Anthropometric Indicators as Predictors of High Blood Pressure in Adolescents

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Abstract

Background: **Hypertension is related to increased body fat, which can be evaluated by anthropometric indicators.**

Objective: **To determine the predictive power of anthropometric indicators and establish their cutoff points as discriminators of high blood pressure.**

Methods: **Cross-sectional study with a sample of 660 adolescents aged 14 to 19 including 51.9% girls. We considered the following anthropometric indicators: body mass index (BMI), waist circumference, waist-to-height ratio and conicity index. High blood pressure was characterized by values above the 90th percentile for systolic and/or diastolic blood pressure. To identify predictors of high blood pressure, we adopted the analysis of receiver operating characteristic curves (ROC) with a confidence interval of 95%. Subsequently, we identified the cutoff points with their relevant sensitivities and specificities.**

Results: **The areas under the ROC curves with confidence intervals were: boys - waist circumference = 0.80 (0.72 to 0.89); BMI = 0.79 (0.68 to 0.89), waist-to-height ratio = 0.77 (0.66 to 0.88); conicity index = 0.69 (0.56 to 0.81) and for girls - waist circumference = 0.96 (0.92 to 1.00); BMI 0.95 (0.87 to 1.00), waist-to-height ratio = 0.93 (0.85 to 1.00); conicity index = 0.74 (0.50 to 0.98). The different cutoff points of anthropometric indicators with better predictive power and their relevant sensitivities and specificities were identified.**

Conclusion: **Although the waist-to-height ratio and BMI have shown good areas under the ROC curve, we suggest the use of waist circumference to predict high blood pressure. (Arq Bras Cardiol 2011; 96(2): 126-133)**

Keywords: **Anthropometry; prediction; hypertension; obesity; adolescent.**

Introduction

Hypertension is considered a potential cardiovascular risk factor for children, adolescents and adults, mainly because it is associated with the presence of early atherosclerotic lesions[1]. Furthermore, high blood pressure in pediatric populations progresses to hypertension in adults, especially among children and adolescents with a tendency to develop excess weight during the growth phase[2].

Evidence that hypertension is related to increases in body fat is well established in literature[2,3]. However, there are controversial opinions on their relationship with the distribution of body fat[3-5].

To discriminate the amount of body fat and its distribution, anthropometric indicators have proven to be effective, especially in epidemiological studies with larger samples. While the body mass index (BMI) predicts the overall fat, waist circumference (WC) and the conicity index (C Index) identify the fat located in the central region of the body. The waist-to-height ratio (WHtR) considers the proportion of central fat by the individual's height.

Detecting high blood pressure at young ages is an important action for the control and prevention of hypertension in adulthood. The difficulty in performing this monitoring lies in the fact that adolescents, in general, do not know the values of their blood pressure for not measuring it routinely[6].

High blood pressure indirectly identified through anthropometric indicators may be an efficient strategy for the detection and control, mainly because these measures can be implemented without specialized technical apparatus. This strategy allows screening adolescents with blood pressure abnormalities in their school environment and referral to a more thorough clinical evaluation.

Thus, the purpose of this study was to determine the predictive power of anthropometric indicators and establish cutoff points for discriminating high blood pressure in adolescents.

Methods

This study is linked to a school-based epidemiological survey entitled "Risk factors for atherosclerosis in adolescents" coordinated by members of the Sports Centre of the

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Universidade Federal de Santa Catarina, in partnership with the Municipal Health Department of Três de Maio, Rio Grande do Sul. The project was approved by the Ethics Committee on Human Research of *Universidade Federal de Santa Catarina* (Opinion No. 41/2006), and the data were collected from June to July 2006.

Três de Maio is located in the northwestern area of the state of Rio Grande do Sul and belongs to the microregion of Santa Rosa. It had a population of around 24,333 inhabitants (IBGE, 2007)[7]. The population of Três de Maio consists predominantly of German, Italian and Polish descendants, which characterizes a strong mixing between the groups. The city has a land area of 424.2 km², basically primary economy and high Human Development Index (HDI = 0.83)[8].

Population and sample

The study population (N = 1642) comprised all adolescents aged 14-19 years (collection period), regularly enrolled in all state and private schools (N = 7) in the urban area of the city of Três de Maio/RS offering Elementary/Middle Education (grade eight), High School and Vocational Courses. The sample was probabilistic, stratified, proportional by sex and economic level proxy, with the following parameters: confidence interval 95% and tolerable sampling error of 3.5 percentage points; 40% prevalence of sedentary lifestyle[9] (by offering greater variability and therefore requiring a larger sample size); and increase of 40% for losses and refusals. Further, for each school, two lists were prepared according to sex, with young people aged 14-19, ordered alphabetically. The selection was developed systematically. We excluded pregnant adolescents.

Data collection

The collection team was trained and calibrated in a pilot study. All anthropometric measurements were performed twice in the morning by the main researcher and recorded by a single recorder, according to a predetermined standardization.

The skin color was self-reported by adolescents, according to the criteria of the Brazilian Institute of Geography and Statistics (IBGE, 2006)[10]. In this study, we chose to establish two categories of analysis: whites and nonwhites (browns, blacks and Indians).

The individuals were weighed and measured according to standardized procedures[11], wearing light clothing and not wearing footwear. We used a mechanical Filizola® branded scale with coupled stadiometer, calibrated by the National Institute of Metrology, Standardization and Industrial Quality of Rio Grande do Sul (INMETRO-RS). Based on these measures, we determined the body mass index [BMI = weight (kg) / height² (m)].

Waist circumference (WC) was measured with an anthropometric fiberglass tape (Mabis) at the midpoint between the last rib and the iliac crest, and we considered the average of both measures.

The waist-to-height ratio (WHtR) was determined by dividing waist circumference (cm) by height (cm), and the conicity index (C index) was determined by measuring weight, height and waist circumference using the following mathematical equation[12]:

$$\text{C Index} = \frac{\text{WaistCircumference(m)}}{0.109\sqrt{\dfrac{\text{BodyWeight(kg)}}{\text{Height(m)}}}}$$

Blood pressure was checked by auscultation, which used a mercury sphygmomanometer (Sankey) with appropriate cuff for the arm circumference, after the student remained five minutes at rest and sitting. The measurement was performed on the right arm at heart level by a single experienced professional (nursing assistant).

Systolic blood pressure (SBP) was determined at the onset of Korotkoff sounds (phase I), and diastolic blood pressure (DBP), at the disappearance of Korotkoff sounds (phase V). The protocol provided that if the first measure exceeded the cutoff point of normality (pre-hypertension or hypertension), a second measure (on another day and time) would be held. If the abnormality persisted, a third measurement would be obtained at a later time. Where two or three blood pressure measurements were taken, the last measurement was used, considering pre-hypertension SBP and/or DBP > percentile 90 and < 95 and hypertension SBP and/or DBP between the percentiles 95 and 99, as recommended by the 1st Brazilian Guideline for the Prevention of Atherosclerosis in Children and Adolescents[13]. This study considered with high blood pressure adolescents who had prehypertension or hypertension.

Statistical analysis

For the characterization of the study variables by gender, we used the Student t test to compare mean values of continuous variables and chi-square test for categorical variables.

The predictive power of anthropometric indicators for high blood pressure were determined by Receiver Operating Characteristic curves (ROC), commonly used for the determination of cutoff points in diagnostic or screening tests[14].

Initially, we identified the total area under the ROC curve between anthropometric indicators (BMI, WC, WHtR and C index) and high blood pressure. The larger the area under the ROC curve, the greater the discriminating power of anthropometric indicators for high blood pressure in adolescents. The confidence interval (CI) determines whether the predictive ability of anthropometric indicators is due to chance and its lower limit should not be less than 0.50[15]. To identify the difference of the areas under the ROC curves, we used the Chi-square test.

For all analyses performed in this study, a confidence interval (CI) of 95% was considered.

Subsequently, we identified the cutoff points for anthropometric indicators that had significant areas under the ROC curve, with their sensitivity and specificity values. Values with sensitivity and specificity closer to each other and not less than 60% were considered criteria for obtaining the cutoff points of anthropometric indicators as predictors of high blood pressure.

The data were organized in a spreadsheet of Microsoft Office Excel©, Version 2003, and analyzed using STATA statistical software, version 7.0.

Results

The sample consisted of 660 adolescents (317 boys and 343 girls), totaling 2.8% of losses (non-participation in both phases of data collection, missing school on the days of collection or school transfer) and 6% of refusals.

Sample characteristics are presented in Table 1. The boys had a higher mean age than girls (p = 0.005). As for color, most adolescents define themselves as white, and those considered non whites were mainly brown (n = 171). Mean body mass, height and waist circumference (WC) (p <0.001) and the prevalence of prehypertension and hypertension were higher in boys (p = 0.004), while WHtR was higher in girls (p = 0.005). High blood pressure, in general, resulted in a prevalence of 3.3% in our sample, with a highest frequency among boys.

The areas under the ROC curve of BMI, WC, WHtR and the C index as predictors of high blood pressure in boys and girls, and their confidence intervals (95%) can be seen in Table 2 and in Figures 1 and 2. All anthropometric indicators had significant areas under the ROC curve. However, WC, BMI and WHtR took over larger areas, with no statistical differences between these indicators in both sexes (boys, p=0.361 and girls p=0.305).

The cutoff points of anthropometric indicators as predictors of high blood pressure, and their relevant sensitivity and specificity (more appropriate balance between them), are presented in Table 3. It is noted that among the anthropometric indicators, WC, BMI, and WHtR attained the best sensitivity and specificity percentages for discriminating high blood pressure, both for boys and for girls.

Table 1 - Mean, standard deviation, minimum and maximum values and percentages of variables analyzed in the study

Variables	Boys (n=317)	Girls (n=343)	p
Age (years)	16.05 ± 1.34 (14-19)	15.76 ± 1.33 (14-19)	0.005 *
Body mass (kg)	63.96 ± 11.65 (31.7-122.3)	56.37 ± 10.86 (33.1-148.5)	<0.001 *
Height (m)	1.73 ± 0.07 (1.46-1.91)	1.62 ± 0.06 (1.44-1.83)	<0.001 *
BMI (kg/m²)	21.29 ± 3.11 (14.9-36.5)	21.34 ± 3.80 (15.5-56.9)	0.829 *
WC (cm)	74.51 ± 7.91 (57.1-112.7)	72.13 ± 7.82 (57.2-116.8)	<0.001 *
WHtR	0.43 ± 0.04 (0.35-0.63)	0.44 ± 0.05 (0.35-0.72)	0.005 *
C Index	1.13 ± 0.04 (1.03-1.32)	1.13±0.05 (1.03-1.27)	0.78 *
Skin color	% (n)	% (n)	
Whites	74.1 (235)	73.5 (252)	
Non whites	25.9 (82)	26.5 (91)	0.847†
Blood pressure	% (n)	% (n)	
Normal	94.3 (299)	98.8 (339)	
Pre-hypertension	2.8 (9)	0.3 (1)	
Hypertension	2.8 (9)	0.9 (3)	0.004 †
Nutritional Status	% (n)	% (n)	
Eutrophic	83.6 (263)	86.3 (296)	
Overweight	13.9 (44)	10.2 (35)	
Obesity	2.5 (8)	3.5 (12)	0.284 †

BMI - body mass index; WC - waist circumference; C Index - conicity index; WHtR - waist-to-height ratio; Student t test for independent samples; † Chi-square test.*

Discussion

This study aimed to identify the predictive power and to propose cutoff points of anthropometric indicators for prediction of high blood pressure with focus in the school environment. From this perspective, it was proposed to screen cases of adolescents with possible chronic abnormalities in blood pressure, and a discussion of a health theme to be worked on in the teaching context. Under no circumstances the data provided by this research are intended to exclude the medical diagnosis; instead they only provide a more comprehensive strategy to be used by schools in a partnership between education and health, which is currently a goal to be reached within the Ministries of Education and Health through the Health Program at School[16].

Despite the recommendation for blood pressure measurement from age three in all clinical visits[17], a study performed in Brasil[6] points out a low frequency of blood pressure in children and adolescents, demonstrating that this procedure has not yet been incorporated into the clinical practice.

Although there is an association between overweight/obesity and high blood pressure, few studies have identified cutoff points of anthropometric indicators that aim to detect pre-hypertension/hypertension[18]. Most investigations have

Table 2 - Area under the ROC curve and 95%CI between anthropometric indicators of obesity and high blood pressure in boys and girls

High blood pressure	Area under the ROC curve (95%CI)			
	Boys	p	Girls	p
BMI (kg/m²)	0.79 (0.68-0.89)*		0.95 (0.87-1.00)*	
WC (cm)	0.80 (0.72-0.89)*		0.96 (0.92-1.00)*	
WHtR	0.77 (0.66-0.88)*		0.93 (0.85-1.00)*	
C Index	0.69 (0.56-0.81)*	0.0004 †	0.74 (0.50-0.98)*	0.0407 †

*BMI - body mass index; WC - waist circumference; WHtR - waist-to-height ratio; C Index - conicity index; ROC - receiver operating characteristic; 95%CI - confidence interval at 95%; * Area under the ROC curve showing discriminatory power for high blood pressure (Li-CI ≥ 0.50); † Chi-square test.*

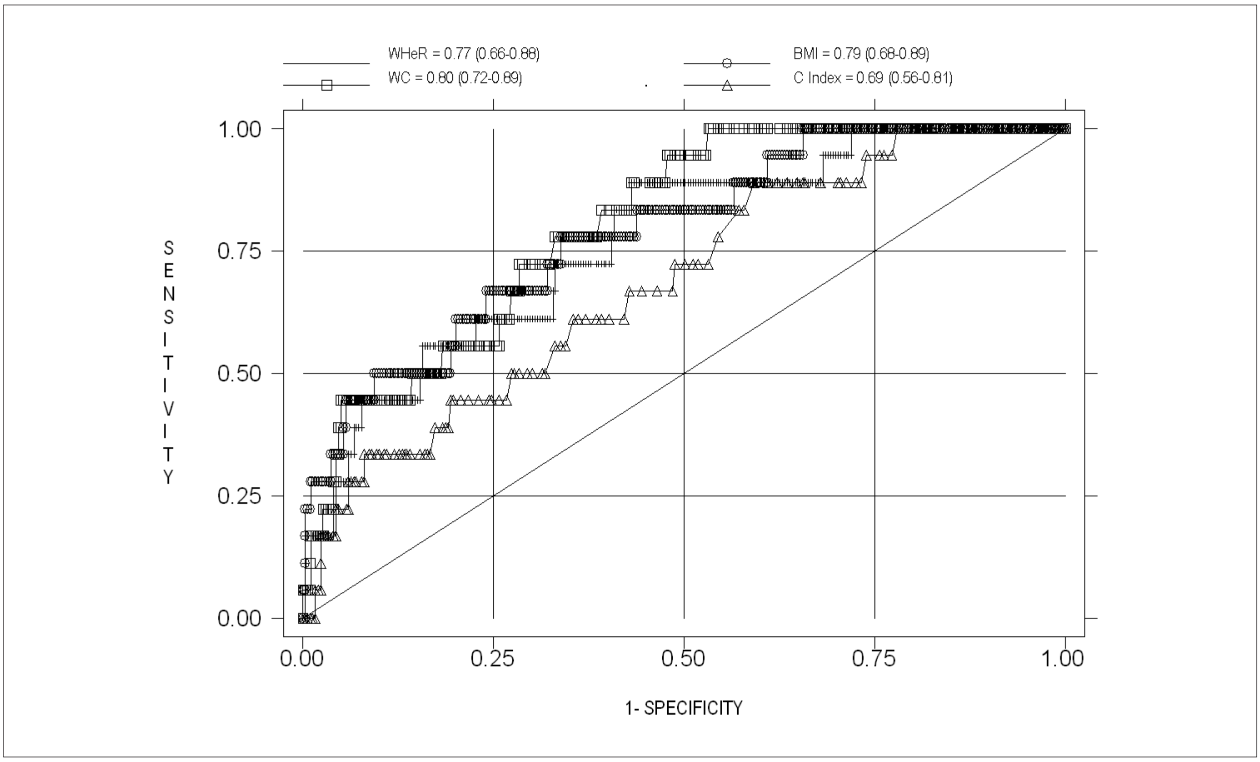

Figure 1 - ROC curves that compare various anthropometric indicators of obesity used in the study as discriminators of high blood pressure (boys). WHtR - waist-to-height ratio; WC - waist circumference; BMI - body mass index; C Index - conicity index.

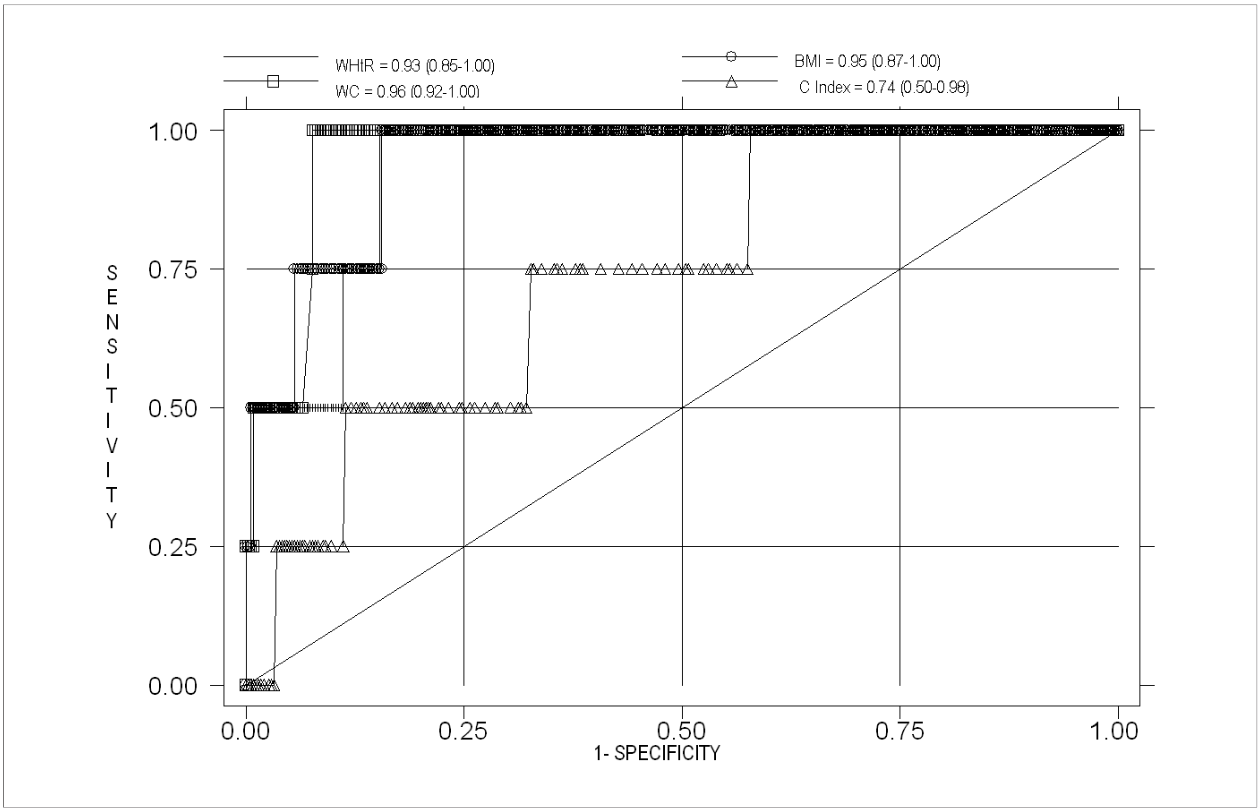

Figure 2 - ROC curves that compare various anthropometric indicators of obesity used in the study as discriminators of high blood pressure (girls). WHtR - waist-to-height ratio; WC - waist circumference; BMI - body mass index; C Index - conicity index.

Table 3 - Cut-off points, sensitivity and specificity of anthropometric indicators as prediction of high blood pressure in boys and girls

High blood pressure	Boys			Girls		
	Cutoff point	Sensitivity (%)	Specificity (%)	Cutoff point	Sensitivity (%)	Specificity (%)
BMI (kg/m²)	21.9	72.22	67.89	24.0	100.00	84.37
WC (cm)	75.4	77.78	66.89	82.4	100.00	92.33
WHtR	0.43	72.22	66.89	0.48	100.00	84.66
C Index	1.13	66.67	57.19	1.14	75.00	67.26

WHtR - waist-to-height ratio; WC - waist circumference; BMI - body mass index; C Index - conicity index.

sought to identify the predictive power of these indicators for the clustering of cardiovascular risk factors[19-21]. However, hypertension is identified as a major cardiovascular risk factor, hence the need for a different look.

A possible limitation of this study was restricted age, which does not include children and adolescents younger than 13, which prevents screening high blood pressure among students at this age.

Consistently with this study, other authors[3] pointed out that the behavior of high blood pressure may differ between sexes. Thus, we chose to identify the predictive power of anthropometric indicators separately.

The prevalence of high blood pressure was lower than that found in other studies[3,18]. However, methodological differences, number of measurements taken and the different reference criteria are the main causes of high variability in the prevalence of high blood pressure among the investigations. In this study, we opted for greater strictness in diagnosing high blood pressure, whereas in conducting three measurements on different days and times, there is a tendency to decrease the frequency of pre-hypertension/hypertension. In this sample, we observed a reduction of 67.7% in the prevalence of high blood pressure from the first to the third blood pressure measurement.

Among the anthropometric indicators, BMI and WC have been widely used in the detection of cardiovascular risk factors[19-21]. Currently, some studies[22,23], especially in Asian populations, have used WHtR to predict central fat and risk factors associated. The C index is more widely used in research with adult populations[24-26].

All anthropometric indicators (BMI, WC, WHtR, C index) were good predictors for high blood pressure. However, the C index presented a smaller discriminatory power than the others. Publications on the prediction of high blood pressure through the C index were not found, making it difficult to compare results found in this study. In Taguatinga, Brasília (DF)[27], it was sought to discriminate insulin resistance in the pediatric population and the C index presented an area under the ROC curve similar to our study, but the cutoff point were higher (C index = 1.23; sensitivity = 63.64 and specificity = 63.27).

WC, BMI and WHtR were the best predictors of high blood pressure, both in males and in females. By comparing the areas under the ROC curve of these three indicators, no differences were observed in both sexes, which suggests that these three anthropometric indicators can be used to predict high blood pressure in adolescents.

Evidence regarding the relationship of body fat distribution with cardiovascular risk factors in children and adolescents are not conclusive. While a survey in Greece found that WHtR and WC are more associated with cardiovascular risk factors than BMI[23], other studies have shown that WC and BMI can be excellent indicators of clustering of cardiovascular risk factors[20,21] and that, when used together, can identify blood pressure variance, especially systolic blood pressure[28]. Other authors[4] also concluded that the pattern of body fat distribution, identified by WC, may be a better indicator for blood pressure control in pediatric populations.

In China[22], we tested the hypothesis that the use of WHtR for children and adolescents could be a measure of central fat irrespective of age, although this was only confirmed for adolescents aged 14 years or more. A study in Iran found cutoff points of WHtR for the detection of high blood pressure among adolescents, and the values found were 0.40 for boys and 0.42 for girls[18]. These cutoff points were lower than those found in this study (boys = 0.43 and girls = 0.48).

Among the studies found, the main purpose of the cutoff points of BMI were to diagnose the weight state and predict cardiovascular risk factors or their clustering[20,29,30]. In Iran[18], a study to discriminate high blood pressure found, for boys, the same cutoff point of this study (BMI = 21.9 kg/m^2) and, for girls, a lower cutoff point (BMI = 19.1 kg/m^2). In China[19], the mean BMI (considering the age group 14-19) for predicting cardiovascular risk factors in male adolescents was similar to the cutoff of this study, but it was lower for girls (BMI = 21.55 kg/m^2).

The Bogalusa study (USA)[31] identified cutoff points of BMI to predict the clustering of cardiovascular risk factors according to age, sex and skin color. By considering the average BMI cutoff points for ages 14-18 and white skin, the BMI found in the American study was higher than in this study for males (BMI = 22.08 kg/m^2) and lower for females (BMI = 22.14 kg/m^2).

Mean BMI cutoff points (14-18 years) to diagnose overweight, according to two different criteria[29,30] were higher than those found in this study, especially for boys. This may suggest that, in our sample, lower body mass indexes may be related to high blood pressure in adolescents.

Regarding WC, the cutoff point identified to predict high blood pressure in girls was higher than that of boys. Moreover, the sensitivity and specificity values of these cutoff points were also higher among girls, which may indicate that the predictive power of WC for high blood pressure is higher among females. Our findings are contrary to the findings of other studies[18-20] where the cutoff points of WC for boys were higher than the cutoff points set for girls.

In a study conducted in Iran[18] and in the Bogalusa study (USA)[20], the cutoff points for predicting cardiovascular risk factors for females were lower than in this study (WC = 82.4 cm), which showed a value close to the percentile 95 of WC of Canadian[31] and Australian[32] adolescents and presented a value lower than the 75th percentile of American adolescents[33].

The cutoff point of WC in boys was very close to the 50th percentile in a sample of American[33] adolescents and to the 75th percentile in Australian[32] adolescents. The study performed in Iran[18] found a cutoff point of 76.5 cm for high blood pressure, and the Bogalusa study (USA)[20] found a cutoff point of WC of 78.4 cm for boys, from the average values of WC in the age group 14-18.

Conclusion

Despite the excellent areas under the ROC curve of WHtR, BMI and WC, as well as the strong correlation between BMI and WC with blood pressure in pediatric populations, it is recommended to use the measurement of WC in cutoff points of 74.5 cm for boys and 82.4 cm for girls in order to detect high blood pressure in adolescents with similar characteristics to our sample. The indication of WC allows that this measure be held in schools as a method of screening adolescents with high blood pressure, since many educational institutions lack scale and stadiometer. Simply using a tape measure may be very effective in detecting this cardiovascular risk factor. Health professionals, who normally performs anthropometric and physical assessments, may resort to an additional interpretation resource and refer specific cases to clinical evaluation. Thus, we can effectively achieve one of the strategies for the prevention of hypertension, which is control of blood pressure since childhood.

However, caution should be exercised in using the cutoff point of WC found for girls, because high blood pressure presented a low prevalence among females, which may have overestimated the result.

It is evident that further studies are required to identify cutoff points of anthropometric indicators focusing on the detection of high blood pressure and other cardiovascular risk factors in Brazilian children and adolescents of different ethnicities and ages.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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References

1. McMahan AC, Gidding SS, Fayad ZA, Zieske AW, Malcom GT, Tracy RE, et al. Risk scores predict atherosclerotic lesions in young people. Arch Intern Med. 2005; 165 (8): 883-90.
2. Bao W, Threefoot SA, Srinivasan SR, Berenson GS. Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood: the Bogalusa Heart Study. Am J Hypertens. 1995; 8 (7): 657-65.
3. Silva KS, Farias Júnior JC. Fatores de risco associados à pressão arterial elevada em adolescentes. Rev Bras Med Esporte. 2007; 13 (4): 237-40.
4. Flores-Huerta S, Klünder-Klünder M, Reyes de la Cruz L, Santos JI. Increase in body mass index and waist circumference is associated with high blood pressure in children and adolescents in Mexico city. Arch Med Res. 2009; 40 (3): 208-15.
5. Guimarães ICB, Almeida AM, Santos AS, Barbosa DBV, Guimarães AC. Pressão arterial: efeito do índice de massa corporal e da circunferência abdominal em adolescentes. Arq Bras Cardiol. 2008; 90 (6): 393-9.
6. Silva MAM, Rivera IR, Souza MGB, Carvalho ACC. Medida da pressão arterial em crianças e adolescentes: recomendações das diretrizes de hipertensão arterial e prática médica atual. Arq Bras Cardiol. 2007; 88 (4): 491-5.
7. Instituto Brasileiro de Geografia e Estatística (IBGE). IBGE @Cidades. [Acesso em 2009 mar 27]. Disponível em http://www.ibge.gov.br/cidadesat/topwindow.htm?1
8. Atlas do desenvolvimento humano no Brasil (IDH-M) 1991 – 2000. [Acesso em 2009 mar 5]. Disponível em http://www.fjp.gov.br/produtos/cees/idh/atlas_idh.php
9. Giuliano ICB. Lípides séricos em crianças e adolescentes da rede escolar de Florianópolis [dissertação]. Florianópolis: Universidade Federal de Santa Catarina; 2003.
10. Instituto Brasileiro de Geografia e Estatística (IBGE). Pesquisa mensal de emprego: mercado de trabalho segundo a cor ou raça. 2006. [Acesso em 2009 mai 5].Disponível em: http://www.ibge.gov.br/home/estatistica/indicadores/
11. Alvarez BR, Pavan AL. Alturas e comprimentos. In: Petroski EL. Antropometria: técnicas e padronizações. Santa Maria: Pallotti; 2005. p. 31-58.
12. Valdez R. A simple model-based index of abdominal adiposity. J Clin Epidemiol. 1991; 44 (9): 955-6.
13. Giuliano ICB, Caramelli B, Pellanda L, Duncan B, Mattos S, Fonseca FAH/ Sociedade Brasileira de Cardiologia. I Diretriz de prevenção da aterosclerose na infância e na adolescência. Arq Bras Cardiol. 2005; 85 (supl. 6): 3-36.
14. Erdreich LS, Lee ET. Use of relative operating characteristics analysis in epidemiology: a method for dealing with subjective judgment. Am J Epidemiol. 1981; 114 (5): 649-62.
15. Schisterman EF, Faraggi D, Reiser B, Trevisan M. Statistical inference for the area under the receiver operating characteristic curve in the presence of random measurement error. Am J Epidemiol. 2001; 154 (2): 174-9.
16. Decreto nº 6.286, de 5 de dezembro de 2007. Institui o programa de saúde na escola – PSE, e da outras providências. Diário Oficial da União (DOU) 2007. 234 (6286) seção 1, 6 de dezembro de 2007. [Acesso em 2007 mar 6]. Disponível em: http://www.in.gov.br/imprensa/pesquisa/pesquisaresultado.jsp.
17. Mion Jr D, Kohlmann Jr O, Machado CA, Amodeo C, Gomes MAG, Praxedes

JN, et al. Sociedade Brasileira de Cardiologia. V Diretrizes brasileiras de hipertensão arterial. Arq Bras Cardiol. 2007; 89 (3): e24-e79.

18. Kelishadi R, Gheiratmand R, Ardalan G, Adeli K, Gouya MM, Razaghi EM, et al. Association of anthropometric indices with cardiovascular disease risk factors among children and adolescents: CASPIAN Study. Int J Cardiol. 2007; 117 (3): 340-8.

19. Sung RY, Yu CC, Choi KC, McManus A, Li AM, Xu SL, et al. Waist circumference and body mass index in Chinese children: cutoff values for predicting cardiovascular risk factors. Int J Obes. 2007; 31 (3): 550-8.

20. Katzmarzyk PT, Srinivasan SR, Chen W, Malina RM, Bouchard C, Berenson G. Body mass index, waist circumference, and clustering of cardiovascular risk factors in a biracial sample of children and adolescents. Pediatrics. 2004; 114 (2): 198-205.

21. Ng VWS, Kong APS, Choi KC, Ozaki R, Wong GWK, So WY, et al. BMI and waist circumference in predicting cardiovascular risk factor clustering in chinese adolescents. Obesity. 2007; 15 (2): 494-503.

22. Sung RY, So HK, Choi KC, Nelson EA, Li AM, Yin JA. Waist circumference and waist-to-height ratio of Hong Kong Chinese children. BMC Public Health. 2008; 8: 324.

23. Savva SC, Tornaritis M, Savva ME, Kourides Y, Panagi A, Silikiotou N, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes Relat Metab Disord. 2000; 24 (11): 1453-8.

24. Pitanga FJ, Lessa I. Anthropometric indexes of obesity as an instrument of screening for high coronary risk in adults in the city of Salvador-Bahia. Arq Bras Cardiol. 2005; 85 (1): 26-31.

25. Ghosh JR, Bandyopadhyay AR. Comparative evaluation of obesity measures: relationship with blood pressures and hypertension. Singapore Med J. 2007; 48 (3): 232-5.

26. Pitanga FJG, Lessa I. Indicadores antropométricos de obesidade como instrumento de triagem para risco coronariano em mulheres. Rev Bras Cineantrop Desempenho Hum. 2006; 8 (1): 14-21.

27. Moreira SR, Ferreira AP, Lima RM, Arsa G, Campbell CSG, Simões HG, et al. Predicting insulin resistance in children: anthropometric and metabolic indicators J Pediatr. 2008; 84 (1): 47-52.

28. Lee S, Bacha F, Arslanian SA. Waist circumference, blood pressure, and lipid components of the metabolic syndrome. J Pediatr. 2006; 149 (6): 809-16.

29. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000; 320 (7244): 1240-3.

30. Conde WL, Monteiro CA. Valores críticos de índice de massa corporal para classificação do estado nutricional de crianças e adolescentes brasileiros. J Pediatr. 2006; 82 (4): 266-72.

31. Katzmarzyk PT. Waist circumference percentiles for Canadian youth 11-18y of age. Eur J Clin Nutr. 2004; 58 (7): 1011-5.

32. Eisenmann JC. Waist circumference percentiles for 7- to 15-year-old Australian children. Acta Paediatr. 2005; 94 (9): 1182-5.

33. Fernández JR, Redden DT, Pietrobelli A, Allison DB. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. J Pediatr. 2004; 145 (4): 439-44.