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The use of Waist-to-Height Ratio for nutritional assessment in the first phase of adolescence

Utilização da Razão Cintura-Estatura na avaliação nutricional na primeira fase da adolescência

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Abstract

Objective. This study evaluated the performance of the Waist-to-Height Ratio (WHR) as an additional indicator of nutritional status in the first phase of adolescence. ***Methods.*** This is a cross-sectional study, developed in 2016/2017, with 148 adolescents (10 to 13 years old) from two public schools of *Macaé*, a municipality in *Rio de Janeiro*, Southeast Brazil. We collected information on sexual maturation, weight, height, and waist circumference (WC). The Kappa Test was performed to verify the accordance among Body Mass Index-for-Age (BMI/A), WC, and WHR in relation to health risk screening. The maximum limits of sensitivity and specificity of WHR according to BMI/A were analyzed by ROC curve (Receiver Operating Characteristics). ***Results.*** Among the participants, 51.4% were girls, and more than 60% were in the first two stages of sexual maturation. The prevalence of excess weight (overweight+obesity) was 31.8%, obesity 17.6%, and high WHR 20.3%, with no difference according to sex and sexual maturation. WHR showed good agreement with excess weight (Kappa=0.707) and obesity (Kappa=0.780). The agreement between BMI/A and WC was poor. The value 0.45 was the most appropriate WHR cutoff point to identify adolescents with excess weight. ***Conclusions.*** This study suggests that WHR performs better than WC as an additional indicator of nutritional status in early adolescence. WHR brings information on central adiposity weighted by height, does not require a comparison curve, and has a cutoff point, which may facilitate screening in health services and epidemiological studies.

Keywords: Nutrition Assessment. Adolescent. Nutrition, Public Health. Anthropometry. Waist-to-Height Ratio.

Resumo

Objetivo. Este estudo visou avaliar o desempenho da razão cintura-estatura (RCE) como indicador complementar do estado nutricional na primeira fase da adolescência. ***Métodos.*** Trata-se de estudo transversal com 148 adolescentes (10 a 13 anos de idade) de duas escolas de Macaé, RJ, realizado em 2016/2017. Foram coletadas informações de maturação sexual, peso, estatura e perímetro da cintura (PC). Para verificar como as classificações do índice de massa corporal-para-idade (IMC/I), PC e RCE dialogam em termos de triagem de risco em saúde, foi feito o teste Kappa. Os limites máximos de sensibilidade e especificidade da RCE segundo o IMC/I foram analisados pela curva ROC (*Receiver Operating Characteristics*). ***Resultados.*** Dentre os avaliados, 51,4% eram meninas e mais de 60% encontravam-se nos dois primeiros estágios de maturação sexual. A prevalência de excesso de peso (sobrepeso+obesidade) foi 31,8%, obesidade 17,6% e RCE elevada 20,3%, sem diferença segundo sexo e maturação sexual. A RCE apresentou boa concordância com excesso de peso (Kappa=0,707) e obesidade (Kappa=0,780). Já a concordância entre IMC/I e PC foi pobre. O valor de 0,45 da RCE foi o ponto de corte mais adequado para identificar os adolescentes com excesso de peso. *Conclusões*: Este trabalho sugere que a RCE apresenta melhor desempenho que o PC como indicador complementar do estado nutricional no início da adolescência. A RCE agrega informação sobre a gordura central ponderada pela estatura, não requer curva de comparação e apresenta ponto de corte, o que facilita ações de triagem nos serviços de saúde e em estudos epidemiológicos.

Palavras-chave: Avaliação Nutricional. Adolescente. Nutrição em Saúde Pública. Antropometria. Razão Cintura-Estatura.

INTRODUCTION

Anthropometry, as a research method in nutrition, is based on the assessment of physical variations and the estimation of body composition to verify the nutritional adequacy of people or populations according to health patterns.[1,2] It is a widely used method in different age groups, mainly because it is relatively lowcost, little invasive, easy to standardize, and effective for nutritional screening and surveillance, which allows early actions and prevents illness and death.[3-5]

The most common anthropometric measurements in the nutritional assessment of adolescents are weight and height, used to calculate the Body Mass Index (BMI), which estimates total body fat; and waist circumference (WC), which estimates fat deposition in the central region.[6,7] However, physiological peculiarities of adolescence concerning the growth process, variability in body dimensions, and sexual maturation can reduce the ability of anthropometric indicators to estimate body compartments and, consequently, affect the correlation between these indicators and health risk.[7-9]

The literature on anthropometric nutritional assessment is relatively more consolidated for adults[2,3] and children[10] than adolescents. Even traditional indicators such as BMI, widely recognized dueits high association with adiposity and the risk of morbidity and mortality among individuals over 20 years of age,[11] there are still doubts regarding reference curves to adjust BMI for age andcutoff points to classify the nutritional status of adolescents worldwide.[8,12]

In biomedical terms, adolescence happens from 10 to 19 years old, subdivided into two phases: 10 to 14, and 15 to 19 years old. The first phase is characterized by the onset of pubertal changes, while the second stage comprises the completion of growth and sexual maturation.[2] It is important to note that, at the same chronological age, adolescents can have different biological characteristics, depending on the stage of development and sexual maturation, which can directly impact their nutritional status.[6]

Regarding the use of WC as an indicator of cardiovascular risk, there is no international consensus on cutoff points for adolescents. There is a cutoff value indicated for adults;[3,13] a recommendation to use the 90th percentile of the WC distribution in the population as a cutoff point for risk classification in adolescents;[14] and recent WC reference curves based on a sample of children and adolescents from different countries,[15] not including Latin America.

The Waist-to-Height Ratio (WHR) is a relatively recent indicator proposed in the literature as an alternative to the single use of WC, and a complement to the Body Mass Index-for-Age (BMI/A) in adolescents. In this age group, WHR has been considered a promising indicator, because it balances WC by height, is simple to use for screening and surveillance, and is highly associated with illness risk, principally cardiovascular diseases.[9,16,17]

Scientific knowledge on anthropometric methods to assess the nutritional status of adolescents is open for research. Thus, the present study aims to evaluate the performance of WHR as an additional indicator of the nutritional status in the first phase of adolescence, by using anthropometric information of students from public schools of *Macaé*, state of *Rio de Janeiro*, Brazil

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METHODS

This is a cross-sectional study carried out in two public elementary schools in *Macaé*, a municipality in *Rio de Janeiro*, Southeast Brazil, between 2016 and 2017. The schools were indicated by the *Macaé* Municipal

Department of Education. The total number of adolescents enrolled in these schools (n=165), of both sexes, aged between 10 and 13 years old, were eligible for this study. The analysis included only students who returned signed consent forms and did not have disabilities that interfered with anthropometric measures (n=148).Data were collected at the schools by trained evaluators, and included age, sex, sexual maturation, weight, height, and WC.

Anthropometric procedures followed the recommendations proposed by Willett and Hu.[1] Adolescents were weighed and measured with minimal clothing and barefoot. To measure weight, we used an electronic scale, brand Welmy®, with an accuracy of 100 g. Height was measured by Alturexata® stadiometer, with an accuracy of 1 mm. WC was measured with an inelastic tape, an accuracy of 1 cm, at the midpoint between the last rib and the iliac crest. During the measurements, the adolescents were standing, with the abdomen relaxed, arms extended along their bodies, feet together and weight divided on both legs. Weight was measured only once, while height and WC were measured twice; the mean of the two measurements was calculated for analysis purposes. When the variation between the two measurements exceeded 0.5 cm for height and 1 cm for WC, these were discarded, and two new measurements were collected

. The evaluation of sexual maturation took place in a private room at school, individually with each adolescent. Printed figures of the stages of sexual maturation proposed by Tanner[18] were showed to the adolescents (breast stages only for girls, and genitalia for both sexes). Through self-evaluation, the adolescents identified the stages they were in. We also asked the girls about their menarche; the answer was registered in a dichotomous way (yes or no). Participants' age was calculated according to the assessment date and their date of birth recorded in school documents.

The nutritional profile was evaluated according tothe World Health Organization (WHO) growth standards.[12] We calculated Z-scores of Height-for-age (H/A) and BMI/A by the software WHO Antro Plus, available at <http://www.who.int/growthref/tools/en>. Adolescents with H/A lower than two negative Standard Deviations (SD) were classified as having low height. Participants' weight was evaluated by BMI/A: underweight (BMI/A < -2 SD), adequate weight (-2 SD ≤ BMI/A < +1 SD), overweight (+1 SD ≤ BMI/A < +2 SD), and obesity (BMI/A ≥ +2 SD). For the purposes of some analyses, adolescents classified as having overweight or obesity were grouped into a single category, in this study called "excess weight" (BMI/A ≥ +1 SD).

To analyze the WC, we calculated the 90th percentile of the sample according to sex. Adolescents at a percentile equal to or greater than 90 were classified as having high WC, while adolescents below the 90th percentile were considered adequate.[14] By the measures of height and WC, we calculated the WHR. Adolescents with WHR greater than 0.5 were classified asout of adequacy.[16]

Data were analyzed in the Statistical Package for the Social Sciences - SPSS, version 19. To characterize the sample, descriptive analysis of anthropometric and sexual maturation variables was performed. Continuous variables were described by mean and standard deviation, while categorical variables were described as proportions (%). To assess normality, we applied the Kolmogorov-Smirnov test. The t test was performed to compare means, while chi-square test (χ2) was used to compare proportions. We considered a significance level of 5% (p-value less than 0.05).

The Kappa Test with Altman classification[19] was performed to verify the accordance among BMI/A, WC, and WHR regarding health risk screening. BMI/A classification was used as standard. To determine the limit that allows classifying WHR according to BMI/A, a ROC (Receiver Operating Characteristics) curve was developed, based on the maximum sensitivity and specificity between WHR and BMI/A for excess weight (≥ +1 SD) and obesity (≥ +2SD).

RESULTS

A total of 148 adolescents were evaluated, and 51.4% were girls. The mean age was 10.8 years (SD=0.7years), weight 40.7 Kg (SD=12 Kg), height 144.9 cm (SD=8 cm), WC 65.5 cm (SD=10.7 cm), and WHR 0.45 (SD=0.06). There was no difference when comparing means bysex (Table 1).

Table 1. Anthropometric characteristics and nutritional status according to sex of adolescents (age=10-13 years) from public schools of *Macaé*, RJ, Brazil, 2016-2017. (n=148)

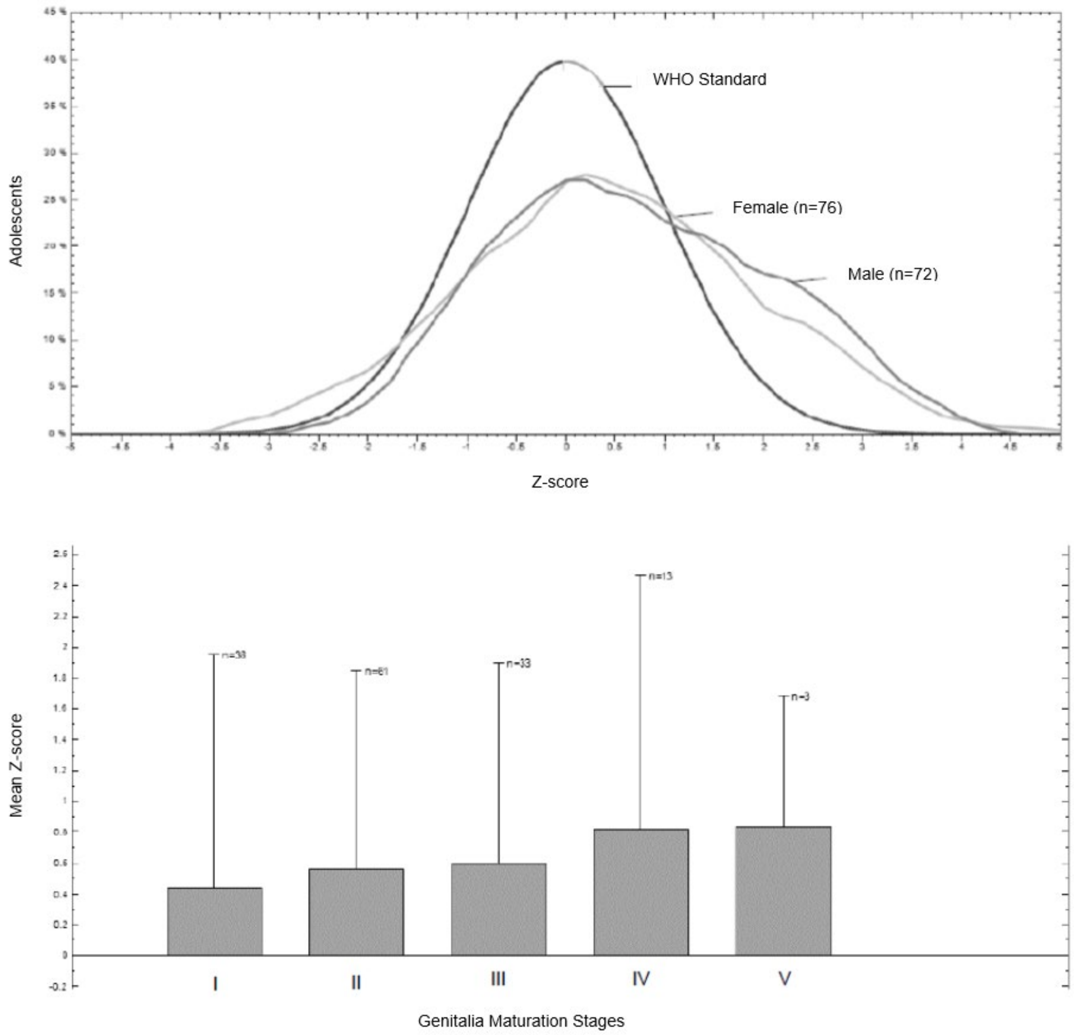
Characteristics	Total Mean (SD)	Boys Mean (SD)	Girls Mean (SD)
Age (years)	10.8 (0.7)	10.8 (0.7)	10.7 (0.7)
Weight (Kg)	40.7 (12.0)	40.7 (11.3)	40.8 (12.7)
Height (cm)	144.9 (8.0)	144.8 (8.1)	144.9 (8.0)
WC (cm)	65.5 (10.7)	66.5 (10.6)	64.6 (10.8)
WHR	0.45 (0.06)	0.45 (0.06)	0.44 (0.06)
BMI/A (Z-score)	0.57 (1.3)	0.70 (1.3)	0.45 (1.4)
H/A (Z-score)	0.30 (1.1)	0.36 (1.1)	0.24 (1.1)
Nutritional Status	Frequency (%)		
Underweight	3 (2.0)	-	3 (3.9)
Adequate Weight	98 (66.2)	46 (63.9)	52 (68.4)
Overweight	21 (14.2)	11 (15.3)	10 (13.2)
Obesity	26 (17.6)	15 (20.8)	11 (14.5)
Total	148	72	76
WHR	Frequency (%)		
Adequate	118 (79.7)	56 (77.8)	62 (81.6)
High	30 (20.3)	16 (22.2)	14 (18.4)
Total	148	72	76

SD=Standard Deviation; WC=Waist Circumference; WHR=Waist-to-Height Ratio; BMI/A=Body Mass Index-for-Age; H/A=Height-for-Age.
Source: Authors' original data

Regarding sexual maturation, menarche had already occurred in 15.8% of the girls. Respectively 25.0%, 50.0%, 17.1%, 6.6% and 1.3% of the girls were in breast stages I, II, III, IV and V. About the genitalia maturation, respectively 31.6%, 39.5%, 14.5%, 11.8% and 2.6% of the girls, and 19.4%, 43.1%, 30.6%, 5.6% and 1.4% of boys were in the stages I, II, III, IV, and V.

H/A distribution of the participants overlapped with the WHO reference curves. However, BMI/A distribution presented a slight deviation to the right (Figure 1). Taking the genitalia stages as an example (Figure 1), mean BMI/A was greater than zero in all the sexual maturation phases. No differences were observed in mean WHR according to sexual maturation.

Figure 1. Distribution of Z-scores of Body Mass Index-for-Age according to sex and stage of genitalia maturation of adolescents (age=10-13 years) from public schools of *Macaé*, RJ, Brazil, 2016-2017. (n=148)



The prevalence of excess weight was 31.8%, obesity 17.6% and high WHR 20.3%, without difference by sex (Table 1). The WC value equivalent to the 90th percentile was 82 cm for boys and 80 cm for girls. No significant difference was observed when comparing the proportion of overweight, obesity, high WC, and high WHR according to sexual maturation.

The ability of WC and WHR to identify adolescents classified by BMI/A as having excess weight (sensitivity) was 29.8% and 63.8%; and regarding obesity it was 50.0% and 88.5%, respectively (Table 2). The agreement between BMI/A and WC was poor, both in theexcess weight (Kappa PC=-0.199) and in the obesity classification (Kappa PC=-0.187). Between BMI/A and WHR, the accordance was good for excess weight(Kappa WHR=0.707) as well as for obesity (Kappa WHR=0.780).

Table 2. Nutritional status according to Body Mass Index-for-Age (BMI/A), Waist Circumference (WC) and Waist-to-Height Ratio (WHR) of adolescents (age=10-13 years) from public schools of *Macaé*, RJ, Brazil, 2016-2017. (n=148)

Nutritional Status by BMI/A	WC Classification n (%)			WHR Classification n (%)		
	High	Adequate	Total	High	Adequate	Total
With excess weight	14 (29.8)	33 (70.2)	47	30 (63.8)	17 (36.2)	47
Without excess weight	-	101(100)	101	-	101(100)	101
With obesity	13 (50.0)	13 (50.0)	26	23 (88.5)	3 (11.5)	26
Without obesity	1 (0.8)	121 (99.2)	122	7 (5.7)	115 (94.3)	122
Total	14 (9.5)	134 (90.5)	148	30 (20.3)	118 (79.7)	148

Source: Authors' original data

The most appropriate WHR value to identify adolescents with excess weight was 0.45, with a sensitivity of 94% and specificity of 90%. However, to identify adolescents with obesity, a WHR equal to 0.48 presented the best parameters of sensitivity (100%) and specificity (91%) (Table 3).

Table 3. Sensitivity and specificity estimated by Receiver Operating Characteristics curve for the Waist-to-Height Ratio to detect excess weight and obesity according to the Body Mass Index-for-Age (BMI/A) of adolescents (age=10-13years) from public schools of *Macaé*, RJ, Brazil, 2016-2017. (n=148)

Waist-to-Height Ratio	Sensibility	Specificity
	Excess Weight (BMIA ≥ +1SD)	
0.40	1	0.24
0.42	0.98	0.59
0.44	0.97	0.81
0.45	0.94	0.90
0.46	0.91	0.94
0.48	0.77	0.90
0.50	0.68	1
	Obesity (BMIA ≥ +2SD)	
0.40	1	0.19
0.42	1	0.50
0.44	1	0.68
0.45	1	0.77
0.46	1	0.81
0.48	1	0.91
0.50	0.92	0.93

Source: Authors' original data

DISCUSSION

In this study, WHR performed well as an additional indicator of nutritional status in early adolescence. WHR stood out as a better indicator than the single use of WC. Regarding the identification of adolescents with obesity, the WHR cutoff point with the highest agreement (0.48) was close to the value recommended in the literature (0.5).[16,17] Concerning the identification of excess weight, the cutoff point 0.45 performed better.

BMI is an anthropometric indicator highly associated with body fat and illness risk.[11] However, to reduce BMI possible limitations, the use of supplementary anthropometric measures related to cardiometabolic risk is frequent. In adults, WC is the most used additional measure, but there is no consensus on cutoff points for adolescents, which makes it difficult screening metabolic risk in this age group. WHR can be an option to complement BMI, as it adds information on central fat weighted by height, which is a critical measure in adolescence, due to the intense growth. Furthermore, WHR does not require a comparison curve and presents a cutoff point, which facilitates screening.

Similar to this study, other researchers have observed that WHR performs better than WC in identifying children and adolescents at risk.[4,17,20] The Avon Longitudinal Study of Parents and Children, which evaluated children between 7 and 9 years old, found that a WHR above 0.5 increased the chance of having cardiovascular risk factors in adolescence by 4.6 times for boys and 1.6 times for girls.[21] High WHR discriminatory power in predicting cardiovascular diseases and diabetes has also been highlighted in meta-analysis studies.[9,17,22]

In contrast, a study carried out with girls in the second phase of adolescence (14 to 19 years old) observed that WC alone had a better performance than WHR in identifying cardiovascular risk.[23] That may be due to the dynamics of growth and development in different stages of adolescence. The participants in the present study were in the first phase (10 to 13 years old), when the peak of growth has not yet occurred. But, in the second stage, the intense growth in height can interfere with WHR, since height composes the denominator of the ratio. Adolescents who are in upper H/A percentiles may have low WHR, even if they have high central adiposity. Hence, it is important to consider the adolescence phase to define indicators and cutoff points.[22]

In tune with this idea, this study suggests a lower WHR cutoff point (0.45) for identifying excess weight in the first phase of adolescence. This finding is especially relevant for nutrition screening and surveillance, as it interferes in the early identification of excess weight, which allows interventions before weight gain is accentuated and other comorbiditiesset in, such as diabetes and hypertension. This view has been highlighted in international studies,[20,22] as well as in a study carried out in public schools of the municipality of *Niterói* (state of *Rio de Janeiro*), in which WHR was considered a good indicator for screening and monitoring excess weight among adolescents.[24]

Screening plays a central role in the nutritional assessment of populations, since small changes in cutoff points can directly influence diagnosis and public health decisions and, thus, affect the inclusion or exclusion of substantial amounts of people in intervention actions. Contrasting with a clinical context, in which several measures of body dimension and composition can be assessed and little variations in the indicators may not impact the diagnosis, in the population level, the refinement of indicators and cutoff points is essential for risk assessment. Therefore, the earlier changes in anthropometric measurements are identified, the greater the possibilities of preventing obesity and other chronic non-transmissible diseases.[5,16,22]

The sample of this study is not representative of the population, which does not allow wide extrapolation of results. Yet, these findings contribute to the discussion on anthropometric methods for the nutritional assessment of adolescents and bring to light the need to improve indicators and cutoff points for the classification of central adiposity, principally in the first phase of adolescence. It should also be noted that there are only a few studies that include adolescents from Latin America. Therefore, it is worth verifying the applicability of the WHR limit values foundin this study in other groups of Brazilian and Latin American adolescents, with different ages and sexual maturation profiles.

Another limitation of this study is having only BMI/A as a comparison measure for assessing WHR and WC. BMI/A estimates total adiposity, whose increase is associated with higher morbidity and mortality, but it does not differentiate body compartments like other more specific methods, such as bioimpedance or double absorbance x-rays.[25,26] Therefore, future research could repeat these analyses having body fat percentage as reference, measured by gold standard methods. The use of these methods in large-scale studies is still restricted, due to relatively high costs and the need for standard measurements, infrastructure, and specialized evaluators. Assessing the ability of WHR to estimate central adiposity in comparison with more specific methods could reinforce WHR pertinence as a low-cost indicator that is simple to measure at the population level and in health services.

CONCLUSION

In this sample of students in the first phase of adolescence, WHR performed better than WC in predicting nutritional risk. In addition, the cutoff points available to identify cardiovascular risk by WHR and WC may not be fully adequate for the first phase of adolescence, which may impact the design of public health actions.

Regarding the high burden of diseases associated with excess weight, these results suggest that other studies should be carried out, mainly in Latin America, to evaluate the performance of anthropometric methods and search for indicators and cutoff points for risk classification in adolescents

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Contributors

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