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Trabajo Original

Valoración nutricional

Waist-to-height ratio may be an alternative tool to the body mass index for identifying Colombian adolescents with cardiometabolic risk factors

La relación cintura-estatura puede ser un indicador alternativo al índice de masa corporal para identificar adolescentes colombianos con factores de riesgo cardiometabólicos

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Abstract

Background: there is limited information about the usefulness of the waist-to-height ratio (WHtR) to identify Colombian adolescents with cardiometabolic risk factors (CRF).

Objective: to compare the utility of WHtR, body mass index (BMI), and waist circumference (WC) to identify adolescents with CRF.

Methods: a study with 346 youths (aged 14.0 ± 2.3 years) was performed. Anthropometric measurements were collected and BMI, WC and WHtR were calculated. Fasting blood lipids, glucose and insulin were measured; the homeostasis model assessment of insulin resistance (HOMA-IR) was computed. The presence of multiple non-WC metabolic syndrome (MetS) factors (high HOMA-IR, high triglycerides and low high-density lipoprotein cholesterol [HDL-C]) was analyzed. The area under the curve (AUC) and the odds ratios (OR) were calculated.

Results: the BMI, WC and WHtR were comparable at identifying adolescents with high HOMA-IR (AUC = 0.686, 0.694 and 0.641, respectively), low HDL-C (AUC = 0.623, 0.652 and 0.572, respectively) and multiple non-WC MetS factors (AUC = 0.694, 0.715 and 0.688, respectively). The OR of having multiple non-WC MetS factors was similar in overweight adolescents (1.65, 95% CI: 0.86-3.14) and those with WHtR ≥ 0.50 (3.76, 95% CI: 1.95-7.3). There were no OR differences of having multiple non-WC MetS factors among adolescent with obesity (9.88, 95% CI: 3.1-31.7), WC ≥ P90 (18.3, 95% CI: 4.0-83.5) and WHtR ≥ 0.55 (11.0, 95% CI: 3.0-4.4).

Conclusions: WHtR, BMI and WC have similar capacities to identify Colombian adolescents with CRF. WHtR showed to be an alternative tool to BMI and WC measurements when screening adolescents for cardiometabolic risk.

Key words:

Youth. Obesity. Abdominal obesity. Anthropometric index. Nutritional screening. Cardiovascular risk factors.

Resumen

Introducción: hay información limitada sobre la utilidad de la relación cintura-estatura (rCE) para identificar adolescentes colombianos con factores de riesgo cadiometabólicos (FRC).

Objetivo: comparar la utilidad de la rCE, el índice de masa corporal (IMC) y la circunferencia de cintura (CC) para identificar adolescentes con FRC.

Metodología: se evaluaron 346 jóvenes (14,0 ± 2,3 años). Se obtuvieron medidas antropométricas, IMC, CC, rCE, glucosa, insulina y lípidos sanguíneos en ayunas e índice HOMA-IR. Se analizó la presencia de múltiples factores del síndrome metabólico (MetS) diferentes a la CC (HOMA-IR alto, triglicéridos aumentados, concentración del colesterol de alta densidad [HDL-C] baja). Se calculó el área bajo la curva (AUC) y razón de ventajas (OR).

Resultados: el IMC, CC y rCE fueron similares para identificar adolescentes con alto HOMA-IR (AUC = 0,686, 0,694 y 0,641, respectivamente), bajo HDL-C (AUC = 0,623, 0,652 y 0,572, respectivamente) y múltiples factores del MetS diferentes a la CC (AUC = 0,694, 0,715 y 0,688, respectivamente). La OR de tener esta última condición fue similar en adolescentes con sobrepeso (1,65, IC 95%: 0,60-3,14) y aquellos con rCE ≥ 0,50 (3,76, IC 95%: 1,95-7,3). La presencia de múltiples factores del MetS diferentes a la CC en adolescentes con obesidad (9,88, IC 95%: 3,1-31,7), CC ≥ P90 (18,3, IC 95%: 4,0-83,5) y rCE ≥ 0,55 (11,0, IC 95%: 3,0 a 4,4) fue similar.

Conclusión: rCE, IMC y CC tienen capacidades similares para identificar adolescentes colombianos con FRC. El rCE demostró ser una herramienta alternativa al IMC y la CC cuando se tamizan adolescentes para identificar la presencia de FRC.

Palabras clave:

Jóvenes. Obesidad. Obesidad abdominal. Índice antropométrico. Tamizaje nutricional. Factores de riesgo cardiovascular.

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INTRODUCTION

Worldwide childhood obesity has significantly increased during the last 42 years (1975-2016) in both, girls (from 0.7% to 5.6%) and boys (from 0.9% to 7.8%) (1). Obesity during youth is associated with early development of atherosclerosis and cardiometabolic risk factors (2-4); therefore, there is a need to find a correct and accurate measure of obesity in children and adolescents (5). For this end, the waist-to-height ratio (WHtR) is suggested as an alternative tool to the body mass index (BMI) and waist circumference (WC), and its usefulness to identify youths at metabolic risk has gain much attention lately (5-9).

BMI is the most commonly used anthropometric index to evaluate overweight and obesity in adolescents. However, BMI is unable to differentiate whether an excess of body weight reflects an increase in fat mass or fat free mass (10,11). This limitation is highlighted in adolescents who have a great variability in the fat mass content for a given BMI (10,11). WC is a measurement more related to the fat tissue than BMI, particularly abdominal fat tissue (5-9). However, WC is height dependent given that taller children generally have larger WC than shorter ones (12). This feature could led to misevaluation of central obesity in youths (12).

The WHtR, calculated by dividing WC by height, is a practical tool to evaluate obesity in youth. WHtR has shown comparable results to BMI at evaluating adolescents' body composition (13). The use of a single value (WHtR ≥ 0.50) is very practical to identify subjects with higher odds of having cardiometabolic risk factors (12,14). However, the application of one cut-off for all age groups and ethnicities generates controversy (15,16). Differences in optimal cut-offs have been found in adolescents from Korea, United States, and Africa (8,16,17). These differences are probably due, at least in part, to the ethnic variability in patterns of body fat distribution, body segment proportions, and their relations with cardiometabolic risk factors (18-20).

There is limited information about the usefulness of WHtR in Colombian adolescents who are a mixture of European, African and Native American (21,22). This study aimed: a) to compare the usefulness of WHtR, BMI and WC to identify adolescents with cardiometabolic risk factors; and b) to explore the utility of a WHtR value corresponding to BMI classification of obesity.

MATERIALS AND METHODS

STUDY DESIGN AND PARTICIPANTS

This is a cross-sectional analytical study. Our study sample included 346 adolescents aged 10 to 18 years living in Medellin-Colombia. They took part in the Medellin's Food and Nutritional Survey *(Perfil Alimentario y Nutricional de Medellín)* carried out during 2015. The survey included a sample of 3,008 homes representative of the six socio-economic strata of the population, and the rural and urban areas of the city. Three hundred and forty six adolescents living in the selected homes who accepted to provide a blood sample were included in this analysis. This sample size assuming a power of 85%, at the 95% level of confidence, allows to detect a minimum difference of 5.62% in metabolic syndrome components between subjects with WHtR < 0.5 and WHtR ≥ 0.50, previously reported (9). Subjects who were sick at the moment of evaluation or were under treatment with steroids, hormones or medications were excluded. The study was performed according to the Declaration of Helsinki and was approved by the Bioethical Review Board from the Faculty of Dentistry of the University of Antioquia (Act of approval No. 01, February 27th of 2015). Informed consent was obtained from all participants and their guardians.

ANTHROPOMETRIC MEASUREMENTS

Anthropometric measurements were performed by experienced and trained personal following the techniques described by Lohman et al. (23). Adolescents were barefoot and wore a T-shirt and short pants for body measurements. Body weight was measured to the nearest 0.1 kg using a digital scale (Seca® 813, California, USA). Height was measured to the nearest 0.1 cm using a wall mounted mechanical measuring tape (Seca® 206, California, USA). The WC was measured to the nearest 0.1 cm, midway between the lowest rib margin and the iliac crest, using a flexible tape (Seca® 206, California, USA). Anthropometric measurements were done at least by duplicate or by triplicate when the difference between the first and the second values was higher than 0.1 kg in body weight, 0.5 cm in height and 1% in WC. This was done in order to get high quality data as recommended by the Anthropometric Standardization Reference Manual (23).

ANTHROPOMETRIC INDICES

BMI was calculated by dividing body weight in kg by height in square meters. Overweight and obesity were assessed using the reference values and cut-offs from the World Health Organization (WHO) (24). WC was classified using the standards and cut-offs suggested by the Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents (25). The WHtR was calculated by dividing WC in cm by height in cm. Two WHtR values were analyzed, the WHtR ≥ 0.50 originally proposed by Ashwell (26) and a WHtR value that matched the proportion of subjects classified with obesity according to WHO cut-offs for BMI (24).

CARDIOMETABOLIC RISK FACTORS

Adolescents were instructed to fast overnight for 10 to 12 hours. Blood was drawn from the antecubital vein in dry tubes. Blood was centrifuged at 3,000 x g for ten minutes to obtain serum. Serum glucose, insulin, total cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) were measured by standardized methods using an automatic analyzer (Roche, Cobas® c501, Mannheim, Germany).

HOMA-IR was calculated as serum glucose (mmol/l) x serum insulin (mU/l)/22.5 (27). Adolescents were classified as having high total cholesterol (≥ 200 mg/dl), high triglycerides (≥ 130 mg/dl), high LDL-C (≥ 130 mg/dl), high non-HDL-C (≥ 145 mg/dl) and low HDL-C (≤ 40 mg/dl) according to the Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents (25). HOMA-IR value ≥ 3.1 was considered as high following the criteria previously applied to our population (28,29). Multiple non-WC MetS factors included high HOMA-IR, high triglycerides and low HDL-C.

STATISTICAL ANALYSIS

Normal distribution of data was tested with the Kolmogorov-Smirnov test. Data are presented as means ± standard deviations or medians and interquartile range according to data distribution. Differences between groups were compared using one-way ANOVA with general lineal models using age as a covariate in the normally distributed data, and the Mann-Whitney test in non-normally distributed data. The adjusted R^2 was calculated to determine the association between anthropometric indices and cardiometabolic risk factors. Receiver-operating characteristic (ROC) curve analysis was run to test the diagnostic accuracy of the anthropometric indices to identify adolescents with cardiometabolic risk factors. Chi-square and McNemar test were used to compare the proportions of anthropometric indices in adolescents by sex, and by the presence of two or more non-WC MetS factors. Odds ratios (OR) were calculated using logistic regression analysis to measure the association between being at risk according to the anthropometric indices (yes/no) and the presence of multiple non-WC MetS factors. Adolescents with normal body weight were used as the reference group (OR = 1.0). $p < 0.05$ was considered as statistically significant. The statistical analysis was developed in SPSS 24.

RESULTS

A total of 346 adolescents (166 girls and 180 boys) were included in this study (Table I). Boys were taller ($p < 0.05$) than girls (155.9 ± 13.6 *vs* 152.3 ± 8.6 cm, respectively). Nonetheless, both genders showed similar proportions ($p > 0.05$)

Table I. Participant characteristics by gender

	All (n = 346)	Girls (n = 166)	Boys (n = 180)	p-value
Age (years)	14.0 ± 2.34	13.9 ± 2.3	14.1 ± 2.36	0.319
Body height (cm)	154.2 ± 11.6	152.3 ± 8.6	155.9 ± 13.6	0.028*
Body weight (kg)	47.9 ± 13.4	47.2 ± 12.2	48.6 ± 14.3	0.710
Body mass index (kg/m^2)	19.1 (17.2-21.6)	19.4 (17.1-22.4)	19.0 (17.3-21.2)	0.244
Waist circumference (cm)	67.6 (63.3-73.4)	66.9 (62.6-73.6)	68.1 (63.7-73.2)	0.614
Waist-to-height ratio (cm)	0.44 (0.42-0.47)	0.44 (0.42-0.47)	0.44 (0.42-0.47)	0.687
Normal weight (BMI z-score ≥ -1 to ≤ 1) (n, %)	219 (63.3)	105 (63.3)	114 (63.3)	0.988
Overweight (BMI z-score > 1 to ≤ 2) (n, %)	51 (14.7)	27 (16.3)	24 (13.3)	0.442
Obese (BMI z-score > 2) (n, %)	16 (4.6)	8 (4.8)	8 (4.4)	0.868
Wasted (BMI z-score < 1) (n, %)	60 (17.3)	26 (15.7)	34 (18.9)	0.428
Central obesity (WC ≥ 90 percentile) (n, %)	14 (4.1)	9 (5.6)	5 (2.8)	0.195
Central obesity (WHtR ≥ 0.50) (n, %)	43 (12.7)	22 (13.6)	21 (11.7)	0.594
Central obesity (WHtR ≥ 0.55) (n, %)	14 (4.1)	9 (5.6)	5 (2.8)	0.195
Glucose (mmol·l)	4.55 (4.27-4.83)	4.50 (4.22-4.83)	4.61 (4.27-4.83)	0.043†
Insulin (pmol·l)	81.3 (54.9-122.9)	92.4 (61.8-145.9)	69.5 (48.6-105.6)	0.001†
HOMA-IR	2.32 (1.48-3.59)	2.69 (1.75-4.15)	2.00 (1.36-3.09)	0.001†
Total cholesterol (mmol·l)	3.98 ± 0.77	4.05 ± 0.72	3.91 ± 0.82	0.282
Triglycerides (mmol·l)	1.29 ± 0.57	1.33 ± 0.55	1.26 ± 0.58	0.098
HDL-C (mmol·l)	1.16 ± 0.26	1.18 ± 0.24	1.15 ± 0.28	0.492
LDL-C (mmol·l)	2.22 ± 0.68	2.26 ± 0.67	2.18 ± 0.69	0.371
Non-HDL-C (mmol·l)	2.81 ± 0.72	2.87 ± 0.69	2.76 ± 0.75	0.163
Non-WC MetS factors (≥ 2) (n, %)	94 (27.2)	52 (31.3)	42 (23.3)	0.095

*Data presented as mean ± standard deviation or medians and interquartile range in parentheses according to data distribution. Nutritional status and non-WC MetS factors are presented as numbers and percentages. *Differences between groups obtained with general linear models adjusted by age. †Differences between groups obtained with the Mann-Whitney test. HOMA-IR: homeostasis model assessment of insulin resistance; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; MetS: metabolic syndrome; WC: waist circumference. BMI: body mass index; WHtR: waist-to-height ratio.*

of normal weight (63.3 *vs.* 63.3%), overweight (13.3 *vs.* 16.3%), and obesity (4.4 *vs.* 4.8%). A value of WHtR ≥ 0.55 classified with central obesity the same proportion of adolescents than BMI cut-off for obesity (4.1 *vs.* 4.6%; p > 0.05); this WHtR value was analyzed as an alternative cut-off (Table I). There were not differences (p > 0.05) in the proportion of boys and girls with central obesity according to WC ≥ 90 (2.8 *vs.* 5.6%), WHtR ≥ 0.50 (11.7 *vs.* 13.6%) or WHtR ≥ 0.55 (2.8 *vs.* 5.6%). The glucose levels were higher in boys than in girls (4.61 *vs.* 4.50 mmol/l, p < 0.05). The girls showed higher values of insulin (92.4 *vs.* 69.5 pmol/l, p < 0.01) and HOMA-IR (2.69 *vs.* 2.00, p < 0.01) (Table I).

Associations between anthropometric indices and cardiometabolic risk factors are shown in table II. After adjusting by age and sex, the anthropometric indices correlated (p < 0.05) with insulin, HOMA-IR, total cholesterol, triglycerides, HDL-C and non-HDL-C. Only WC showed a significant correlation with glucose (p < 0.05) and WHtR with LDL-C (p < 0.01) (Table II).

The anthropometric indices showed similar performance detecting adolescents with cardiometabolic risk factors (Table III). The AUC for BMI, WC and WHtR were alike to identify adolescents with high HOMA-IR (AUC = 0.686, 0.694 and 0.641, respectively), low HDL-C (AUC = 0.623, 0.652 and 0.572, respectively), and multiple non-WC MetS factors (AUC = 0.694, 0.715 and 0.688, respectively). None of the anthropometric indices showed capacity to detect adolescents with high total cholesterol, high LDL-C or high non-HDL-C (Table III).

The proportion of adolescents with overweight, obesity or central obesity having multiple non-WC MetS factors is shown in figure 1. Overweight adolescents represented 14.7% (n = 51), 4.6% had obesity (n = 16), 4.1% (n = 14) had WC ≥ P90, 12.7% (n = 43) had WHtR ≥ 0.50 and 4.1% (n = 14) had WHtR ≥ 0.55. The proportions of adolescents with multiple non-WC MetS factors were similar in overweight (33.3%) and those with a WHtR ≥ 0.5 (53.5%). The proportion of adolescents with multiple non-WC MetS factors was lower (p < 0.05) in the overweight (33.3%) than in the obese (75.0%) or those having a WC ≥ P90 (85.7%) or a WHtR ≥ 0.55 (78.6%). There were no significant differences in the proportion of adolescents with multiple non-WC MetS factors among the obese (75.0%), those having a WC ≥ P90 (85.7%), a WHtR ≥ 0.50 (78.6%) and a WHtR ≥ 0.55 (78.6%) (Fig. 1).

The OR for having multiple non-WC MetS factors in adolescents with overweight, obesity or abdominal obesity are presented in table IV. Adolescents with normal body weight were used as a reference group. Compared to the reference group: a) adolescents with obesity were 9.88 (95% CI: 3.1-31.7) times more likely of having multiple non-WC MetS factors; b) adolescents with WC ≥ P90 were 18.30 (95% CI: 4.01-83.47) times more likely of having multiple non-WC MetS factors; and c) youths with WHtR ≥ 0.50 or WHtR ≥ 0.55 were 3.76 (95% CI: 1.95-7.25) and 11.00 (95% CI 3.0-40.0) times more likely of having multiple non-WC MetS factors, respectively. In overweight adolescents, those with WC ≥ P90 or WHtR ≥ 0.55 significantly increased their chances to have multiple non-WC MetS factors (Table IV). In obese participants, those with WC ≥ P90, WHtR ≥ 0.50 or WHtR ≥ 0.55 did show higher chances of having multiple non-WC MetS factors (Table IV).

DISCUSSION

The purpose of this study was to compare the utility of BMI, WC and WHtR to identify adolescents with cardiometabolic risk factors. The main finding was the anthropometric indices have similar capacity to identify adolescents with high HOMA-IR, low HDL-C and multiple non-WC MetS factors. None of the anthropometric indices showed capacity to detect adolescents with high total cholesterol, high LDL-C or high non-HDL-C. Thus, it does not appear to exist advantage of using either BMI, WC or WHtR to identify youths with cardiometabolic risk factors, though the practicality of the WHtR could be a plus in epidemiological studies.

Similar capacities were shown among BMI, WC and WHtR to identify adolescents with cardiometabolic risk factors, which is in agreement with previous studies (8,17,30). In adults, by the contrary, measurements of central adiposity as WC and WHtR have shown superiority over BMI at identifying subjects with cardiometabolic alterations (31,32). To this point, there are not clear explanations for the dissimilar results between adults and adolescents.

Table II. Associations between antropometric indices and cardiometabolic risk factors*

	Body mass index		Waist circumference		Waist-to-height ratio	
	Adjusted R^2	p-values	Adjusted R^2	p-values	Adjusted R^2	p-values
Glucose	0.020	0.277	0.023	0.041	0.015	0.237
Insulin	0.180	< 0.001	0.216	< 0.001	0.155	< 0.001
HOMA-IR	0.166	< 0.001	0.203	< 0.001	0.142	< 0.001
Total cholesterol	0.027	0.043	0.031	0.050	0.041	0.007
Triglycerides	0.054	< 0.001	0.092	< 0.001	0.064	< 0.001
HDL-C	0.058	0.015	0.067	0.007	0.061	0.023
LDL-C	0.010	0.116	0.009	0.274	0.018	0.039
Non HDL-C	0.027	0.002	0.028	0.002	0.040	< 0.001

**Adjusted by sex and age. HOMA-IR: homeostasis model assessment of insulin resistance; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol.*

Table III. Area under the ROC curve of anthropometric indices to predict cardiometabolic risk factors

	Body mass index AUC (95% CI)	Waist circumference AUC (95% CI)	Waist-to-height ratio AUC (95% CI)
All (n = 346)			
High HOMA	0.686 (0.625-0.748)‡	0.694 (0.633-0.754)‡	0.641 (0.577-0.705)‡
High total cholesterol	0.484 (0.319-0.648)	0.509 (0.343-0.676)	0.557 (0.408-0.706)
High triglyceride	0.619 (0.554-0.685)‡	0.636 (0.567-0.704)‡	0.621 (0.554-0.689)‡
Low HDL-C	0.623 (0.559-0.688)‡	0.652 (0.589-0.715)‡	0.572 (0.506-0.638)*
High LDL-C	0.497 (0.318-0.676)	0.506 (0.328-0.685)	0.549 (0.379-0.72)
High non HDL-C	0.577 (0.446-0.709)	0.573 (0.444-0.703)	0.602 (0.473-0.732)
Non-WC MetS factors ≥ 2	0.694 (0.627-0.761)‡	0.715 (0.648-0.783)‡	0.688 (0.621-0.754)‡
Girls (n = 166)			
High HOMA	0.678 (0.592-0.674)‡	0.700 (0.617-0.784)‡	0.649 (0.562-0.736)‡
High total cholesterol	0.504 (0.269-0.740)	0.493 (0.232-0.753)	0.490 (0.251-0.730)
High triglyceride	0.550 (0.455-0.644)	0.559 (0.456-0.661)	0.574 (0.475-0.672)
Low HDL-C	0.660 (0.560-0.760)‡	0.660 (0.560-0.760)†	0.629 (0.528-0.73)*
High LDL-C	0.593 (0.376-0.809)	0.581 (0.332-0.829)	0.541 (0.299-0.783)
High non HDL-C	0.638 (0.474-0.801)*	0.615 (0.440-0.790)	0.622 (0.454-0.789)
Non-WC MetS factors ≥ 2	0.650 (0.552-0.749)†	0.669 (0.568-0.770)‡	0.671 (0.575-0.766)‡
Boys (n = 180)			
High HOMA	0.696 (0.609-0.784)‡	0.718 (0.632-0.804)‡	0.635 (0.537-0.733)†
High total cholesterol	0.458 (0.231-0.685)	0.523 (0.308-0.738)	0.624 (0.453-0.795)
High triglyceride	0.695 (0.608-0.783)‡	0.720 (0.637-0.803)‡	0.672 (0.581-0.763)‡
Low HDL-C	0.607 (0.521-0.693)*	0.638 (0.554-0.722)†	0.534 (0.446-0.621)
High LDL-C	0.321 (0.068-0.575)	0.409 (0.172-0.647)	0.560 (0.334-0.786)
High non HDL-C	0.467 (0.261-0.673)	0.508 (0.323-0.693)	0.575 (0.376-0.774)
Non-WC MetS factors ≥ 2	0.745 (0.657-0.832)‡	0.773 (0.690-0.857)‡	0.709 (0.619-0.799)‡

**p < 0.05; †p < 0.01; ‡p < 0.001. ROC: receiver operating characteristic; AUC: area under the curve; CI: confidence intervals; HOMA-IR: homeostasis model assessment of insulin resistance; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; MetS: metabolic syndrome; WC: waist circumference.*

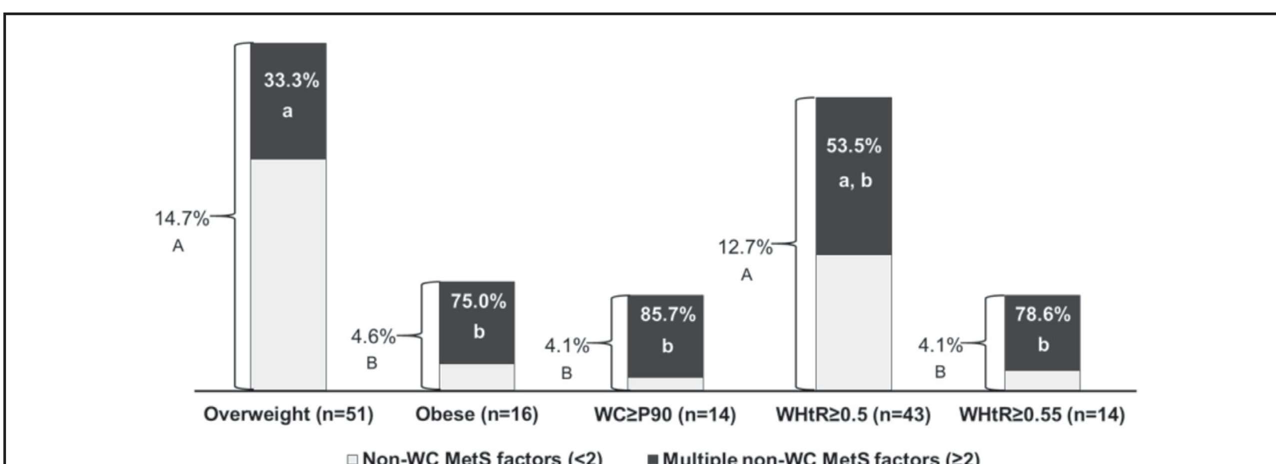

Figure 1.

Proportion of adolescents with overweight, obesity or central obesity having multiple non-waist circumference metabolic syndrome factors. Different capital letters indicate differences (p < 0.05) in the proportions of overweight, obesity or central obesity, using McNemar test. Different small letters indicate differences (p < 0.05) in the proportions of having multiple non-waist circumference metabolic syndrome factors, using McNemar test (MetS: metabolic syndrome; WC: waist circumference; WHtR: waist-to-height ratio).

Table IV. Odds ratio (OR) for two or more non-waist circumference metabolic syndrome factors across anthropometric indices*

Anthropometric indices	OR	OR 95% CI	p-value
Overweight (BMI z-score > 1 to ≤ 2)	1.65	(0.86-3.14)	0.1300
Obese (BMI z-score > 2)	9.88	(3.08-31.67)	0.0000
Waist circumference ≥ P90	18.30	(4.01-83.47)	0.0000
Waist-to-height ratio ≥ 0.50	3.76	(1.95-7.25)	0.0000
Waist-to-height ratio ≥ 0.55	11.00	(3.00-40.40)	0.0000
Overweight with WC ≥ P90	19.75	(4.31-90.54)	0.0000
Overweight with WHtR ≥ 0.50	1.74	(0.74-4.10)	0.2020
Overweight with WHtR ≥ 0.55	12.40	(3.35-45.82)	0.0000
Obese with WC ≥ P90	30.43	(3.78-244.8)	0.0010
Obese and WHtR ≥ 0.50	10.14	(3.16-32.55)	0.0000
Obese and WHtR ≥ 0.55	10.14	(2.67-38.60)	0.0010

**Adolescents with normal body weight were used as the reference group (OR = 1.0). WC: waist circumference; WHtR: waist-to-height ratio; BMI: body mass index; P: percentile; CI: confidence intervals.*

It has been suggested that a threshold level of visceral and abdominal subcutaneous fat exists; when it is exceeded, these fat depots are more likely to be associated with cardiometabolic risk factors (33,34). Thus, it could be that the adolescents of this study who had a low prevalence of abdominal obesity (4.1%) did not reach the abdominal obesity threshold. Under these conditions, the central adiposity indices (WC and WHtR) and BMI related similarly to cardiometabolic risk factors in this young population.

The WHtR ≥ 0.50 cut-off was proposed by Ashwell to identify people at risk for cardiovascular disease, who should be aware and do follow-ups (14). In this study, the WHtR ≥ 0.50 cut-off classified similar number of adolescents with central obesity than the BMI category for overweight. Furthermore, the subjects with a WHtR ≥ 0.50 or classified as overweight showed comparable OR of having multiple non-WC MetS factors. Thus, the WHtR ≥ 0.50 behaved similarly to the BMI classification for overweight in this population, and it allowed providing a similar warning health message. Nonetheless, controversy remains about the use of a single WHtR cut-off for all ages and both sexes (15,16). Borderlines lower than WHtR ≥ 0.50 have been reported in youths from Asia (0.41-0.44) and Africa (0.47) (8,16,35). Applying a lower value than 0.50 in this population will decrease the WHtR specificity and will probably increase the number of individuals at risk compared to those classified with overweight. This situation could be overwhelming for health systems of countries like Colombia, where overnutrition has increased in the last years and coexists with the undernutrition problem (36).

People with a WHtR ≥ 0.60 are at higher risk for cardiometabolic factors than those with a WHtR ≥ 0.50, and they should take corrective actions (14). In this study, few people showed a WHtR ≥ 0.60 (n = 6; 1.7%) and further analysis with this group was ruled out. Instead, a WHtR ≥ 0.55 that matched the proportions of subjects classified with obesity by BMI was explored. The proportion of adolescents with a WHtR ≥ 0.55 who had multiple non-WC MetS factors was high (78.6%) and similar to those classified with obesity by BMI and WC. Also, the odds of having multiple non-WC MetS factors among those with WHtR ≥ 0.55 were high (OR = 11.0) and comparable to youths with obesity according to BMI or WC. These results suggest that WHtR ≥ 0.55 could be used as an alternative to the BMI and WC classification for obesity to identify adolescents with non-WC MetS factors. Similar results have been reported (8,17,30), and support the use of the WHtR as an alternative to BMI and WC, given the following advantages: a) the use of a single cut-off for all ages, sexes and ethnicities allowing comparison worldwide; b) it is more practical since it does not require the use of reference values according to sex and age; and c) it is easier to obtain than BMI (14,37).

The study had some strengths and limitations. Among the strengths: a) the comparison of the WHtR cut-offs with BMI categories of overweight and obesity; b) the analysis of having multiple non-WC MetS factors, since the presence of one factor might be due to day-to-day changes (e.g., triglycerides); and c) the OR analysis combining the anthropometric indices. Among the limitations: a) this is a cross-sectional study and it does not allow to establish cause-effect relationships; b) the study model does not provide information about the anthropometric indices ability for predicting future health outcomes; and c) the lack of blood pressure data limiting the analysis of this MetS component.

In conclusion, BMI, WC and WHtR showed similar capacities to identify Colombian adolescents with cardiometabolic risk factors. The WHtR cut-offs of 0.50 and 0.55 behave similarly to the BMI classification of overweight and obesity for identifying Colombian adolescents with cardiometabolic risk factors. Although, the use of WHtR as an alternative to BMI and WC is promising, more research is needed comparing the performance of BMI, WC and WHtR cut-offs in adolescents.

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