ORIGINAL ARTICLE

Anthropometric markers of abdominal adiposity and its relation to dyslipidemia and insulin resistance among overweight/obese schoolchildren and adolescents

Marcadores antropométricos de adiposidade abdominal e sua relação com dislipidemia e resistência à insulina em escolares e adolescentes com sobrepeso/obesidade

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ABSTRACT

Objective: to assess the relationship between anthropometric indicators and laboratorial markers of cardiovascular risk in overweight/obese children and adolescents, in order to verify whether any anthropometric indicator has a better potential for use in screening cardiovascular risk in the population. **Method:** retrospective cross-sectional study enrolling 237 individuals aged 7 to 18 years. Body mass index (BMI), waist circumference (WC), waist circumference/height index (WC/H), glucose, HOMA-IR, total cholesterol (TC), LDL, HDL, triglycerides and TC/HDL and LDL/HDL indexes were obtained. Associations between anthropometric and laboratory markers were tested in contingency tables using the chi-square test. Correlations were tested by Spearman's correlation. **Results:** higher WC (Freedman cutoffs) was associated with lower levels of HDL and higher score in the TC/HDL and LDL/HDL indexes, but, using +2 z-scores as the cutoff, there were associations with low HDL and higher HOMA-IR. WC/H indicator (0.5 cutoff) was not associated with any of the outcomes, but, using +2 z-scores, an association was found with HOMA-IR. Z-scores of WC, WC/H and BMI showed positive correlation with HOMA-IR, TC/HDL and HOMA-IR, respectively. Negative correlations were found between WC and WC/H z-scores with HDL. WC and WC/H z-score were related to changes in HDL and HOMA-IR. **Conclusions:** there seems to be an advantage in using WC alone as a possible predictor of dyslipidemia and insulin resistance in children and adolescents. It is not possible to state that WC, WC/H or BMI measurements differ in their abilities to identify Brazilian children and adolescents with risk factors for cardiovascular diseases.

Keywords: Obesity, Insulin resistance, Dyslipidemia, Waist circumference, Anthropometry, Child.

RESUMO

Objetivo: avaliar a relação entre indicadores antropométricos e marcadores laboratoriais de risco cardiovascular em crianças e adolescentes com sobrepeso / obesidade, a fim de verificar se algum indicador antropométrico tem melhor potencial para uso no rastreamento de risco cardiovascular na população. **Método:** estudo transversal retrospectivo com 237 indivíduos com idades entre 7 e 18 anos. Índice de massa corporal (IMC), circunferência da cintura (CC), índice de circunferência da cintura / altura (CC / H), glicose, HOMA-IR, colesterol total (CT), LDL, HDL, triglicerídeos e índices CT/HDL e LDL/HDL foram obtidos. As associações entre marcadores antropométricos e laboratoriais foram testadas em tabelas de contingência por meio do teste do qui-quadrado. As correlações foram testadas pela correlação de Spearman. **Resultados:** CC mais elevado (pontos de corte de Freedman) foi associado a níveis mais baixos de HDL e maior pontuação nos índices TC/HDL e LDL/HDL, mas, usando +2 escores z como ponto de corte, houve associações com HDL baixo e HOMA-IR mais alto. O indicador CC/H (0,5 ponto de corte) não foi associado a nenhum dos desfechos, mas, usando +2 escores z, foi encontrada associação com o HOMA-IR. Os escores Z de CC, CC/E e IMC mostraram correlação positiva com HOMA-IR, TC/HDL e HOMA-IR, respectivamente. Correlações negativas foram encontradas entre CC e escores z de CC/H com HDL. CC e escore z de CC/H foram relacionados a mudanças em HDL e HOMA-IR. **Conclusões:** parece haver vantagem em usar a CC isoladamente como possível preditor de dislipidemia e resistência à insulina em crianças e adolescentes. Não é possível afirmar que as medidas de CC, CC/E ou IMC diferem na capacidade de identificar crianças e adolescentes brasileiros com fatores de risco para doenças cardiovasculares.

Palavras-Chave: Obesidade, Resistência à insulina, Dislipidemia, Circunferência da cintura, Antropometria, Criança.

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INTRODUCTION

Obesity in childhood and adolescence is a disease of high prevalence and incidence and that brings relevant health risks throughout the life cycle (1). Its diagnosis is relatively simple, just by proving the excess body fat. For this, the body mass index (BMI) can be used as a population indicator with sensitivity and specificity[1]. BMI results above the cutoff point defined for age and sex indicate the presence of overweight or obesity, since the likelihood of a child with a high BMI having a condition other than obesity is low.

On the other hand, when evaluating a child individually, it is possible that high BMI values do not represents fat. Thus, in outpatient care, it is suggested that some assessment of body composition must be performed, in order to prove that the verified excess weight is, in fact, due to fat. For this, there are methods with different degrees of precision, complexity and costs, such as dexacytometry, bioimpedanciometry, skinfold analysis, hydrostatic weighing, use of marked water, measurement of different perimeters and relationships between measurements.

Two of these methods have been extensively studied, due to their simplicity and low cost of implementation: the simple measurement of waist circumference (WC) and the waist circumference/ height index (WC/H)[2,3]. These two indicators are able to demonstrate the presence of excessive deposits of abdominal fat, which is associated with comorbidities, with the advantage of dispensing weighing and BMI calculation.

The value obtained in the WC measurement must be evaluated through specific age and gender cutoff points as described by Freedman's reference, that defines percentiles widely used[3] or data obtained from the National Health and Nutrition Examination Survey (NHANES) III, which uses Z scores[4]. In the case of the WC/H index, there is a possibility to dispense with the correction for gender and age, since the value of 0.5 has been used as a universal cutoff point, which is well accepted especially between 6 to 18 years[2] or the evaluation can be done through the z scores of the index, which, in this case, is corrected for age and sex, and values above z score +2 can be considered as high[4].

Both WC measurement and WC H index can be used in two ways: to prove excess of abdominal adiposity, which, together with the BMI, defines that the excess weight detected is indeed due to excess fat. Second using these indicators in a unique way, as a screening, as high values point to a high probability of excess adiposity and, especially, excess in the central area[2,3].

Among the possible consequences of childhood obesity, dyslipidemia and insulin resistance stand out. These two conditions can evolve the riskiest health outcomes related to excessive adiposity: cardiovascular diseases and diabetes. In addition to traditional indicators, such as total cholesterol (TC), low density lipoprotein (LDL-c), high density lipoprotein (HDL-c), triglycerides (TG) and Homeostasis Model Assessment of Insulin Resistance (HOMA-IR), some indexes have been used as predictors of cardiovascular risk, such as TC/HDL e LDL/HDL[5].

The present study aimed to assess which of the anthropometric indicators (BMI, WC and WC/H index) is best related to the outcomes linked to cardiovascular risk, seeking to verify whether any of them has better potential for use in population screening.

METHODS

Study design and participants

This is a retrospective cross-sectional study with data obtained through databases built to carry out scientific research, derived from a private clinic, located in a traditional area of medical offices in Ribeirão Preto, and which serves private clients and/or health insurance owners mainly from upper social class. Sampling was not performed because all patients treated during the period determined for the study and who respected the criteria of inclusion and exclusion were included.

The inclusion criteria were individuals aged 7 to 18 years, with a BMI z score greater than +1 (overweight and obesity), attended between January 2009 and December 2018. The exclusion criteria were an impediment for performing anthropometry, absent or incomplete laboratory tests, family dyslipidemia, hypothyroidism and type 1 diabetes mellitus.

During this period, 1125 individuals were treated, 832 within the proposed age range. Of these, 302 were overweight or obese and met the inclusion criteria; 44 did not complete the laboratory evaluation, 17 could not have their measurements adequately obtained, 2 met the criteria for familial dyslipidemia and 2 received a diagnosis of hypothyroidism. The final number of individuals evaluated was 237.

Data collection and analysis

Anthropometric assessment followed standardized technique (6) of measuring weight, height and WC. Laboratory tests for fasting blood glucose, blood lipids and HOMA-IR were carried out in one of three laboratories in the city chose by that the family, all of which are certified institutions that used the same techniques and kits for the proposed tests. All patients underwent anthropometric assessment at the first consultation, at which time they were asked to collect laboratory tests after 12 hours of fasting, with an interval of up to 30 days being allowed to return with the requested tests. To assess the prevalence of altered indicators, the following cutoff points were defined:

- Blood glucose > 99 mg/dL[7];
- HOMA-IR corrected for age and sex as proposed by Nogueira-de-Almeida et al (8,9):
    - 6 to 8,9 years: ≥1,76 (boys) and ≥1,39 (girls)
    - 9 to 10,9 years: ≥1,97 (boys) and ≥2,62 (girls)
    - 11 to 12,9 years: ≥2,65 (boys) and ≥3,02 (girls)
    - 13 to 14,9 years: ≥3,21 (boys) and ≥3,46 (girls)
    - 15 to 17,9 years: ≥2,39 (boys) and ≥2,89 (girls)
- Total cholesterol ≥ 170 mg/dL (10)
- LDL ≥ 110 mg/dL (10)
- HDL ≤ 45 mg/dL (10)
- Triglycerides > 75 between 7 and 9 years and > 90 mg/dL between 10 and 18 years (10)
- WC with values above the 90th percentile in the table proposed by Freedman et al with data derived from Bogalusa Heart Study (3)
- WC z score > +2 (4)
- WC/H ≥ 0,5 (2)
- WC/H z score > +2 (4)
- TC/HDL > 5 for boys and > 4,5 for girls (5)
- LDL/HDL > 3,5 for boys and > 3,0 for girls (5)

Ethical aspects

The study was approved by the Ethics Committee of the University of Ribeirão Preto on March 11, 2014 (number 538.137).

STATISTICAL ANALYSIS

For the univariate analysis of categorical variables, the distribution of absolute frequency was performed. For univariate analysis of continuous numerical variables, which had a normal distribution, the results were expressed according to the mean ± standard deviation. The normal distribution of data was analyzed using the Kolmogorov-Smirnov test.

For the bivariate analysis of categorical variables, an association was made between anthropometric indexes and cardiovascular risk factors. The increased WC (using the cut points of percentile and z score) and the increased WC/H (using cut points of 0.5 and z score) were considered the independent variables, while changes in TC, LDL, HDL, TG, HOMA-IR, TC/HDL and LDL/HDL, were the dependent variables. Thus, measures of association were calculated using contingency tables, such as prevalence ratio (odds ratio), and the chi-square test (χ^2) was used, determining a 95% confidence interval (CI).

For the bivariate analysis between numerical and categorical variables, Spearman's correlation was performed. Correlations between z-BMI, z-WC and z-WC/H and the studied outcomes (TC, LDL, HDL, TG, HOMA, TC/HDL and LDL/HDL) were verified. For this, the z-scores of the indicators that showed expected variation with age were calculated: BMI, WC and WC/H index. The z-scores of BMI were obtained through the *software* Anthro-plus[11] and the z-scores of WC and WC/H were obtained through an online application that uses data from NHANES III[4]. The level of significance used was 5%. Statistical analysis was performed using the SPSS for Windows application (Statistical Package for the Social Sciences), version 22.0.

RESULTS

237 overweight/obese children and adolescents, 50.2% of whom were female, participated in the study. The mean age was 130 ± 27 months and the mean BMI z score was 1.95 ± 0.42. Approximately half of the individuals had dyslipidemia when traditional cutoff points were used. However, when the TC/HDL and LDL/HDL indices were used, this prevalence was much lower. Likewise, WC was considered increased in more than 70% of the participants using the cut points suggested by Freedman; however, this number was substantially reduced when z scores using +2 cutoff point (Table 1).

Table 1. Percentage of individuals with anthropometric and metabolic disorders

Variable	n (%)
TC high	105 (44,3%)
HDL low	104 (43,9%)
LDL high	77 (32,5%)
TG high	142 (59,9%)
HOMA high	115 (48,5%)
TC/HDL index > 5 (boys) and > 4,5 (girls)	24 (10,1%)
LDL/HDL index > 3,5 (boys) and > 3,0 (girls)	24 (10,1%)
WC high according Freedman	170 (71,7%)
WC Z score > +2	64 (27,0%)
WC/H Z score > +2	51 (21,5%)
WC/H index > 0,5	231 (97,4%)

The use of the WC/H index also yielded different results according to the criteria used to define normality. When using z scores with a +2 cutoff point, only approximately 20% of the participants showed increased values; however, when the fixed value of 0.5 was used for the index, almost all children were in the high range (Table 1).

Table 2 shows the association between metabolic and anthropometric indicators. A low association was verified between WC or WC/H index with metabolic outcomes. When the WC measurement was used according to the cutoff points suggested by Freedman et al, it was observed that the increase in WC is associated with lower levels of HDL and a higher score in the TC/HDL and LDL/HDL indexes; when +2 z scores were used as the cutoff point, an association was found with low HDL levels and a higher HOMA-IR score. The WC/H indicator, using a cutoff point of 0.5, was not associated with any of the outcomes and, when assessed using +2 z scores as the cutoff point, the association was found only with the highest HOMA-IR score.

Table 3 shows the correlation results. Anthropometric measurements showed a high correlation with each other. However, the classification of the z score of the anthropometric indicators of WC, WC/H and BMI showed a weak positive correlation with changes in HOMA-IR, TC/HDL and HOMA-IR, respectively. In addition, weak negative correlations were found between WC and WC/H z scores with HDL. The analyzes in Tables 2 and 3 show that the WC and WC/H z score were related to changes in HDL and HOMA-IR.

Table 2. Risk for dyslipidemia and insulin resistance according to WC and WC/H

	TC high OR (IC 95%)	LDL high OR (IC 95%)	HDL low OR (IC 95%)	TG high OR (IC 95%)	HOMA-IR high OR (IC 95%)	TC/HDL high OR (IC 95%)	LDL/HDL high OR (IC 95%)
WC high (FREEDMAN)	1,06 (0,59 – 1,87)	0,81 (0,44 – 1,47)	2,35* (1,28- 4,29)	1,55 (0,87 – 2,75)	1,46 (0,82 – 2,58)	4,83* (1,10 – 21,15)	10,33* (1,36 – 78,08)
WC high (Z-score)	0,72 (0,40 – 1,28)	0,73 (0,39 – 1,37)	2,41* (1,34 – 4,32)	1,44 (0,79 – 2,61)	2,26* (1,26 – 4,07)	1,37 (0,56 – 3,37)	1,1 (0,43 – 2,79)
WC/H high (>0,5)	0,79 (0,15 – 4,00)	0,47 (0,09 – 2,39)	4,09 (0,47 – 35,59)	1,51 (0,29 – 7,64)	0,94 (0,18 – 4,76)	0,55 (0,06 – 4,93)	0,55 (0,06 – 4,93)
WC/H high (Z-score>2)	0,77 (0,41 – 1,44)	0,74 (0,37 – 1,47)	1,72 (0,92 – 3,21)	1,44 (0,75 – 2,77)	1,88* (1,00 – 3,54)	0,95 (0,34 – 2,69)	0,95 (0,34 – 2,69)

*p<0,05

Table 3. Correlation between z scores of anthropometric and metabolic indicators

Correlations	ρ	p-valor
Z score of WC *vs* Z score of BMI	0,846	0,000*
Z score of WC/H *vs* Z score of BMI	0,783	0,000*
Z score of WC *vs* Z score of WC/H	0,924	0,000*
Z score of WC *vs* TC	-0,05	0,445
Z score of WC *vs* LDL	-0,027	0,685
Z score of WC *vs* HDL	-0,145	0,025*
Z score of WC *vs* TG	0,091	0,161
Z score WC *vs* HOMA-IR	0,134	0,04*
Z score of WC *vs* TC/HDL	0,106	0,105
Z score of WC *vs* LDL/HDL	0,082	0,211
Z score of WC/H *vs* TC	-0,009	0,885
Z score of WC/H *vs* LDL	0,013	0,837
Z score of WC/H *vs* HDL	-0,142	0,029*
Z score of WC/H *vs* TG	0,096	0,14
Z score of WC/H *vs* HOMA-IR	0,103	0,114
Z score of WC/H *vs* TC/HDL	0,135	0,038*
Z score of WC/H *vs* LDL/HDL	0,112	0,085
Z score of BMI *vs* TC	-0,121	0,062
Z score of BMI *vs* LDL	-0,116	0,074
Z score of BMI *vs* HDL	-0,104	0,109
Z score of BMI *vs* TG	0,068	0,296
Z score of BMI *vs* HOMA-IR	0,157	0,015*
Z score of BMI *vs* TC/HDL	0,031	0,636
Z score of BMI *vs* LDL/HDL	0,003	0,962

DISCUSSION

The use of the WC/H index as a predictor of excess weight, dyslipidemia and insulin resistance in children and adolescents has been proposed as a complementary alternative to measures of WC and BMI[12-15]. The WC/H index is considered an indicator of simple execution, since it does not require weight measurement[16,17].

In the present study, the WC/H z score correlated negatively with HDL and positively with the TC/HDL index. In addition, it was positively associated with HOMA-IR. However, using the fixed cutoff point of 0.5, there was no association with any of the outcome indicators. The WC/H z score appears to be useful in predicting dyslipidemia and insulin resistance. Tables and cols. (2019), in a Brazilian study, also found a negative correlation between absolute WC/H and HDL values in individuals between 6 and 17 years of age[18].

Aristizabal et al.[12] evaluated 346 adolescents and found that the WC/H index correlated with low HDL levels and higher HOMA-IR scores. However, WC and BMI measurements also showed the same correlations with the metabolic outcome. The authors conclude that WC/H, WC and BMI measurements have a similar ability to identify adolescents with high HOMA-IR and low HDL concentrations.

The present study also found that the increase in WC z score was associated with higher HOMA-IR scores and low HDL levels, demonstrating the same utility of WC/H z score in the prediction of dyslipidemia and insulin resistance. It is known that the simple measurement of WC provides relevant information that points to the presence of increased cardiovascular risk[12,19,20]. The main reference for the definition of metabolic syndrome for children and adolescents, proposed by the International Diabetes Federation (IDF)[21], uses only WC as an anthropometric indicator.

Two studies with Brazilian adolescents also found a positive correlation between WC and HOMA-IR, but both used absolute measures instead of z score[22,23]. Using data from NHANES of the United States, Gaston et al[24] observed that the increase in WC z score increased the risk of having reduced HDL. In our study, we found that WC classification according to z score seems to be more useful for detecting insulin resistance, while WC adjustment for age and sex was better associated with dyslipidemia.

Regarding BMI, the z score > +1 showed a positive correlation with HOMA-IR. There was no correlation with markers for dyslipidemia. Lee & Laurson (2016), using NHANES data, observed significantly higher values of HOMA-IR in the highest BMI percentiles in 1985 American adolescents[25].

In the present study, no anthropometric indicator was observed associated with the values of TC, LDL and TG. However, it was found that the WC/H and WC indices were better related to the outcomes linked to cardiovascular risk, such as HDL, HOMA-IR and TC/HDL, compared to BMI. In clinical practice, it seems in fact easier and better to prefer WC to BMI, with the advantage of being a simpler measure to obtain. However, several studies[2,12,26,27], including a systematic review and meta-analysis[28], observed that WC/H, WC and BMI measurements are equivalent in detecting cardiovascular risk. It is not yet possible to stay that one measure is better than the other.

This study has some limitations. Because of the cross-sectional design, the cause-effect relationship cannot always be well established, as some changes in the studied outcomes may occur over a longer period of observation. Another limitation is that the population studied is not representative of the age group in the city of Ribeirão Preto and patients belong in the majority to higher socio-economic class, and it is not possible to extrapolate these data to the whole population.

In conclusion, the use of WC/H or WC z-score was related to laboratory markers of insulin resistance (increased HOMA-IR) and dyslipidemia (reduced HDL). WC assessed by cutoff points, according to sex and age, was associated with dyslipidemia (reduced HDL and increased TC/HDL and LDL/HDL). WC/H assessed using fixed cutoff point of 0.5 was not associated with any of the outcome indicators. The z score of BMI was shown to be related only to insulin resistance (increased HOMA-IR). According to the findings of the present study, there seems to be an advantage in using WC alone as a possible predictor of dyslipidemia and insulin resistance in children and adolescents. However, it is still not possible to state that WC, WC/H or BMI measurements differ in their abilities to identify Brazilian children and adolescents with risk factors for cardiovascular diseases.

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