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Original Article

Waist circumference as screening instrument for cardiovascular disease risk factors in schoolchildren

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Abstract

Objective: To propose cutoff points for waist circumference of schoolchildren for the identification of cardiovascular disease risk factors.

Methods: This school-based cross-sectional study surveyed 1,413 schoolchildren aged 7 to 12 years old, selected by random cluster sampling. Waist circumference, total cholesterol and systolic and diastolic pressures were measured. Reference values for cardiovascular disease risk factors were developed from measures of total cholesterol and systolic and diastolic blood pressures. The receiver operating characteristic (ROC) curve and bivariate analysis, followed by calculation of sensitivity, specificity and odds ratio, were used in data analysis.

Results: The cutoff points had area values under the ROC curve ranging between 0.603 and 0.949, while sensitivity and specificity ranged between 0.500 and 1.00. Among all proposals analyzed, the one presented by this study best balanced sensitivity and specificity values. Bivariate analysis followed by odds ratios calculation indicated that subjects with waist circumference above the proposed cutoff points have increased chances of presenting cardiovascular disease risk factors.

Conclusions: The cutoff points proposed in the present study seem to be a valid alternative and better balance sensibility and specificity than other proposals for screening students with increased chances of presenting cardiovascular disease risk factors.

J Pediatr (Rio J). 2010;86(5):411-416: Anthropometry, ROC curve, sensitivity, specificity, children.

Introduction

Studies with adults suggest abdominal fat deposition is a more important indicator for the onset cardiovascular disease (CVD) and its risk factors than overall fat levels.[1-3] Measuring waist circumference (WC) is a good way to determine central adiposity,[4] making it a viable alternative to screen individuals at high risk for CVD. Among children and adolescents, the measure also seems to be firmly related to central adiposity.[5-7]

As well as their direct relationship with central adiposity, WC measures from children and adolescents are associated with CVD risk factors,[8-10] enabling their use as an instrument to screen children and adolescents for greater likelihood of developing these conditions. However, while specific values for adult men and women[4] allow us to assess WC in terms of cardiovascular health, the growth process requires us to establish age-dependent cutoff points for children and

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adolescents.[11] Thus, some authors have proposed solutions that would enable us to assess WC values for children and adolescents.[8,12,13]

In Brazil, only one study has proposed cutoff points for children's WC.[14] However, there have been no proposed cutoff points for children and adolescents of various ages using a representative sample, requiring the use of international proposals in order to classify individuals according to WC values. Considering the information presented and discussed below, the objectives of this study are: a) to propose cutoff points for WC values for schoolchildren; b) to assess the performance of the WC cutoff points found in the literature as screening instruments for CVD risk factors in schoolchildren; c) to identify which proposed cutoff points for WC can best identify which schoolchildren have CVD risk factors.

Methods

This school-based cross-sectional study surveyed schoolchildren aged 7 to 12 years old of both genders enrolled in city, state and private institutions in Caxias do Sul, in the Brazilian state of Rio Grande do Sul. In 2005, according to data from the State Department of Education, there were 33,241 schoolchildren aged 7 to 12 years old in the state. Based on similar studies,[15,16] mean prevalence of high blood pressure and hypercholesterolemia was estimated at 20 percent to calculate the appropriate sample size. Using a 95 percent confidence interval, test power of 80 percent, and error of estimation of 3 percent, the study required a sample of 669 children. Using a design effect of 2 to control for confounding factors, as well as an additional 15 percent to compensate for possible losses and refusals, initial estimates suggested the study needed to assess 1,573 children. Of the 1,573 children assessed in this study, WC and blood pressure (BP) was measured for 1,413 of them; 1,294 allowed the collection of blood samples. The study used random cluster sampling, with each school representing one cluster. All schools took part of the random selection process and had the same odds depending on the number of enrollees aged 7 to 12 years old in each school. The study was approved by the Research Ethics Committee of Universidade Luterana do Brasil (Protocol 2006-365H). Data were collected between April and August 2007.

Waist circumference measurements were made using a Sanny® (American Medical do Brasil Ltda., São Bernardo do Campo, Brazil) tape measure by positioning the tape between costal margin and iliac crest of subjects.[17] The reference criteria for the analysis comes from cutoff points proposed by Freedman et al.,[8] Taylor et al.[12] and Fernández et al.[13]

The following CVD risk factors were measured in the participants: total cholesterol (TC), systolic blood pressure (SBP), and diastolic blood pressure (DBP). TC values were obtained using an Accutrend® GCT (Roche Diagnostics, São Paulo, Brazil) portable monitor. Schoolchildren were not required to fast for any period before collection, since there was no significant variation whether the individual fasted or not.[18] This form of measuring TC (Accutrend® GCT portable monitor) and this procedure (not fasting) were used by Sociedade Brasileira de Cardiologia (Brazilian Cardiology Society) in a national campaign that surveyed over 81 thousand individuals.[19] Total cholesterol was considered "desirable" if below 170 mg/dL; "threshold" if between 170 and 199 mg/dL; and "high" if 200 mg/dL or higher.[18]

BP measures were taken using (pediatric) stethoscopes and cuffs manufactured by Becton Dickinson® (Becton, Dickinson and Company, São Paulo, Brazil) as well as sphygmomanometers by Cardiomed® (Curitiba, Brazil) and Oxigen®, all certified by Instituto Nacional de Metrologia. SBP was determined by the first Korotkoff sound, while DBP was determined by their disappearance. Three measures were taken from each patient, at intervals of 3 minutes. BP was categorized by gender, age and height percentile. Subjects were considered normal if they had SBP and DBP below the 90th percentile; "pre-hypertensive" if between the 90th and 95th percentiles; and "hypertensive" if above the 95th percentile.[20]

In order to propose cutoff points for WC, we used the receiver operating characteristic (ROC) curve to analyze the data. The procedure requires a reference variable (binary variable) and a test variable (in this study, WC). To that end, CVD risk factors were used to establish three possible references. These references were CVD risk factors score ≥ 5 (CVD score ≥ 5); CVD risk factors score ≥ 6 (CVD score ≥ 6); and CVD risk factors score ≥ 7 (CVD score ≥ 7). The three CVD risk factors scores were developed by adding other factors, considering TC classification proposed by III Diretrizes Brasileiras Sobre Dislipidemias (III DBSD, third Brazilian dyslipidemia guidelines)[18]; and SBP and DBP by the National High Blood Pressure Education Program (NHBPEP)[20]. In this categorization, lack of risk factors (TC = desirable; SBP and DBP = normal) equals "1," presence of intermediate risk factors (TC = threshold; SBP and DBP = prehypertensive) equals "2" and presence of risk factors (TC = high; SBP and DBP = hypertensive) equals "3."

After establishing these three references for CVD risk factors, the ROC curve between each of them was determined and WC stratified into gender and age groups. The reference with the greatest area under the curve, according to age averages, was chosen as the reference value for CVD risk factors. For boys, the reference was CVD score ≥ 6 (0.789), while for girls it was ≥ 7 (0.688). With definite CVD risk factor references, specific WC values that best balanced sensitivity and specificity were identified for each age and gender group, thus establishing cutoff points for WC from the data collected in this study.

In the attempt to identify individuals at higher odds of having CVD risk factors, we analyzed the validity of

WC cutoff points suggested by the literature and by this study. The analysis used bivariate analysis to assess the WC of schoolchildren in this sample, as categorized by each proposed cutoff point and using the references with the greatest area under the ROC curve, followed by sensitivity and specificity calculations. To identify how much each individual surpassing the WC cutoff point in each proposal was at higher of having CVD risk factors than their peers with smaller WC, this study used bivariate analysis followed by odds ratio calculations (OR). Analyses used to identify cutoff points considered an area under the ROC curve of at least 50% (0.5)[21], while bivariate analyses used a 95% confidence interval (95%CI) and $p \leq 0.05$. All analysis was performed using Statistical Package for the Social Sciences (SPSS®, SPSS Inc., IBM, Chicago, IL, EUA) for Windows, version 13.0.

Results

The results of the analysis of the ROC curve between WC and CVD risk factor references by age and gender can be found in Table 1. Analyzing the results, we see that proposed cutoff points become higher as male and female subjects grow older. The area under the ROC curve was greater than 50 percent for all ages and both genders, ranging from 0.603 (60.3%) to 0.949 (94.9%). Sensitivity values ranged from 0.500 (50%) to 1.00 (100%) for all ages and both genders, thus showing the ability to identify schoolchildren classified as having CVD risk factors above cutoff values (true positives). Specificity values ranged from 0.549 (54.9%) to 0.898 (89.8%), thus showing the ability to identify schoolchildren classified as not having CVD risk factors below cutoff values (true negatives).

Table 2 shows sensitivity and specificity values calculated using bivariate analysis between WC cutoff points proposed by Freedman et al.,[8] Taylor et al.,[12] Fernández et al.[13] and the present study, with their respective CVD risk factors reference values stratified into gender groups. Analyzing the results, we find the proposal put forth by this study has the highest values and best balances sensitivity and specificity, recommending it for the choice of WC cutoff points. The cutoff points found in the literature had low sensitivity and high specificity values, making them less capable of identifying true positives, though more capable of identifying true negatives (Table 2).

When WC is categorized according to the cutoff points proposed by this study and associated to CVD risk factor references through bivariate analysis followed by OR calculations, we see that schoolchildren of both genders who are above the cutoff points are at higher odds of having CVD risk factors (Table 3). Boys above the cutoff point are 10.2 times more likely to have CVD risk factors than those below it, while girls are 4.59 times more likely to have CVD risk factors if they are above the cutoff point (Table 3).

Discussion

Considering the evidence that individuals with greater central adiposity are more susceptible to CVD and its risk factors,[1-3] and that these diseases begin in childhood and adolescence[22], identifying values that increase the risk of developing these problems among schoolchildren seems critically important and a useful instrument for primary prevention. Thus, this study is a first national attempt to propose WC cutoff points in a school-based population sample, with empirical validation through association with CVD risk factors.

Mean values for ages below the ROC curve in our study (0.789 and 0.688 for boys and girls, respectively) were similar (0.88 and 0.74 for boys and girls, respectively) to those found by Lunardi & Petroski.[14] In the latter study, the

Table 1 - Results of receiver operating characteristic curve between waist circumference and reference values for cardiovascular disease risk factors

	Boys CVD score ≥ 6						Girls CVD score ≥ 7					
Age	**n**	**AUC**	**95%CI**	**SENS**	**SPEC**	**CP**	**n**	**AUC**	**95%CI**	**SENS**	**SPEC**	**CP**
7 years old	61	0.697	0.56-0.83	0.667	0.736	63.85	56	0.603	0.31-0.90	0.500	0.788	58.25
8 years old	116	0.949	0.86-1.00	1.00	0.898	64.00	108	0.569	0.31-0.83	0.500	0.567	59.65
9 years old	140	0;841	0.54-1.00	0.857	0.844	66.45	111	0.589	0.27-0.90	0.600	0.651	61.10
10 years old	128	0.744	0.62-0.86	0.667	0.702	66.75	126	0.692	0.45-0.94	0.600	0.719	65.85
11 years old	118	0.859	0.76-0.96	0.800	0.796	72.65	135	0.879	0.79-0.97	0.800	0.792	70.50
12 years old	80	0.643	0.27-1.00	0.667	0.844	75.75	87	0.797	0.60-0.99	0.750	0.771	71.75

AUC = area under receiver operating characteristic curve; CP = cutoff point for waist circumference (cm) above which subject is at increased risk for cardiovascular disease risk factors; CVD = cardiovascular disease; n = sample; SENS = sensitivity; SPEC = specificity.

Table 2 - Sensitivity and specificity of waist circumference cutoff points proposed by Fernández et al.,[13] Taylor et al.,[12] Freedman et al.[8] and this study in relation to CVD score ≥ 6 (male) and CVD score ≥ 7 (female)

	Boys - CVD score ≥ 6		Girls - CVD score ≥ 7	
Suggested CP	**SENS (95%CI)**	**SPEC (95%CI)**	**SENS (95%CI)**	**SPEC (95%CI)**
Fernández et al.[13]	0.56 (0.52-060)	0.80 (0.77-0.83)	0.38 (0.34-0.42)	0.84 (0.81-0.87)
Taylor et al.[12]	0.54 (0.50-0.58)	0.83 (0.80-0.86)	0.34 (0.30-0.38)	0.84 (0.81-0.87)
Freedman et al.[8]	0.15 (0.12-0.18)	0.95 (0.93-0.97)	0.21 (0.18-0.24)	0.95 (0.93-0.97)
Presente estudo	0.73 (0.76-0.79)	0.79 (0.76-0.82)	0.65 (0.61-0.69)	0.70 (0.66-0.74)

95%CI = 95% confidence interval; CP = cutoff points; CVD = cardiovascular disease; SENS = sensitivity; SPEC = specificity.

Table 3 - Result of bivariate analysis followed by odds ratio calculations for cardiovascular disease risk factor reference values and waist circumference categorized by various proposed cutoff points

	Boys (CVD score ≥ 6)				Girls (CVD score ≥ 7)			
CP suggested	**n (%)**	**OR**	**95%CI**	**p**	**n (%)**	**OR**	**95%CI**	**p**
Fernández et al.								
Below CP	503 (78.2)	1.00	–	–	517 (17.0)	1.00	–	–
Above CP	140 (21.8)	5.32	2.78-10.18	0.000	106 (83.0)	3.22	1.47-7.04	0.002
Taylor et al.								
Below CP	518 (80.6)	1.00	–	–	520 (83.5)	1.00	–	–
Above CP	125 (19.4)	5.63	2.94-10.78	0.000	103 (16.5)	2.85	1.28-6.32	0.007
Freedman et al.								
Below CP	609 (5.0)	1.00	–	–	590 (94.7)	1.00	–	–
Above CP	34 (95.0)	3.53	1.37-9.08	0.006	33 (5.3)	5.50	2.07-10.70	0.000
This study								
Below CP	486 (75.6)	1.00	–	–	430 (69.0)	1.00	–	–
Above CP	157 (24.4)	10.20	4.97-20.91	0.000	193 (31.0)	4.59	2.09-10.06	0.000

95%CI = 95% confidence interval; CP = cutoff points; CVD = cardiovascular disease; n (%) = absolute and (percentage) sample number; OR = odds ratio; p = significance.

authors proposed WC cutoff points using a sample of 374 schoolchildren, mean age 11, by analyzing the ROC curve and using blood lipid levels as reference. However, a study by Taylor et al.[12] used trunk fat as measured by dual energy X-ray absorptiometry (DEXA) as reference to calculate the area under the ROC curve, and it found higher values for the area under the ROC curve (0.97 for both genders) above those found by the present study.

The higher values for the area under the ROC curve found in the study by Taylor et al.[12] may be explained by the fact it used DEXA to measure of trunk fat (WC also measures the trunk), and so it makes sense to find a greater area under the ROC curve. That perspective is supported by the strong association between WC and trunk fat as measured by imaging techniques in children and adolescents.[5-7]On the other hand, despite the association between higher WC and higher blood lipid and blood pressure levels, correlation between WC and CVD risk factors are only moderate to low,[8,23] possibly because many variables contribute to the variation in CVD risk factors results, such as physical fitness, habitual physical activity, nutritional status, dietary habits, family history, socioeconomic status, and maturational stage.[15,24-29] We should also stress that the CVD risk factor scores used in this study do not consider other risk factors, such as triglycerides and high- (protective factor) and low- (risk factor) density proteins. Not controlling for these represents a limitation of the results of the present study. However, since we have found satisfactory values for the area under the ROC curve, sensitivity and specificity, that limitation does invalidate the results found by the study as proposed WC cutoff points for schoolchildren.

Among the cutoff points studied, none better balanced sensitivity and specificity than those proposed by this study. Thus, said values may be recommended for the task of identifying schoolchildren at higher odds of presenting CVD risk factors. On the other hand, the waist circumference evaluation values proposed by Freedman et al.[8] had the worst balance between sensitivity and specificity, and were the least useful at identifying true positives. The study by Almeida et al.,[30] which calculated sensitivity and specificity values for the WC cutoff points proposed by Freedman et al.[8] and Taylor et al.,[12] using, among other parameters, TC, and the study by Rosa et al.,[10] which calculated sensitivity and specificity values for the WC cutoff points proposed by Fernández et al.,[13] using high blood pressure, had low sensitivity and high specificity values for the three proposals, which agrees with the findings of the present study.

Bivariate analysis, followed by odds ratio calculation, identified that schoolchildren above the proposed cutoff points are at higher risk of presenting CVD risk factors than those below these cutoff points. The results of this analysis agrees with the available literature, which indicates an association between high WC values and the presence of CVD risk factors among children and adolescents.[8-10,28]

Considering the results of this study, the evidence indicates individuals with higher WC values are more likely to have CVD risk factors than those with lower values. Also, the cutoff points proposed by the present study are more appropriate than those provided by the literature for the task of identifying schoolchildren more likely to have CVD risk factors. Thus, the study suggests that we should measure WC and use its proposed cutoff points to screen schoolchildren at higher risk of having CVD risk factors.

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