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Trabajo Original

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Prevalence of metabolic syndrome in Brazilian children using three different sets of international criteria

Prevalencia del síndrome metabólico en niños brasileños utilizando tres diferentes criterios internacionales

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Abstract

Background: the aim of the present study was to compare the prevalence of metabolic syndrome in Brazilian children aged 6-10 years using three different international criteria.

Methods: systolic and diastolic blood pressure (SBP and DBP), high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, triglycerides, fasting glucose, and insulin levels were measured in 290 schoolchildren, and the presence of metabolic syndrome was analyzed according to the criteria established by Cook, Boney, and Ferreira.

Results: the prevalence of metabolic syndrome was 2.27 % (Boney and Ferreira criteria) and 7.58 % (Cook criteria) for girls, and 3.8 % (Boney and Ferreira criteria) and 5.06 % (Cook criteria) for boys. Agreement in pairs showed a concordance of 57.5 % (*Kappa* = 0.57) between Boney and Cook criteria, and 65.2 % (*Kappa* = 0.65) between Cook and Ferreira. The greatest concordance found was 77 % (*Kappa* = 0.77) between Boney and Ferreira criteria, demonstrating a substantial agreement.

Conclusion: prevalences according to Boney and Ferreira criteria was lower than according to Cook criteria. Therefore, we suggest the use of Cook criteria in clinical practice for the diagnosis of metabolic syndrome, since this criterion provided a wider diagnostic range, thereby reducing the risk of underdiagnosis.

Keywords:

Metabolic syndrome. Children. Brazil.

Resumen

Antecedentes: el objetivo del presente estudio fue comparar la prevalencia del síndrome metabólico en niños brasileños de 6 a 10 años de edad, usando tres diferentes criterios internacionales.

Métodos: se midieron la presión arterial sistólica y diastólica, el colesterol de alta y baja densidad, los triglicéridos, la glucemia en ayunas y la insulinemia en 290 escolares, y se analizó la presencia del síndrome metabólico de acuerdo con los criterios de Cook, Boney y Ferreira.

Resultados: la prevalencia del síndrome metabólico encontradas fueron del 2,27 % (criterios de Boney y Ferreira) y 7,58 % (criterios de Cook) para las niñas, y del 3,8 % (criterios de Boney y Ferreira) y 5,06 % (criterios de Cook) para los niños. La concordancia por pares fue del 57,5 % (Kappa = 0,57) entre los criterios de Boney y Cook, y del 65,2 % (Kappa = 0,65) entre los criterios de Cook y Ferreira. La mayor concordancia encontrada fue del 77 % (Kappa = 0,77) entre los criterios de Boney y Ferreira, demostrando una concordancia sustancial.

Conclusiones: la prevalencia de acuerdo con los criterios de Boney y Ferreira fue inferior a la encontrada con los criterios de Cook. Por lo tanto, sugerimos el uso de los criterios de Cook en la práctica clínica para el diagnóstico del síndrome metabólico, ya que utilizando este criterio se obtiene un rango diagnóstico más amplio, reduciéndose así el riesgo del infradiagnóstico.

Palabras clave:

Síndrome metabólico. Niños. Brasil.

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INTRODUCTION

In 1988 Reaven et al. described a metabolic disorder called insulin resitance, which would later give rise to the concept of syndrome X. From then on, the concept of metabolic syndrome (MetS) emerged from the link between insulin resistance, hypertension, dyslipidemia, obesity, diabetes, and other metabolic disorders, which are associated with a high risk for atherosclerotic cardiovascular disease in adults (1). Currently, metabolic syndrome is defined as an aggregation of metabolic risk factors that together may be involved in the development of cardiovascular disease and atherosclerosis (2).

In adults, several health organizations have developed criteria for the diagnosis of MetS (3). In children and adolescents, although the use of the term MetS has been usual, there are still no accepted diagnostic criteria for this condition (4,5), since parameters such as blood pressure, lipid profile, and anthropometric factors change according to age and pubertal stage (6).

The association of MetS with overweight and obesity is well established even in children and adolescents (1,7,8). This association is stronger when considering not only the excess of body fat, but when related to central obesity (9). According to systematic reviews, the prevalence of overweight in children in developing countries ranges from 2.7 % in Indonesia to 16.6 % in Brazil (10), whereas the prevalence for MetS ranges from 2.2 % in normal-weight Turkish children (11) to 36 % in obese Bolivian children and adolescents (12). In Brazil, the prevalence of MetS reaches values of 3.2 % in normal-weight children and 42.2 % in obese children, according to different diagnostic criteria (13-15).

Despite the lower prevalence of MetS in children, the prevalence of its isolated components is increasing in this population. It has been demonstrated that increased waist circumference (WC) in children and adolescents is associated with an increase in multiple cardiovascular risk factors (16). In addition, higher WC values are determinants for insulin resistance, dyslipidemia, and hypertension (6,9). The prevalence of MetS was 45.5 %, 33 %, and 22 % for obese, overweight, and normal-weight Brazilian children and adolescents, respectively (14). Although the definition of MetS is clear, there is no consensus regarding its diagnosis in children (15,17,18). Additionally, there is no agreement on the cut-off points to be used for MetS components. Many studies have compared different MetS diagnostic criteria in different populations, but there is no consensus about which one shows a higher accuracy in children (7,15,17,19-21). As children with MetS have an increased risk of developing cardiovascular disease during their adulthood (22,23), the diagnosis of MetS during childhood and an early intervention might probably benefit their health status in the future.

The aim of the present study was to compare the prevalence of metabolic syndrome in Brazilian children aged 6-10 years as obtained with three different international criteria sets.

MATERIAL AND METHODS

A descriptive cross-sectional study was conducted with children aged 6-10 years from all public schools in Itaúna (Brazil), constituting a random sample selected from a population of 4,649 students. To determine the minimum sample size, a pilot study was conducted in 25 students of both genders aged 6-10 years. Systolic and diastolic blood pressure (SBP and DBP), high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, triglycerides, fasting glucose, and insulin levels were measured. Further details on the experimental design are described in the study by Gonçalves et al. (16). The maximum error tolerance allowed for the estimation of the population mean for each variable, not compromising the reliability of results, was established. To calculate the minimum sample for each variable the respective sample's standard deviation was used with a 5 % significance level. Therefore, it was decided to derive the maximum sample size from the minimum obtained, which was 228 individuals for the insulin variable, which in turn was the limiting variable for sampling because of its having the highest variability. Therefore, sample size was set at 228 students as the minimum to meet the margin of error in the population measures for all the variables of interest. However, estimating a loss of 50 %, the final sample was set on 456 children. Stratification by gender and age was carried out within each school so that the proportions for age and gender were maintained. Inclusion criteria were established for the age group between 6 and 10 years, with subjects enrolled in State and municipal public schools. Exclusion criteria included children with medical and/or motor limitations, unable to conduct a physical test described elsewhere (16), and children enrolled in rural schools, representing 6 % of the city's students.

LABORATORY TESTS

Assays for glucose, triglycerides, and HDL-c were performed using a commercial diagnostic kit (Labtest Diagnóstica SA/Lagoa Santa, Brazil) as described by Granjeiro et al., 2015 (7). After 12 hours of fasting, 10 mL of blood were collected into a disposable plastic syringe, and this amount was equally divided and distributed into two tubes. One of the tubes, containing a fluoride anticoagulant, was centrifuged to obtain plasma, and the fasting glucose level was measured by an automated enzymatic method in a Clinline 150 machine (Biomerieux, USA). After centrifugation, the serum was obtained from the remaining 5 mL, and 500 µL were removed for the analysis of total cholesterol and fractions by the colorimetric enzymatic method, as well as for the analysis of triglycerides by the automated enzymatic method. All tests were performed on the Clinline 150 machine (Biomerieux, USA). An endpoint kinetic method was used for the determination of glucose and triglyceride levels. A reagent was used for selective measurement of HDL-c.

ANTHROPOMETRY

Body mass was measured with the children wearing light clothes on a Seca 803 digital electronic scale (Seca, Hamburg, Germany) with a maximum capacity of 150 kg and a precision of 0.1 kg. Height was measured on an Alturaexata vertical anthropometer (Alturaexata, São Paulo, Brazil), which was graduated in centimetres and had a precision of 0.001 m. The body mass index (BMI) was calculated using the ratio of total body mass in kilograms to height in square meters. Waist circumference was measured at the end of a normal expiration and by setting a reference point located between the lowest rib and the top of the iliac crest. A flexible, inelastic tape measure (Venosan, Pernambuco, Brazil) was used, which was 2 m in length with a precision of 0.001 m. Body weight, height, and waist circumference were measured twice, and the mean was calculated.

BLOOD PRESSURE

Systolic blood pressure and diastolic blood pressure were measured through an automated blood pressure monitor (Omron HEM711, China), which has been validated (24 - GRIM; GRIM, 2008) for scientific purposes. Three measurements were performed on the right arm after at least 5 minutes of rest, with the child seated and his or her legs, and arms in a relaxed position. A 2-minute interval was provided between each measurement. The mean of the three measurements was calculated.

CRITERIA FOR THE DIAGNOSIS OF METABOLIC SYNDROME

The cut-off values for waist circumference, body mass index, blood pressure, fasting glucose, HDL cholesterol, and triglycerides were established according to Cook et al. (2003) (25), Boney et al. (2005) (26), and Ferreira et al. (2007) (27) for the 6-10 years age group, as shown in table I.

STATISTICAL ANALYSIS

The statistical analysis was performed using the statistical package Epi-InfoTM, version 7. The means of numerical variables were compared using Student's *t*-test for independent samples. The significance level for all tests was set at 5 % ($p < 0.05$). The prevalence and number of MetS components with alterations were presented with 95 % confidence intervals, and the significance was evaluated according to the chi-squared test, Fisher type. The comparison among the different criteria for agreement in the diagnosis of MetS was determined using the kappa coefficient. This coefficient quantifies the degree of reliability by comparing the observed agreement with the agreement that would be expected by chance. Thus, a kappa coefficient greater than 0.80 means a perfect correlation between criteria, whereas a coefficient between 0.61 and 0.80 indicates substantial agreement. Finally, a kappa coefficient equal to or lower than 0.4 demonstrates at least a reasonable correlation (28).

ETHICAL CONSIDERATIONS

The parents of the children signed a consent form in advance. All procedures were approved by the Research Ethics Committee of Universidade Federal de Minas Gerais (No. 0040.0.203.000-10) and Universidade de Itaúna (No. 012/10) in accordance with the Helsinki Declaration.

RESULTS

A total of 290 children, aged 6-10 years, 54.5 % boys, participated in this study. Their anthropometric characteristics and components of MetS are shown in table II. Excess weight (overweight + obesity), overweight, and obesity were observed in 25.8 % (n = 75), 8.9 % (n = 26), and 16.9 % (n = 49) of the sample, respectively.

The most prevalent metabolic alteration with all the criteria used in this study was obesity, followed by triglycerides, HDL-c, blood pressure, and fasting glucose (Table III). The prevalence of altered WC was almost 2 times higher according to Cook criteria when compared to Ferreira criteria, whereas the prevalence of altered HDL-c was almost 2 times higher according to Cook than according to Boney criteria. The prevalence of altered blood pressure was almost 2 times higher for Cook in comparison with Boney and Ferreira criteria. The prevalence of altered fasting glucose estimated with Boney and Ferreira criteria was 4 times higher than with Cook criteria. The prevalence of MetS ranged from 3.1 % for Boney (26) and Ferreira (27) criteria to 6.2 % for Cook (25) criteria.

Table I. International criteria for the diagnosis of metabolic syndrome in children according to Boney et al. (2005), Cook et al. (2003), and Ferreira et al. (2007)

Criteria	Individual parameters for diagnosis				
	Obesity	HDL-c*	Triglycerides*	Hypertension	Glucose*
Boney et al., 2005 (6)	BMI ≥ 85th percentile	< 5th percentile	> 95th percentile	> 95th percentile	> 100
Cook et al., 2003 (22)	WC ≥ 90th percentile	≤ 40	≥ 110	≥ 90th percentile	≥ 110
Ferreira et al., 2007 (31)	BMI ≥ 95th percentile	≤ 38	≥ 110	> 95th percentile	> 100

*BMI: body mass index; WC: waist circumference; HDL-c: high density lipoprotein-cholesterol; *Values in mg/dL.*

Table II. Age, BMI, and components of MetS in Brazilian children aged 6-10 years (n = 290)

Variables	Total		Boys (n = 158)		Girls (n = 132)	
	Mean	SD	Mean	SD	Mean	SD
Age	8.18	± 0.98	7.67	± 0.82	8.80	± 0.83
BMI (kg/m^2)	17.21	± 3.41	17.46	± 3.27	16.91	± 356
Waist circumference (cm)	60.34	± 9.07	61.30	± 9.03	59.19	± 9.02
Systolic blood pressure (mm Hg)	95.35	± 10.74	95.81	± 11.38	94.80	± 9.93
Diastolic blood pressure (mm Hg)	58.30	± 8.75	57.50	± 8.94	59.26	± 8.46
Fasting glucose (mg/dL)	88.50	± 8.06	88.31	± 8.19	88.70	± 7.91
Triglycerides (mg/dL)	83.24	± 36.45	79.77	± 33.47	87.40	± 39.46
HDL-c (mg/dL)	51.76	± 10.86	53.08	± 10.91	50.20	± 10.62

BMI: body mass index; WC: waist circumference; HDL-c: high density lipoprotein cholesterol.

Table III. Prevalence and number of metabolic syndrome components with alterations according to Boney et al. (2005) (26), Cook et al. (2003) (25), and Ferreira et al. (2007) (27) in Brazilian children aged 6-10 years (n = 290)

	Boney et al., 2005	Cook et al., 2003	Ferreira et al., 2007
Components with alterations			
Obesity (WC or BMI)	25.86 % (75/290)	31.03 % (90/290)	17.93 % (52/290)
Blood pressure (mm Hg)	3.79 % (11/290)	7.24 % (21/290)	3.79 % (11/290)
Fasting glucose (mg/dL)	3.79 % (11/290)	0.69 % (2/290)	3.79 % (11/290)
Triglycerides (mg/dL)	22.41 % (65/290)	18.62 % (54/290)	18.62 % (54/290)
HDL-c (mg/dL)	6.90 % (20/290)	14.14 % (41/290)	8.62 % (25/290)
Number of components			
0	56.21 % (163/290)	51.72 % (150/290)	62.76 % (182/290)
1	28.97 % (84/290)	32.41 % (94/290)	25.86 % (75/290)
2	11.72 % (34/290)	9.66 % (28/290)	8.28 % (24/290)
3	2.07 % (6/290)	4.83 % (14/290)	2.07 % (6/290)
4	1.03 % (3/290)	1.38 % (4/290)	1.03 % (3/290)
MetS	3.1 % (9/290)	6.2 % (18/290)	3.1 % (9/290)

BMI: body mass index; WC: waist circumference; HDL-c: high density lipoprotein cholesterol.

When just one of the MetS components above the cut-off point was considered, a prevalence of 28.97 %, 32.41 %, and 25.86 % was found according to Booney, Cook, and Ferreira, respectively. Only about 1 % of the children showed four MetS components above the cut-off point with all the criteria investigated.

Table IV shows the prevalence of MetS according to gender, nutritional status, and age. The prevalence of MetS was higher in boys according to Boney and Ferreira; on the other hand, it was higher among girls according to Cook. In the sample with excess weight (overweight and/or obesity) the prevalence of MetS was higher when compared to the total sample for all criteria. Children with obesity presented the highest prevalence of MetS, ranging from 16.33 % according to Boney and Ferreira, to 24.49 % according to Cook. In relation to gender and nutritional status, the prevalence of MetS was higher considering the Cook criteria as compared to the Boney and Ferreira criteria. Regarding the age group, the lowest prevalence of MetS was found for 7 year-old children according to the Ferreira criteria (0 %), and the highest prevalence was found for 8 year-olds according to Cook's criteria (10 %).

The agreement between parameters for each set of criteria is shown in table V. Agreement in pairs for MetS was analyzed with the kappa coefficient, and showed a concordance of 57 % (kappa = 0.57) between Boney (26) and Cook (25) criteria, and 65 % (kappa = 0.65) between Cook (25) and Ferreira (27), which may be considered an intermediate agreement. The greatest concordance found was 77 % (kappa = 0.77) and was observed between Boney (26) and Ferreira (27) criteria, demonstrating a substantial agreement.

Table IV. Prevalence of MetS according to nutritional status, gender, and age by Boney et al. (2005), Cook et al. (2003), and Ferreira et al. (2007) criteria in Brazilian children aged 6-10 years (n = 290)

	Boney et al., 2005	Cook et al., 2003	Ferreira et al., 2007
Gender			
Girls	2.27 % (3/132)	7.58 % (10/132)	2.27 % (3/132)
Boys	3.80 % (6/158)	5.06 % (8/158)	3.80 % (6/158)
Nutritional status			
General	3.10 % (9/290)	6.21 % (18/290)	3.10 % (9/290)
Excess weight	12.00 % (9/75)	21.33 % (16/75)	10.67 % (8/75)
Overweight	3.85 % (1/26)	15.38 % (4/26)	0 % (0/26)
Obesity	16.33 % (8/49)	24.49 % (12/49)	16.33 % (8/49)
Age (years)			
6	2.50 % (1/40)	2.50 % (1/40)	2.50 % (1/40)
7	2.00 % (1/50)	4.00 % (2/50)	0 % (0/50)
8	5.00 % (3/60)	10.00 % (6/60)	6.67 % (4/60)
9	2.56 % (2/78)	6.41 % (5/78)	1.28 % (1/78)
10	3.23 % (2/62)	6.45 % (4/62)	4.84 % (3/62)

BMI: body mass index; WC: waist circumference; HDL-c: high density lipoprotein cholesterol.

Table V. Concordance (*Kappa* coefficient (95 % CI)) between the criteria by Boney et al., Cook et al., and Ferreira et al. in Brazilian children aged 6-10 years (n = 290)

Criteria	Boney x Cook	Boney x Ferreira	Cook x Ferreira
MetS	0.57 (0.47-0.68)	0.77 (0.66-0.89)	0.65 (0.54-0.76)
Obesity (WC or BMI)	0.82 (0.71-0.94)	0.77 (0.66-0.88)	0.64 (0.53-0.74)
Blood pressure (mm Hg)	0.67 (0.50-0.23)	1.00 (0.89-1.11)	0.67 (0.56-0.78)
Fasting glucose (mg/dL)	0.29 (0.22-0.38)	1.00 (0.89-1.11)	0.29 (0.22-0.38)
Triglycerides (mg/dL)	0.72 (0.60-0.83)	0.72 (0.60-0.83)	1.00 (0.89-1.11)
HDL-c (mg/dL)	0.62 (0.51-0.73)	0.88 (0.77-0.99)	0.73 (0.62-0.84)

MetS: metabolic syndrome; BMI: body mass index; WC: waist circumference; HDL-c: high density lipoprotein cholesterol.

The best agreements found for WC, blood pressure, fasting glucose, triglycerides, and HDL-c were 0.82 (Boney (26) x Cook (25) criteria), 1.0 (Boney (26) x Ferreira (27) criteria), 1.0 (Boney (26) x Ferreira (27) criteria), 1.0 (Boney (26) x Cook (25) criteria, and Boney (26) x Ferreira (27) criteria), and 0.88 (Boney (26) x Ferreira (27) criteria), respectively. Boney (26) x Ferreira (27) demonstrated the best agreement in 3 parameters (blood pressure, fasting glucose, and HDL-c).

DISCUSSION

In the last decades the socio-economic growth of developing countries such as Brazil was followed by changes in the nutritional status and lifestyle of their inhabitants. These changes have been characterized by increased consumption of high-energy-dense foods rich in sugars and fat, and decreased physical activity, factors that favor obesity (29). Moreover, the role of fetal programming in MetS and obesity is an emerging theme. According to it, in developing countries poor maternal nutrition and low birth weight cause harmful metabolic adaptations, which followed by improved food provision in the postpartum period may increase abdominal obesity and chronic diseases (29).

Children may develop transient insulin resistance during puberty, and normal lipid levels may vary according to age, gender, and ethnicity. Therefore, the definition of diagnostic criteria for MetS in children has been difficult to establish (15,18,30). There is no consensus on MetS criteria in Brazil or worldwide during childhood, which difficults comparisons between studies. Considering the aforementioned limitations for the diagnosis of MetS, questions arise regarding the importance of its identification during childhood and adolescence. Moreover, studies have demonstrated a positive relationship of MetS during childhood with risk of MetS and type-2 diabetes after reaching adulthood (18,22,23). The presence of components of MetS in childhood and adolescence may have no predictive value for adults but allows to identify children who are at higher risk. Thus, greater attention may be given to children with potential risk, providing prevention for MetS and diabetes in adulthood (30,31).

In the present study the prevalence of MetS ranged from 3.10 % according to Boney's (26) and Ferreira's (27) criteria to 6.21 % according to Cook's (25) criteria, which corroborates the reports by Seki et al. (2009) (13), who found a 3.6 % prevalence using the Boney (26) and Ferreira (27) criteria. However, Ferreira et al. (2009) observed a higher prevalence of MetS (11.9 %) when compared with the present study (32).

Additionally, Pitangueira et al. (2014) found in children and adolescents with 7-14 years of age a prevalence of 12.8 % according to the NCEP ATP III criteria (1). In the study by Strufaldi et al. (2008) the prevalence of MetS was 13.5 % and 15 % for IDF and Jolliffe and Janssen´s criteria, respectively, in Brazilian children from 6 to 10 years (19). A wider range of MetS prevalences was found by Guilherme et al. (2019) in a 10-to-14-year-old Brazilian sample, which corresponds to 1.7 %, 3.3 %, and 17.4 % according to the IDF (33), Cook (25), and Ferranti (4) criteria, respectively (15). As far as we know, this is the first study to investigate the prevalence of MetS in a representative sample of the total population of children under 10 years in a Brazilian city.

As regards other Latin American countries, such as Chile, a study conducted by Mardones et al. (2014) analyzed a sample of children and adolescents using the criteria suggested by Cook and found a MetS prevalence of 7.3 %. This value is similar to that found in the present study considering the same criteria (34). In Guatemala, the prevalence of MetS according to the NCEP ATP III criteria for children of 8-13 years of age was 2 %, which is similar to the prevalences found in our study considering the criteria proposed by Boney and Ferreira (35).

In the sample with excess weight (overweight and obesity) in the present study, the prevalence of MetS was 10.67 %, 12 %, and 21.33 % according to Ferreira's, Boney's, and Cook's criteria, respectively. A similar result was found in another Brazilian study using the criteria by Ferreira (11.7 %) (27), Boney (12.5 %) (26), and Cook (11.5 %) (25) (20). Other Brazilian studies conducted in other regions found in samples with excess weight a higher prevalence of MetS in comparison with the present study (between 26.4 % and 59.7 %) (1,36).

A Brazilian study including children with 7-11 years of age found MetS only among obese children (32). A study analyzing data from children and later adults found a significant association with the risk of MetS later in life when children had a BMI above the 75th percentile (22). Since epidemiological data show that the prevalence of MetS is high among obese children and adolescents, Weiss and colleagues suggest that screening for MetS should be directed only to this group rather than all of the pediatric population (30). However, the authors declare that it is important to emphasize that obesity is not the cause of this metabolic disorder but a marker (30). Thus, limiting the screening of MetS in obese children may be a risk, since the presence of MetS is not exclusive to this population.

When we analyzed the number with only one changed parameter our findings are lower than that those observed in the study by Ferreira (27), namely 38.50 %. However, Pitangueira et al. (2014) demonstraded a high prevalence for only one altered parameter (81.7 %) in another region of Brazil. Although in the Pitangueira study (1) the percentage of children with only one changed parameter was much higher than that found in the present study, we believe that a prevalence between 25 % and 32 % with at least one altered component is a warning sign for the population, especially considering our younger age range (6-10 years). When 2 (8.28 % to 11.72 %), 3 (2.07 % to 4.83 %) and 4 (1.03 % to 1.38 %) altered parameters were analyzed, the prevalence found in this study was lower than that found in three other Brazilian studies. Ferreira et al. (2007) found 44.20 %, 15.40 %, and 1.90 % for 2, 3 and 4 changed parameters, respectively (27). Pitangueira et al. (2014) found 32.50 % with 2 changed parameters and 12.80 % with three or more altered parameters (1). Guilherme et al. (2019), in a sample of Brazilian children and adolescents (10-14 years), found 1 or 2 changed parameters in 63.9 %, 52.3 %, and 43.2 % for Ferranti's (4), Cook's (25), and IDF (33) criteria, respectively (15).

Obesity was the most prevalent MetS component in the present study. This result is in agreement with the study by Tabares-Braga & Fonseca (37). On the other hand, the prevalence of abdominal obesity was the 2nd and 4th abnormality for the studies by Seki and Pitangueira, respectively (1,13). According to Guilherme et al. (2019) (15), the most prevalent altered component of MetS was low HDL-c for Ferranti (4), and hypertension for Cook (25) and IDF (33).

When comparing the three criteria analyzed in the present study, Cook used the measure of waist circumference (WC) and had the highest prevalence in this parameter. The criteria by Boney (26) and Ferreira (27) use the BMI percentile, and the value found by Boney (26) was greater than that found by Ferreira (27). This happens because the cutoff for obesity is a lower percentile (p85) than the second percentile (p95). The discussion on which is the best parameter to be used, waist circumference or BMI percentile, is extensive regarding the classification of obesity in MetS. Gonçalves et al. (16) identified different cutoff points for waist circumference and BMI in their grouping of cardiovascular risk factors in children. We know that BMI does not identify visceral fat and therefore can identify children who are at risk according to waist circumference as out of risk. In this way, central adiposity appears to be the predominant diagnostic criterion for MetS (38).

A cohort study of 159 adolescents indicated that WC is a very useful indicator for the diagnosis of MetS as it is an expression of abdominal fat accumulation (39). Although all these different obesity components have been used among the criteria for MetS, the best agreement in these paramaters was found between Boney's (26) and Cook's (25) criteria (kappa = 0.82) and Boney's (26) and Ferreira's (27) criteria (kappa = 0.77). Our results suggest that even with different parameters, BMI and WC may present substantial or perfect agreement for the classification of MetS. Moreover, obesity in childhood is a risk for MetS in adulthood, and early actions may help to prevent metabolic disease (8). For this reason, the use of clinically relevant predictors for cardio-metabolic abnormalities, such as anthropometric indices (BMI and WC), could be useful for population-based obesity prevention strategies (40).

High fasting glucose levels was the MetS component with the lowest prevalence according to all the criteria used in this study. These results are in agreement with other studies (1,13,15,35). The present study found a prevalence three times lower for altered fasting glucose, according to Cook's criteria (25). This may be explained by a difference in cut-off values. Boney (26) and Ferreira (27) criteria used the same cut-off values (> 100 mg/dL) whereas Cook used a value above 110 mg/dL. Regarding glucose, the agreements found between the criteria by Boney (26) and by Ferreira (27) and Cook's (25) criteria were the lowest when compared to all other factors (kappa = 0.29). It is well known that the use of fasting blood glucose as a MetS component in children is questionable. Therefore, some other indices of insulin resistance have been suggested for MetS diagnosis, whereas its change preceeds a fasting blood glucose alteration in children and adolescents (15).

It was found that the agreement between the criteria by Boney (26) and by Cook (25) was moderate (kappa = 0.57). The agreement between Cook's (25) and Ferreira's (27) criteria was substantial, with a slightly larger kappa coefficient (kappa = 0.65), which can be explained by the fact that these two criteria used the same cut-off value for tryglicerides. The agreement between Boney's (26) and Ferreira's (27) criteria was 77 % (kappa = 0.77), which is considered a substantial level of agreement. This better agreement was expected because both studies used the same cut-off values for blood pressure and fasting glucose. Rinaldi and colleagues (2010) (20) reported on a study with Brazilian children in the same age group as in the present investigation, which compared the prevalence of MetS using six different diagnostic criteria, including the three sets of criteria used in the current study: Cook (25), Boney (26) and Ferreira (27). The agreement found between the criteria by Boney (26) and by Cook (25) was substantial (kappa = 0.67), and that between Boney's (26) and Ferreira's (27) criteria was also substantial (kappa = 0.73), as in the present study. On the other hand, the agreement obtained between Cook's (25) and Ferreira's (27) criteria was higher, and is considered by the authors a perfect agreement (kappa = 0.84) (20). In the study by Guilherme et al. (2019), agreement was substantial between Cook (25) and Ferranti (4) (kappa = 0.72), also substantial between IDF (32) and Ferranti (4) (kappa = 0.67), and perfect between IDF (32) and Cook (25) criteria (kappa = 0.95) (15). Another Brazilian study in obese adolescents examined the prevalence of MetS using three different sets of diagnostic criteria, which were not the same sets used in the present study. Among the three sets of criteria analyzed, two moderate agreements and one almost perfect agreement were found (17). While using different populations, age group, and criteria, the present study also found two moderate agreements and one good agreement. Therefore, standardizing the diagnostic criteria used for MetS in the pediatric population is important both for research and clinical practice.

LIMITATIONS OF THE STUDY

The main limitation of the present study was the absence of a maturation analysis of the children.

CONCLUSION

The prevalences of metabolic syndrome in school children aged 6-10 years were 2.27 % (Boney and Ferreira criteria) and 7.58 % (Cook criteria) for girls, and 3.8 % (Boney and Ferreira criteria) and 5.06 % (Cook criteria) for boys. The prevalence of metabolic syndrome was progressively higher as body mass increased. The prevalences according to Boney and Ferreira were lower than according to Cook. Therefore, when considering the three above-mentioned criteria, we suggest the use of Cook's criteria for the diagnosis of MetS in clinical practice, since using these criteria a wider diagnostic range is obtained, thereby reducing the risk of underdiagnosis.

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