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Research Article

Waist-To-Height Ratio as an Indicator of Dyslipidemia in Brazilian School-Aged Children and Adolescents

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Abstract

Objectives: To evaluate whether BMI-for-age Z-score (BAZ), Waist Circumference (WC), or Waist-to-Height ratio (WHtR) accurately identifies dyslipidemia in a school age population.

Study Design: This was a cross-sectional design study from a city of South of Brazil. A total of 592 children and adolescents from 11 schools were stratified into four groups: boys 6-11 years; boys 12-17 years; girls 6-11 years; girls 12-17 years. Area under the Curve (AUC) for ROC distribution evaluated anthropometric tools' performance to identify two or more alterations on lipid profile (Total Cholesterol, Triglycerides, HDL-cholesterol, LDL-cholesterol). Youden Index was used to extract optimal cut-off points for each anthropometric tool.

Results: All anthropometric indices achieved moderate to high ability to identify dyslipidemia. WHtR was among the best performances for AUC in all groups, when compared to other anthropometric tools, and presented the strongest performance for boys at 12-17 years (0.902±0.04). According to best performances, optimal cut-offs points were: 0.74 for BAZ, 63.25 cm for WC, and 0.485 for WHtR in boys at 6-11. WHtR's cut-off of 0.5 for boys at 12-17 presented the highest accuracy (0.757) when compared to all indices among all groups. Girls at 6-11 presented optimal cut-off values of 1.71 for BAZ, and 0.499 for WHtR, while the older ones presented 71.25 cm for WC and 0.498 for WHtR.

Conclusions: The three anthropometric indices were useful to identify dyslipidemia in school children and adolescents. Overall, WHtR can improve and simplify the screening process and should be encouraged as an index of cardiovascular risk factors.

Keywords: Body Mass Index; Waist Circumference; Waist-Height Ratio; Child; Cholesterol; Hdl; Lipids; Cardiovascular Diseases; Risk

Abbreviations

AUC: Area under the Curve; BAZ: BMI-for-age Z-score; BMI: Body Mass Index; CVD: Cardiovascular Disease; DALYs: Disability Adjusted Life Years; ROC: Receiver Operating Characteristic; UFCSPA: Federal University of Health Sciences of Porto Alegre; WC: Waist Circumference; WHtR: Waist-to-Height Ratio

Introduction

The increased prevalence of obesity and overweight is now considered to be a global pandemic [1-3]. In 2010, it was estimated that overweight and obesity caused 3-4 million deaths, a loss of 4% loss of life years, and 4% of Disability Adjusted Life Years (DALY) due to co-morbidities associated with excessive body fat mass [4]. Globally, the prevalence of overweight and obesity is 27.5% for adults is 47.1% for children. In absolute numbers, this population has increased from 857 million to 2.1 billion people, from 1980 to 2013 [5]. Thus, it is clear that obesity and overweight are serious public health problems and it is important not just to improve our understanding of how excess body weight increases the risk for chronic disease but how to prevent this scenario from growing.

Excess body weight and obesity are positively associated with Cardiovascular Diseases (CVD), the leading cause of death in the world [6,7]. The development of CVDs is associated with a number of risk factors, such as the consumption of high-fat diets and high levels of plasma lipids, which generally begin in childhood [8,9]. As reported by Berenson et al. [10], the level of cholesterol in infancy is a predictive factor of the cholesterol level in adulthood, a primary risk factor for CVDs. Atherosclerosis begins in infancy by the increase of plasma cholesterol and can be accelerated by obesity through a number of indicators, such as family history, physical inactivity, and hypertension [11]. Therefore, it is important to intervene as soon as possible to prevent risk factors from becoming more severe or numerous. Yet, it is unclear what anthropometric variable is most associated with abnormal lipid profiles, making the criteria for intervention difficult to determine.

The assessment of excess body weight and its relationship to other biological risk factors can be accomplished with relatively simple anthropometric markers. Two of the most common anthropometric assessments of overweight are Body Mass Index (BMI) and Waist Circumference (WC) which may explain part, but not all, of the potential risk for CVD in children. These two anthropometric indices have presented strong associations with fat mass for children and

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adults [12]. Waist-to-Height Ratio (WHtR) has been proposed as an alternative measure that concerns both longitudinal growth and central adiposity [13]. This index can be used to screen relevant changes in body composition and have already been used to identify risk for chronic diseases in adults and children [14,15]. However, how these three anthropometric indices are able to identify dyslipidemia in children of different ages and sex has not been well established. Therefore, the aim of this study was to compare the accuracy of BMI-for-age Z-score (BAZ), WC and WHtR to identify lipid profile alterations in school age children and adolescents from Sapucaia do Sul, Brazil.

Materials and Methods

Study design and population

This cross-sectional study was based on a population of 592 children and adolescents of school age (6-17 years) from Sapucaia do Sul city, an urban city with an estimated population of 130,957 located in the state of Rio Grande do Sul, in the south of Brazil, enrolled in 2008. All public schools ruled by the city's government were invited in a collaborative work with Municipal Department of Health. School's directors that declared an interest and viability to participate in the study represented the eleven municipal schools. Groups were classified according to age and sex. Children and adolescents were stratified into four groups: Boys at 6 to 11.99 years; Boys at 12 to 17.99 years; Girls at 6 to 11.99 years; Girls at 12 to 17.99 years.

The staff that conducted the data collection was previously trained and informed according to the project's technical and ethical aspects. Children of school age and regularly matriculated at the selected schools were invited to initiate in the study. Familiar responsible accompanied the children and signed the Informed Consent with the supervision of a previously trained member of the research's staff. Data was collected in a regular school day by the morning period.

Anthropometry

A single trained field worker obtained both subject's weight and height. Weight was measured with no shoes and light clothes on using a digital weighing-machine (Techline®, Brazil), precision of 100g. Height was measured to the nearest 0.1 cm using a wall-mounted stadio-meter (Seca®, Germany). Waist Circumference (WC) was obtained from the narrowest point of the subject's chest with a non-extensive tape measure. Waist-to-Height Ratio (WHtR) value was obtained from the equation: Waist (cm)/Height (cm). Body-Mass-Index (BMI) value was obtained from the equation: weight (kg) / height (m^2). Definition of overweight and obesity was, according to BMI-for-age Z-score (BAZ). Children who presented >1 Z-score were classified as overweight, and >2 Z-score were classified as obese [16]. Those who presented ≥90 percentile of WC were considered as central obese [17]. Values ≥0.5 for WHtR were considered high [13].

Blood analysis

Blood samples were obtained in 12 hours fasting state, with a vacuum system from the brachial vein. The samples were collected in tubes with no anti-coagulant for serum. The tubes were centrifuged at 3,500/10 minutes and analyzed immediately afterwards. Analysis were obtained using automation apparatus Lab max (Lab test, Brazil), after quality control (3 times for control and 3 times for pathologic serums), at The Laboratory of Clinics Analysis in Divina Providência Hospital-Porto Alegre. Total Cholesterol and Triglycerides were extracted by colorimeter enzymatic test (altered values were established at ≥170 and ≥130 mg/dL, respectively), HDL-cholesterol was extracted by precipitation (altered value was established at ≤45 mg/dL) and LDL-cholesterol was calculated by the Friedwald equation (altered value was established at ≥130 mg/dL). Lipid concentrations were measured with Lab test kits. Two or more altered values in lipid concentrations were classified as dyslipidemia.

Statistical analysis

Data were analyzed with the software Statistical Package for the Social Sciences (SPSS) version 21.0. In order to evaluate the homogeneous distribution, Kolmogorov-Smirnov test was applied. Normal distribution variables were presented as mean and standard deviation, while non-parametric variables as median and interquartile intervals. Qualitative variables were presented as absolute and relative frequencies. One-way Analysis of Variance (ANOVA) was applied to compare the groups according to anthropometric and biochemistry data. Tukey's post-hoc test was applied to express significant differences among groups, defined as <5%.

Receiver Operating Characteristic (ROC) analysis was used to explore anthropometric indices' performance to associate lipid profile alterations. The accuracy of the anthropometric indices to identify dyslipidemia were assessed by the Area under the Operating Characteristic Curve (AUC); A 95% confidence interval was used (95% CI), based on two or more alterations in the lipid profile. In order to calculate the optimal cut-off point, Youden index (sum of sensitivity and specificity-1) was used [18].

Ethical aspects

The current study was submitted and approved by the Ethical and Scientific Committee of Universidade Federal de Ciências da Saúde de Porto Alegre - UFCSPA (716/08).

Results

This study was a cross-sectional analysis of 592 low income children and adolescents from 6 to 17 years old. A significant number of families were of low-income, as 44.3% had a family annual income of under USD 3.141.52, which represents a monthly income equal to or lower than the national minimum wage (approximately USD 261.79 per month). Mothers spent an average of 6.79±2.8 years in school, while fathers spent 7.01±2.8 years in school.

Prevalence of overweight was 40.5% for the boys and 34.4% for the girls, while 20% of the boys and 12.9% of the girls were classified as obese. High WHtR was identified in 28.2% of the boys and 29.6% of the girls. Central obesity was observed in 22.2% of the boys and in 25.4% of the girls. There were no differences in anthropometric indices between the same age groups (Table 1). Boys showed lower levels of HDL-cholesterol, in mg/dL, at 12-17 years when compared to younger ones (48.7±12 *vs* 43.9±9.4) and when compared to girls of the same age (48.7±10.9 *vs* 43.9±9.4). The boys presented higher prevalence of triglycerides alterations at both age groups, when compared to girls (8.5% *vs* 5.8% at 6-11 and 11.4% *vs* 6.1% at 12-17) (Table 2). Dyslipidemia was identified in 11.8% of the boys and 10.5% of the girls

All anthropometric indices reached moderate to high performance

Table 1: Anthropometric indices for boys and girls stratified by age group.

	Boys (M±SD)			Girls (M±SD)		
	6-11 (n=141)	12-17 (n=79)	Total Boys (n=220)	6-11 (n=224)	12-17 (n=148)	Total Girls (n=372)
Age (years)	9.5±1.6	13.6±1.2	11.0±2.5	9.8±1.3	13.7±1.2	11.4±2.2
Weight (kg)	35.5±11.4	53±14.0	41.9±15.0	36.8±10.6	51.6±12.8	42.7±13.6
Height (cm)	136.9±10.7	158.5±11.7	144.8±15.2	138.8±10.4	156±7.0	145.7±12.5
BAZ (median±IR)	0.83±1.4	0.5±1.4	0.7±1.4	0.68±1.2	0.38±1.1	0.56±1.2
WC (cm)	65.6±11.2	74.3±11.2	68.8±12.0	66.8±10.7	74.4±11.0	69.8±11.4
WHtR	0.48±0.06	0.47±0.06	0.47±0.06	0.48±0.06	0.48±0.06	0.48±0.06

M: Mean; **SD:** Standard Deviation; **IR:** Interquartile Range; **BAZ:** Body Mass Index-Per-Age Z-score; **kg:** Kilograms; **cm:** Centimeters; **WC:** Waist Circumference; **WHtR:** Waist-to-Height Ratio.

Table 2: Lipid profiles for boys and girls stratified by age group.

	Boys (M±SD)			Girls (M±SD)		
	6-11 (n=141)	12-17 (n=79)	Total Boys (n=220)	6-11 (n=224)	12-17 (n=148)	Total Girls (n=372)
TC	158.4±27.2	148.8±25.8	155±27.0	158.9±26.3	154.3±27.3	157±26.8
Tg	69.3±31.2	78±42.5	72.4±35.8	74.8±34.0	74±30.7	74.5±30.7
HDL-c	48.7±12.0	43.9±9.4*	47±11.4	46.8±11.5	48.7±10.9†	47.6±11.3
LDL-c	95.8±23.9	89.3±22.3	93.5±23.5	97.1±23.0	90.8±22.0	94.6±22.8

The results are expressed as mg/dL. **TC:** Total Cholesterol; **Tg:** Triglycerides; **HDL-c:** High Density Lipoprotein Cholesterol; **LDL-c:** Low Density Lipoprotein Cholesterol; **M:** Mean; **SD:** Standard Deviation; **mg/dL:** milligrams/deciliters. ***p**=0.03 *vs.* 6-11 years; †**p**=0.001 Vs. boys 12-17 years.

Table 3: Area under ROC curve of body mass index, waist circumference, and waist-to-height ratio as identifiers of dyslipidemia in boys and girls stratified by age group.

	6-11		12-17	
	AUC±SD	CI 95%	AUC±SD	CI 95%
	Boys			
BAZ (Z-score)	0.735±0.05	0.63-0.83	0.855±0.05	0.76-0.95
WC (cm)	0.728±0.06	0.61-0.84	0.872±0.04	0.80-0.94
WHtR	0.719±0.06	0.61-0.83	0.902±0.04*	0.83-0.97
	Girls			
BAZ (Z-score)	0.704±0.06	0.59-0.81	0.635±0.08‡	0.48-0.79
WC (cm)	0.661±0.06†	0.55-0.77	0.712±0.06	0.60-0.82
WHtR	0.696±0.05	0.59-0.79	0.702±0.06	0.59-0.81

BAZ: Body Mass Index-per-age Z-score; **cm:** Centimeters; **WC:** Waist Circumference; **WHtR:** Waist-to-Height Ratio; **AUC:** Area under the Curve; **SD:** Standard Deviation; **CI 95%:** Confidence Interval 95%.*p<0.05 Vs. WC and BMIz; †p<0.05 Vs. BMIz and WHtR; ‡p<0.05 Vs.WC and WHtR.

to identify dyslipidemia for all groups, according to AUC. WHtR had the strongest performance for boys at 12-17 years (0.902±0.04) (Table 3).

Optimal cut-off values of the anthropometric tools to identify children and adolescents with dyslipidemia using the ROC curve analysis are displayed in (Table 4). The Younden Index summarizes the best equation considering sensitivity and specificity of a single screening value, which was 0.74 for BAZ, 63.25 cm for WC, and 0.485 for WHtR in boys at 6-11. WHtR's cut-off of 0.5 for boys at 12-17 presented the highest accuracy (0.757) when compared to all indices among all groups. Girls at 6-11 presented optimal cut-off values of 1.71 for BAZ, and 0.499 for WHtR, while the older ones presented 71.25cm for WC and 0.498 for WHtR.

Table 4: Optimal cut-off points for anthropometric indices as identifiers of dyslipidemia in boys and girls by age group.

	BAZ		Waist Circumference (cm)		Waist/Height Ratio	
	6-11	12-17	6-11	12-17	6-11	12-17
			Boys			
Cut-off	0.740	1.450	63.25	81.25	0.485	0.500
Sensitivity	0.850	0.857	0.850	1.000	0.700	1.000
Specificity	0.574	0.811	0.623	0.717	0.730	0.757
			Girls			
Cut-off	1.710	0.840	73.75	71.25	0.499	0.498
Sensitivity	0.583	0.667	0.500	0.917	0.583	0.583
Specificity	0.836	0.669	0.811	0.493	0.721	0.763

BAZ: Body Mass Index-per-Age Z-Score; **cm:** Centimeters.

Discussion

Briefly, in our study, we found that WHtR was the most reliable anthropometric index to identify increased cholesterol, triglycerides, LDL and decreased HDL in children and adolescents aged 6-17 years. Furthermore, a cut-off of 0.5 can be simple and accurate to screen dyslipidemia for this population. Thus, it may be proposed that an index that incorporates both central body size and growth may be a more robust marker for CVD risk than traditional markers, such as BMI or WC.

Previous studies of anthropometric markers of CVD risk in children focused on alteration of central adiposity as a risk for cardiovascular disease [19,20]. WC and WHtR showed better performance than BMI as predictors for cardiovascular disease in child populations [14,21]. A systematic review of cross sectional analyses, forty-four in adults, thirteen in children, supported these predictions. Analysis revealed mean areas under ROC values of 0.704, 0.693 and 0.671 for WHtR, WC and BMI, respectively. The AUC for ROC analyses indicate that WHtR may be a more useful global clinical screening Indice than WC, with a weighted mean boundary value of 0.5, as in our study [22]. However, further investigation is required to affirm this claim for children and adolescents.

The results presented in our study are consistent with most, but not all, studies looking at the association between various anthropometric indices in childhood and risk of developing chronic diseases. Freedman et al. [23] found that the AUC for BMI and WHtR were similar to identify cardio-metabolic risk in children and adolescents. The values ranged from 0.85-0.86 for the risk factor sum of lipid variables, insulin and blood pressure. However, WHtR was slightly better in predicting concentrations of total-to-HDL cholesterol ratio and LDL cholesterol, similar to our findings. Although WHtR may be chosen due to its simplicity, additional longitudinal data are needed to examine its relation to disease outcomes. It is important to note that there is no gold standard for cardiovascular risk diagnostic measures in childhood, which is largely the result of instability during this period of growth.

It's important to notice that there are different protocols to measure WC [24], which can present systematic bias when comparing studies. Moreover, there is no universal cut-off point that can be used to identify alterations in WC for children of all ages [25]. Contrary to WC, WHtR has the advantage of not requiring specific reference tables according to age and sex.

Our results suggest that BAZ's optimal cut-off points below 1 Z-score can identify dyslipidemia in boys from 6-11 and in girls from 12-17 years. These findings may provide evidence for the early development of risk factors, likely due consequences of unhealthy eating and physical activity habits [26]. Widespread change in children's lifestyles may affect their body composition, which results in higher fat mass and lower fat-free mass, even when BMI falls in the normal range.

BAZ and WC's optimal cut-off points presented high sensitivity for boys at both ages, suggesting good capacity to screen true positives alterations in lipid profile. For older boys, WHtR showed maximum sensitivity, with a strong specificity. This demonstrates how accurate the value of 0.5 is to identify a risk of cardiovascular disease, as suggested in other studies [14,22,27]. On the other hand, BAZ and WC showed high specificity for younger girls. Both optimal cut-off points were adequate to identify true negatives alterations in lipid profiles. For girls at 12-17 years, WC presented a very high sensitivity. Most of these girls should already be in post-pubertal stage, as alerting by Solorzano et al. [28], suggesting a consequence of a more stable group height. Thus, WC can influence the screening's sensitivity more important for this group. Therefore, these girls require further attention for diagnosis.

Most studies that investigate WHtR in children and adolescents either lack to present data on AUC performance [14,29] or do not consider the same attention to the optimal cut-off points according to their accuracy [22,23]. Furthermore, in distinction from other studies, we examined the anthropometric tools' performances and accuracy stratified for age and sex. Differences among these groups demonstrate why it is important to consider these variables before generalization of screening capacity, except for WHtR. Our study brings further elucidation to this index because it suggests not only why it can identify CVDs risk factor, but also how universally applied it can be.

While the results presented are robust, there is a need to discuss potential limitations that may limit broader conclusions. Our study showed a higher absolute number of girls in comparison to boys in both age groups; nevertheless the proportions between the two groups were the same and did not impair statistical analysis. Although, our study has not analyzed the biological state of maturation for this population, chronological age can be considered as a proxy of biological maturation. The literature infers that most of girls from 12-17 years would be considered of post-pubertal stage and most of the boys from 6-11 would be considered pre-pubertal stage [30].

In conclusion, we've found that BAZ, WC and WHtR were capable to identify dyslipidemia in children and adolescents from 6-17 years. WHtR was among the best performances in the AUC for all groups, when compared to other anthropometric indices. In addition, WHtR's optimal cut-off points were able to screen the true positive and the true negative alterations in lipid profiles more clearly, especially in boys. By using WHtR the diagnostic process is facilitated and a single cut-off point (0.5) is possible to be used for both sexes, with the simple message of "Keep Your Waist Circumference to Less Than Half of Your Height". Overall, this indicator of dyslipidemia and consequently cardiovascular risk should be encouraged to be used by pediatric health professionals, thus improving and facilitating the diagnosis process.

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