweight.

An Omron HEM-742 digital meter, previously validated for use with adolescents, was used to measure systolic (SBP) and diastolic blood pressure (DBP).[14] One of two different cuff sizes was used, depending on the diameter of each child's arm: one for young children (6 x 12 mm) and the other for older children (9 x 18 mm), as recommended in the literature.[15]

Blood pressure was measured twice, on the right arm, with the child sitting down. The first measurement was taken after a minimum of 5 minutes' rest, and the second measurement was taken two minutes after the first. Each child's arterial blood pressure was taken as the mean of these two measurements. The cutoff points used to classify children on the basis of their blood pressure were those recommended by the I Directive on the Prevention of Atherosclerosis in Childhood and Adolescence (I Diretriz de Prevenção da Aterosclerose na Infância e na Adolescência).[16] Children were classified as having HBP if their SBP and/or DBP results were above the 95th percentile recommended for their age and height. Furthermore, their chronological age was calculated on the basis of their date of birth and the date of the evaluation day. All measurements for this study were performed by two investigators with a minimum of 3 years' experience, first measuring body weight, followed by height and then blood pressure.

Initially, the normality of the dataset was verified using the Kolmogorov-Smirnov test (K-S), which confirmed that all of the variables fitted parametric distribution models. Therefore, means and standard deviations were adopted as measures of central tendency and range for numerical variables. Furthermore, one way analysis of variance followed by Tukey's post hoc test was used to make comparisons between the variables analyzed for the two age groups defined (10-13 and 14-17 years). Pearson's correlation coefficient was used to indicate linear correlations between numerical variables.

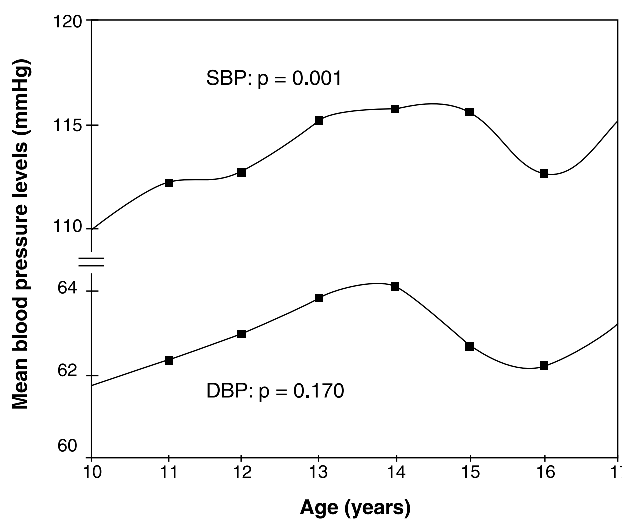
Receiver operating characteristic (ROC) curves and their parameters – area under the (AUC) or accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) – were used to indicate the accuracy of the three BMI cutoffs for indicating high blood pressure levels.

Throughout this study, p values lower than 5% were defined as significant from a statistical point of view. Analyses were carried out using the Statistical Package for the Social Sciences (SPSS) version 10.0.

Results

Figure 1 illustrates SBP and DBP levels by age group. It can be observed that as age increased there was a significant increase in SBP values, although this trend was not followed by the 16-year-old children. The reduction in mean blood pressure levels in this subset of the sample may have been the result of the fact that the majority of the adolescents in the 7th and 8th grades (mean age of 16 years) were assessed during the morning, when baseline levels are lower.

The BMI results also increased significantly as age increased (data not shown; p = 0.001). The coefficients for the correlations between BMI, SBP and DBP are shown in Table 1. A significant and positive relationship could be observed between SBP and BMI for both sexes and age groups, with the exception of the female adolescents in the 14 to 17 years group (borderline significance; p = 0.089). However, for the DBP levels, a significant relationship was only observed for adolescents aged 10 to 13 years; the same was not observed for adolescents with ages greater than or equal to 14 years.



SBP = systolic blood pressure; DBP = diastolic blood pressure.

Figure 1 - Results of SBP and DBP measurements, by age

Table 1 - Correlation between body mass index and arterial blood pressure for adolescents of both sexes (Londrina, Brazil)

	SBP		DBP	
Age groups	**r**	**p**	**r**	**p**
10-13 years				
Males (n = 406)	0.23	0.001	0.32	0.001
Females (n = 439)	0.18	0.001	0.24	0.001
14-17 years				
Males (n = 87)	0.38	0.001	0.18	0.081
Females (n = 89)	0.18	0.089	0.009	0.932

DBP = diastolic blood pressure; SBP = systolic blood pressure.

The ROC curve parameters are given in Table 2 and illustrated in Figure 2. The cutoff points proposed by Conde & Monteiro[12] exhibited the largest AUC (males: 0.636±0.038; females: 0.585±0.043), which is a general coefficient of the overall accuracy of the instrument in question. Sensitivity, which is the capacity of the instrument to indicate the presence of HBP, was also greatest using the Conde & Monteiro[12] cutoffs (males: 53; females: 38.9). However, the other two cutoff points exhibited greater specificity, which is the instrument's capacity to indicate the absence of HBP.

Furthermore, these sensitivity and specificity values were reflected in the PPV and NPV scores: the Brazilian proposal had the highest PPV values, while the two international proposals had the greatest NPV values.

Discussion

The arterial blood pressure levels observed in this study had a significant relationship with BMI, which is comparable with the findings of earlier studies.[17-21] This relationship appears to be attributable to the formation of atheromatous plaques on the walls of vessels as a result of the greater quantities of lipoproteins in the bloodstream.[22] Undeniably, these correlations were small, despite being significant. Nevertheless, since blood pressure is affected by other agents (autonomic control, dietary habits such as salt intake, etc.) and not just by body fat, these correlation coefficients are still relevant indicators.

This linear relationship is an indication that elevated BMI values can be used to monitor young people at the greatest risk of developing HBP. However, these values are

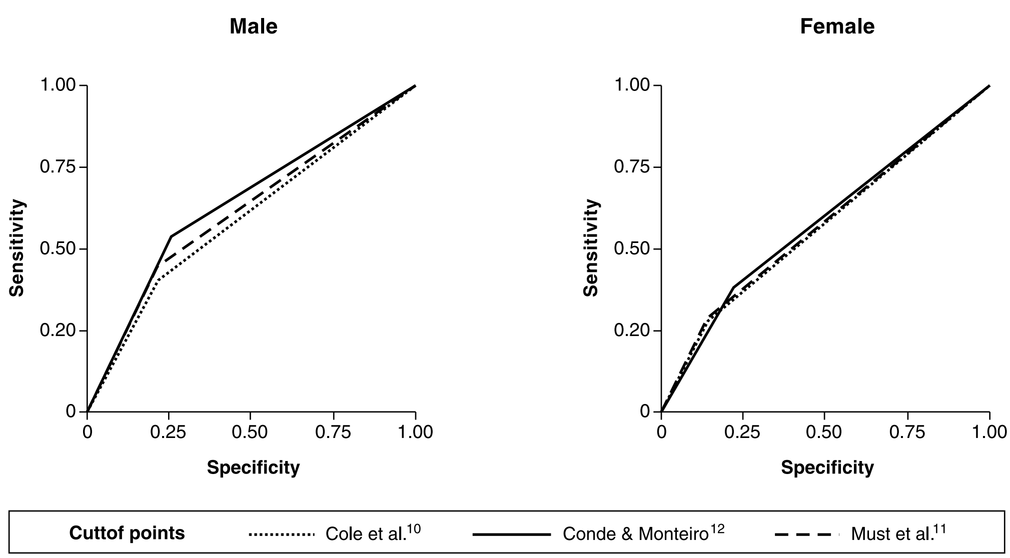


Figure 2 - Receiver operating characteristic curve parameters

Table 2 - Sensitivity and specificity scores for identifying high blood pressure for the three different body mass index BMI cutoff points

	ROC curve parameters				
Cutoff points	**Sensitivity**	**Specificity**	**AUC**	**PPV (%)**	**NPV (%)**
Males					
Cole et al.[10]	39.4	79.3	0.594±0.040	22	100
Conde & Monteiro[12]	53	74.2	0.636±0.038	24	93
Must et al.[11]	43.9	78.4	0.612±0.039	23	98
Females					
Cole et al.[10]	27.8	86.3	0.570±0.044	18	100
Conde & Monteiro[12]	38.9	78.1	0.585±0.043	20	100
Must et al.[11]	27.8	87.8	0.578±0.044	19	100

AUC = area under the curve; NPV = negative predictive value; PPV = positive predictive value; ROC = receiver operating characteristic.

not on their own enough to perform screening since they do not indicate a specific cutoff point above which a given young person would be at greatest risk.[23] To achieve such an identification, diagnostic tests are necessary.

Studies already carried out in Brazil have analyzed the agreement and accuracy of different critical BMI values for detecting nutritional status and indicate that there is a significant variation depending on the cutoff point adopted. Of these studies, the one carried out by Fernandes et al.[8] is of note, assessing 807 young people from the city of Presidente Prudente, Brazil. These authors found that the Conde & Monteiro proposal[12] was the best at detecting excess fat, confirmed by bioimpedance, and abdominal obesity, confirmed by waist circumference, among the children analyzed. Similar results were found by Vitolo et al.,[9] when they compared the values of the Brazilian proposal with the values proposed by Cole et al.[10] for detecting excess body fat (DXA).

Both these studies stated that the critical values provided by Conde & Monteiro[12] were more sensitive for indicating excess body fat, in agreement with the findings of our study, where the Conde & Monteiro[12] values were more sensitive for detecting HBP. Lower critical values are generally more sensitive than specific since they include a greater proportion of the sample; although the interaction between sensitivity and specificity may be a safer indicator of accuracy. The Conde & Monteiro[12] values also exhibited the largest AUC for both sexes.

The lower critical values proposed by Conde & Monteiro[12] exhibit these characteristics because they were developed on the basis of data from young Brazilians collected some decades ago, when obesity rates were not as high as they are today.[24] The values produced by Must et al.,[11] despite also being a relatively old reference, were developed from a population where obesity is a much more common problem and exhibited lower sensitivity than the figures published by Conde & Monteiro.[12]

The use of more sensitive or specific instruments depends directly on the health-related-outcome in question, and on the context in which they are administered. Therefore, in an epidemiological context, since HBP is an important risk factor for the development of cardiovascular diseases in adulthood and since its early identification is a valuable tool for healthcare management in the Brazilian scenario, opting for more sensitive values, i.e. those produced by Conde & Monteiro,[12] appears to be the more appropriate choice. This indication would also appear to be applicable to clinical context, in which more sensitive instruments are better than more specific ones.

The primary limitation of this study is based on the fact that it analyses the capacity of BMI to identify just one of the components of metabolic syndrome. Therefore, it is suggested that future studies analyze the other components in isolation and in combination (the metabolic syndrome itself) so that, in this manner, additional information will be acquired about the possible application of BMI as an indicator of risk among Brazilian pediatric populations.

In summary, the results of our study indicate that BMI is a moderate indicator of HBP in the sample studied. Furthermore, the critical values for BMI that originated from the Brazilian pediatric population were most sensitive for detecting HBP in the sample analyzed.

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