FAMED PUCRS Scientia Medica
Sci Med. 2016;26(3):ID22854
ISSN 1980-6108
http://dx.doi.org/10.15448/1980-6108.2016.3.22854
ORIGINAL ARTICLE
Open Access

Frequency of metabolic syndrome in children and adolescents from public schools of Divinópolis, Minas Gerais, Brazil, according to three international diagnostic criteria

Frequência de síndrome metabólica em crianças e adolescentes de escolas públicas de Divinópolis, Minas Gerais, Brasil, conforme três critérios diagnósticos internacionais

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ABSTRACT

Aims: To assess the frequency of metabolic syndrome in children and adolescents according to three international diagnostic criteria determining the level of agreement between these different criteria.

Methods: Waist circumference, blood pressure, blood glucose, high-density lipoprotein cholesterol, and serum triglycerides were evaluated in students from public schools of different regions of Divinópolis, MG, Brazil. Children and adolescents aged between 10 and 17 years were selected. Criteria adapted from the World Health Organization (WHO), National Cholesterol Education Program – Adult Treatment Panel III (NCEP/ATPIII), and International Diabetes Federation (IDF) were used for the diagnosis of metabolic syndrome. The kappa coefficient was used to evaluate the level of agreement among the three criteria.

Results: The study evaluated 202 students (86 boys and 116 girls). The frequency of metabolic syndrome was 1.16% for boys and none of the girls presented with metabolic syndrome, according to WHO criteria. According to the NCEP/ATPIII and IDF criteria, metabolic syndrome was not detected in the studied sample. Low blood levels of high-density lipoprotein cholesterol was the most frequent metabolic alteration in all teenagers according to the NCEP/ATPIII and IDF criteria, while body mass index was the most frequent one according to WHO criteria. The level of agreement for one altered parameter was poor when comparing WHO and NCEP/ATP/III, moderate when comparing WHO and IDF and high when comparing the NCEP/ATP/III and IDF criteria.

Conclusions: Significant differences between the frequencies of individual metabolic syndrome parameters were found in the studied sample of children and adolescents, depending on the criteria used. According to WHO criteria, metabolic syndrome was found at a low frequency and only in boys, while the NCEP/ATPIII and IDF criteria did not diagnose metabolic syndrome. The present findings suggest the need to reach a consensus on the cut-off points for risk factors and a single diagnostic definition of metabolic syndrome in children and adolescents.

KEY WORDS: metabolic syndrome X; child; adolescent.

RESUMO

Objetivos: Avaliar a frequência de síndrome metabólica em crianças e adolescentes de acordo com três critérios diagnósticos internacionais, determinando o grau de concordância entre esses diferentes critérios.

Métodos: Circunferência da cintura, pressão arterial, glicemia, colesterol ligado à lipoproteína de alta densidade e triglicérides séricos foram avaliados em alunos de escolas públicas de diferentes regiões de Divinópolis, MG, Brasil. Foram selecionadas crianças e adolescentes entre 10 e 17 anos de idade. Critérios adaptados da Organização Mundial da Saúde (OMS), National Cholesterol Education Program, Adult Treatment Panel III (NCEP/ATP III) e da Federação Internacional de Diabetes (IDF) foram utilizados para o diagnóstico da síndrome metabólica. O coeficiente kappa foi utilizado para avaliar o grau de concordância entre os três critérios.

Resultados: O estudo avaliou 202 alunos, sendo 86 meninos e 116 meninas. A frequência de síndrome metabólica foi de 1,16% para os meninos e nenhuma das meninas apresentou síndrome metabólica, de acordo com os critérios da OMS. De acordo com os critérios de NCEP/ATP III e IDF, não foi detectada síndrome metabólica na amostra estudada. Baixos níveis sanguíneos de colesterol ligado à lipoproteína de alta densidade foi a alteração metabólica mais frequente para todos os adolescentes de acordo com os critérios do NCEP/ATP III e IDF, enquanto o índice de massa corporal foi o mais frequente para a OMS. O grau de concordância para um parâmetro alterado foi pobre na comparação entre OMS e NCEP/ATP III, moderado entre OMS e IDF e alto entre NCEP/ATP/III e IDF.

Conclusões: Foram encontradas diferenças significativas entre as frequências dos parâmetros individuais da síndrome metabólica na amostra estudada de crianças e adolescentes, dependendo dos critérios utilizados. De acordo com os critérios da OMS, a síndrome metabólica foi encontrada com uma frequência baixa, e apenas nos meninos, enquanto NCEP/ATP III e IDF não diagnosticaram síndrome metabólica. Os achados sugerem a necessidade de estabelecer um consenso sobre os pontos de corte para fatores de risco e uma única definição diagnóstica de síndrome metabólica em crianças e adolescentes.

DESCRITORES: síndrome X metabólica; criança; adolescente.

Received: *January, 2016*
Accepted: *May, 2016*
Published: *June, 2016*

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Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FUNEDI, Fundação Educacional de Divinópolis; HDL-c, high-density lipoprotein cholesterol; IBGE, Brazilian Institute of Geography and Statistics; IDF, International Diabetes Federation; MetS, metabolic syndrome; NCEP ATP III, National Cholesterol Education Program's Adult Treatment Panel III; SBP, systolic blood pressure; WC, waist circumference; WHO, World Health Organization.

INTRODUCTION

Metabolic syndrome (MetS) is characterized as a complex disorder represented by a constellation of factors associated with central obesity, hypertension, diabetes, dyslipidemia, and insulin resistance described since the last century [1]. It is currently seen as a global epidemic with alarming numbers, associated with cardiovascular morbidity and mortality and high socioeconomic cost for public health services. The number of cardiovascular risk factors of metabolic syndrome evidenced in most cases corresponds to the phenomenon called peripheral insulin resistance, a consequence of obesity [2]. MetS can be identified when more than three of five factors are altered, for example, increased blood pressure, elevated blood glucose, increased triglyceride, decreased high-density lipoprotein cholesterol (HDL-c), and increased abdominal circumference.

Despite the existence of different criteria for the diagnosis of MetS, the Brazilian Society of Cardiology adopts the National Cholesterol Education Program-Adult Treatment Panel III (NCEP/ATPIII) criteria, as established by the First Brazilian Guidelines for Diagnosis and Treatment of Metabolic Syndrome [3]. However, all the criteria that have been formulated are for adults and there is not a consensus for MetS diagnosis in children and adolescents. This syndrome has been considered problematic, since blood pressure, lipid profile, and anthropometric measurements vary with age and with pubertal stage [4]. In 2005, Ford et al. [5] presented adapted parameters from the NCEP/ATPIII for the 12- to 19-year-old age group, which has been used by American and other studies worldwide. There are reports in the literature about other criteria also adapted for children and adolescents, such as the International Diabetes Foundation (IDF) [6] and the World Health Organization (WHO) [7]. However, this lack of consensus prevents us from knowing how many children and adolescents are really affected by MetS around the world.

The occurrence of MetS in children and adolescents is associated with cardiovascular disease and metabolic disorders, such as non-alcoholic fatty liver disease; diabetes and dyslipidemia, and motor development disorders. Longitudinal studies report that children with MetS have increased health risks with direct consequences into adulthood, anticipating the onset of non-communicable chronic degenerative diseases in future years [8,9].

A systematic review with students aged 10 to 19 years has shown that studies with children and adolescents, especially in North American and Middle Eastern countries and in some parts of Asia and Europe [10], are rare. The prevalence of MetS in children and adolescents can vary from 2.2% (95%CI: 1.40-3.0) to 52.1% (95%CI: 47.4-56.9) [11]. In Latin America, studies show that the prevalence of MetS varies from 5.5% to 22.7% in normal-weight adolescents and from 31.6 to 43.3% in obese adolescents [12]. In Brazil, a literature review with 15 studies demonstrated that the prevalence of MetS ranges from zero (in normal-weight individuals) to 42.4% (in overweight individuals) [13]. The prevalence may increase with age [14]; there is greater risk of MetS among boys than among girls [15]; and overweight and obese youngsters are at a greater risk than normal-weight adolescents [16].

Studies that compare the different criteria for MetS in children and adolescents have demonstrated that the application of different criteria can substantially influence the estimated prevalence [13,15]. Moreover, a significant difference in the level of agreement among criteria has been demonstrated [17,18]. Disagreement concerning the choice of the best diagnostic criteria is common because, due to children's and adolescents' rapid growth, doubts still exist as to which cut-off points should be used and whether they should be expressed in absolute values or in percentiles, taking into account age, gender, and pubertal stage [19].

Owing to the paucity of studies, knowledge on the prevalence of MetS in Brazil is concentrated in the southeast and in some cities and, therefore, the data cannot be extended to the country as a whole [15]. The purpose of this paper was to evaluate the frequency of MetS in students aged 10 to 17 years attending public education institutions in different regions of Divinópolis, State of Minas Gerais (MG), Brazil, using the adapted NCEP/ATPIII, IDF, and WHO criteria, and to determine the level of agreement among these criteria.

METHODS

A cross-sectional study was conducted with children and adolescents from public schools in

Divinópolis (MG, Brazil), whose population is 213,016 inhabitants. In 2011, the base year for the calculation of the sample, 5,036 students were enrolled in the fifth and ninth years of elementary school and in the third year of high school. The sample calculation was based on the prevalence of MetS, estimated at 7.7% [20], using a 95% confidence interval, absolute precision of 5%, and clustering as sampling method (draw of classes) for a total of 107 students [21]. Predicted loss was 30% and the sample size was estimated to be 69 children and adolescents.

The inclusion criteria were male and female students aged 10 to 17 years enrolled in the fifth and ninth years of public elementary school and in the third year of public high school who were available to participate in two days of data collection and who signed the informed consent form or whose parents or guardians (in the case of minors) did. The exclusion criteria were absence of physical impairment in anthropometric measurements, no pregnancy or breastfeeding, no current disease and/or use of medication that could interfere in the test results.

Blood samples were collected for biochemical tests and an interview about socioeconomic characteristics, pre-existing disease, and lifestyle was conducted on the first day. A venous blood sample (10 mL) was collected from each participant after a 12-hour fasting period using a vacuum system. Assays for glucose, triglycerides, and HDL-c were performed using a commercial diagnostic kit (Labtest Diagnóstica SA/Lagoa Santa, Brazil) and a semi-automatic biochemistry analyzer (Thermo Plate, Belo Horizonte, Brazil). An endpoint kinetic method was used for the determination of glucose and triglyceride levels. A reagent was used for selective measurement of HDL-c. The applied questionnaire included information about age, ethnicity, and lifestyle (e.g., diet, smoking, alcohol consumption, and physical activity) according to the Brazilian Institute of Geography and Statistics – IBGE [22]. The following definitions were used: smoker – individual who smoked cigarettes every day; alcoholic – individual who consumed alcoholic beverages at least three times a week; physically inactive – individual who practiced any exercise less than two times a week. All the answers should be related to the frequency of such habits in the past 30 days. On the second day, the volunteers had their waist circumference and blood pressure measured. Waist circumference was measured using an anthropometric tape corrected to one decimal place. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using a mercury sphygmomanometer, according to the technique recommended for children [23].

For the purpose of this study, we adapted the three criteria to determine the presence of MetS among children and adolescents, as described by Alvarez et al. [14]. The cut-off values used for diagnosis are presented in **Table 1.** In line with Viner et al. [7], we applied body mass index (BMI) cut-off points according to sex and age in order to classify overweight. Also, fasting glucose was used instead of the oral glucose tolerance test due to its practical aspects and viability in epidemiological studies. For Ford et al. [5] and Zimmet et al. [6], waist circumference values in the 90th percentile for age and sex were obtained according to the distribution of the investigated sample. In order to allow comparisons among the three criteria used in this study, the criteria suggested by IDF for the diagnosis of MetS among adolescents aged up to 16 years were used for all adolescents. High blood pressure was defined by sex, age, and height-for-age percentile when the criteria proposed by Viner et al. [7] and Ford et al. [5] were applied.

Table 1. Adapted criteria used in the diagnosis of metabolic syndrome in children and adolescents aged 10 to 17 years in Divinópolis, Minas Gerais, Brazil.

Criteria	Viner et al. (WHO)	Ford et al. (NCEP/ATPIII)	Zimmet et al. (IDF)
Overweight/obesity	BMI ≥ 25	WC ≥ 90th percentile	WC ≥ 90th percentile
HDL-c	< 35mg/dL	≤ 40 mg/dL	< 40mg/dL
Glucose	≥ 110mg/dL	≥ 100mg/dL	≥ 100mg/dL
High blood pressure	≥ 95th percentile	≥ 90th percentile	≥ 130mmHg or ≥ 85mmHg
Triglycerides	≥ 150mg/dL	≥ 110mg/dL	≥ 150mg/dL
Metabolic syndrome	3 or + abnormalities	3 or + abnormalities	WC ≥ 90th percentile + 2 or + abnormalities

WHO, World Health Organization; NCEP/ATP III, National Cholesterol Education Program, Adult Treatment Panel III; IDF, International Diabetes Federation; BMI, Body Mass Index; WC, waist circumference; HDL-c, high-density lipoprotein cholesterol.

Statistical analyses were performed using Epi-Info TM, version 7. The means of numerical variables were compared using the t test for independent samples. Student's t and Fisher's exact tests were used to verify significance between boys and girls. The significance level for all tests was $p < 0.05$. The prevalence of components and the number of abnormal MetS parameters were presented using a 95% confidence interval. The different criteria for agreement on the diagnosis of MetS were compared using the kappa coefficient with the following benchmarks: > 0.75 = high agreement; 0.4 to 0.75 = moderate agreement; < 0.4 = poor agreement [24].

All procedures were approved by the Ethics Committee of the State University of Minas Gerais (FUNEDI/UEMG), protocol no. 88/2009, in December of 2009.

RESULTS

We had selected 300 students, but 98 refused to participate. Therefore, 202 students (86 boys and 116 girls) were included in the study. Baseline characteristics of the study population according to sex are shown in **Table 2**. We observed that there were statistically significant differences in age between genders and in blood pressure and triglyceride levels**.** The frequency of MetS among adolescents was 1.16% (95%CI: 0.06-5.6) for boys according to WHO criteria (**Table 3**). MetS was not detected by the NCEP/ATPIII and IDF criteria. According to the three criteria used, none of the girls presented with MetS. The frequency of each individual MetS parameter in accordance with the selected criteria is shown in **Table 4**.

Low blood levels of HDL-c were the most frequent metabolic alteration for all teenagers according to the NCEP/ATPIII and IDF criteria, while BMI was the most frequent alteration according to WHO criteria. The second most frequent metabolic alteration was HDL-c, according to WHO, and high blood pressure, according to NCEP/ATPIII. The third most frequent alteration according to WHO criteria was hypertriglyceridemia and BMI according to the NCEP/ATPIII and IDF criteria.

The frequency of altered individual MetS parameters among the criteria showed disagreement, since the HDL-c parameter was approximately two times more frequent in the NCEP/ATPIII than in the other criteria. Overweight, according to the BMI parameter, was approximately seven times more frequent in WHO criteria than in the other ones. The hypertension factor was 3.7 and 5 times greater according to WHO and IDF criteria, respectively. The frequency of hyperglycemia was two times higher according to the NCEP/ATPIII and IDF criteria than according to WHO criteria, which have a higher cut-off.

Significant differences in HDL-c were observed only between boys and girls (higher in girls), according to the IDF criteria. When lifestyle was considered, sedentary behavior was the highest risk factor among adolescents, being significantly higher among girls. None of the adolescents smoked and only a minority (mostly boys) drank alcohol.

The number of altered individual parameters varied according to the different criteria, as shown in **Table 4**. Note that the frequency of one altered individual parameter was higher in boys, according to WHO criteria. The frequency of two altered parameters was higher according to the NCEP/ATPIII criteria. More than three altered parameters were not found by the NCEP/ATPIII and IDF criteria.

Table 2. Age, BMI, and metabolic syndrome components in children and adolescents aged 10 to 17 years in Divinópolis, Minas Gerais, Brazil.

	Total (N=202) Mean±SD	Boys (N=86) Mean±SD	Girls (N=116) Mean±SD	p-value*
Age (years)	14.21±2.56	14.02±2.47	15±2.63	< 0.05
BMI	20.45±3.73	20.27±3.52	20.59±3.865	> 0.05
Waist circumference (cm)	67.67±8.63	79.17±8.33	66.10±8,76	> 0.05
Systolic blood pressure (mmHg)	106.6±9.41	109.8±8.79	104.1±9.15	< 0.05
Diastolic blood pressure (mmHg)	67.65±7.8	69.24±7.28	66.47±8.00	< 0.05
Glucose (mg/dL)	83.49±14.11	82.27±16.69	84.4±11.84	> 0.05
HDL-c (mg/dL)	51.10±18.07	49.63±15.98	52.19±19.48	< 0.05
Triglycerides (mg/dL)	64.82±28.64	59.15±28.68	69.00±28.00	< 0.05

* Student's t test.
SD, standard deviation; WHO, World Health Organization; NCEP/ATP III, National Cholesterol Education Program, Adult Treatment Panel III; IDF, International Diabetes Federation; BMI, Body Mass Index; WC, waist circumference; HDL-c, high-density lipoprotein cholesterol.

Table 3. Weighted frequency of metabolic syndrome diagnosed in children and adolescents aged 10 to 17 years in Divinópolis, Minas Gerais, Brazil.

Criteria	Total (N=202) % (95%CI)	Boys (N=86) % (95%CI)	Girls (N=116) % (95%CI)
Viner et al. (WHO)	0.5 (0.02-2.41)	1.16 (0.06-5.6)	0
Ford et al. (NCEP/ATPIII)	0	0	0
Zimmet et al. (IDF)	0	0	0

CI, confidence interval; WHO, World Health Organization; NCEP/ATP III, National Cholesterol Education Program, Adult Treatment Panel III; IDF, International Diabetes Federation.

Table 4. Frequency of metabolic abnormalities according to different criteria adapted for the diagnosis of metabolic syndrome based on cut-off points and number of altered parameters in children and adolescents aged 10 to 17 years in Divinópolis, Minas Gerais, Brazil.

Criteria	Total (N=202) %(95%CI)	Boys (N=86) %(95%CI)	Girls (N=116) %(95%CI)	p
Viner et al. (WHO)				
Overweight/obesity (BMI)	14.35 (10.02-19.71)	16.28 (9.57-25.22)	12.93 (7.1-19.99)	0,56*
HDL-c < 35mg/dL	10.9 (7.13-15.77)	10.46 (5.22-18.33)	11.2 (6.37-17.95)	0,86*
Triglycerides ≥ 150mg/dL	1.48 (0.38-3.99)	1.16 (0.06-5.6)	1.73 (0.29-5.58)	0,99**
Glucose ≥ 110mg/dL	1.98 (0.64-4.71)	1.16 (0.06-5.6)	2.58 (0.66-6.87)	0,86**
Hypertension ≥ 95th percentile (SBP and/or DBP)	3.46 (1.53-7.11)	3.49 (0.89-9.20)	3.45 (1.10-8.11)	0.99**
Ford et al. (NCEP/ATPIII)				
Overweight/obesity (WC > 90)	1.98 (0.64-4.7)	3.49 (0.89-9.20)	0.86 (0.04-4.18)	0.42**
HDL-c ≤ 40mg/dL	23.26 (17.83-29.47)	23.55 (15.24-33.04)	23.27 (16.26-31.61)	0.99*
Triglycerides ≥ 110mg/dL	6.93 (3.99-11.09)	5.81 (2.16-12.41)	7.75 (3.85-13.76)	0.59*
Glucose ≥ 100mg/dL	4.45 (2.19-8.07)	6.97 (2.87-13.94)	2.58 (0.62-6.87)	0.25*
Hypertension ≥ 90th percentile (SBP and/or DBP)	12.87 (8.76-18.03)	13.95 (7.78-22.52)	12.07 (7.03-18.98)	0.69*
Zimmet et al. (IDF)				
Overweight/obesity (WC > 90)	1.98 (0.64-4.71)	1.16 (0.06-5.6)	0.86 (0.04-4.18)	0.99**
HDL-c < 40mg/dL	13.86 (9.59-19.15)	1.16 (0.06-5.6)	23.27 (16.26-31.61)[a]	<0.01*
Triglycerides ≥ 150mg/dL	1.48 (0.38-3.99)	1.16 (0.06-5.6)	1.73 (0.29-5.58)	0.99**
Glucose ≥ 100mg/dL	4.45 (2.19-8.02)	6.97 (2.87-13.94)	2.58 (0.66-6.87)	0.25**
Hypertension ≥ 130/85mmHg	2.47 (0.91-5.4)	4.65 (1.49-10.84)	0.86 (0.04-4.18)	0.21**
Race/Ethnicity				
White	42.08 (35.2-49.2)	40.7 (30.22-51.83)	43.1 (33.94-52.62)	0.73*
Non-white	57.92 (50.8-64.82)	59.3 (48.17-69.78)	56.9 (47.66-66.06)	0.73*
Lifestyle				
Physical inactivity	26.73 (20.97-33-16)	12.79 (6.9-21.14)	37.06 (28.65-46.13)[a]	<0.01*
Alcohol consumption	2.97 (1.21-6.07)	5.81 (2.16-12.41)	0.86 (0.04-4.17)[b]	<0.05*
Smoking	0	0	0	0
Number of altered parameters				
Viner et al. (WHO)				
1	32.18 (26.01-38.86)	41.86 (31.79-52.47)	25 (17.76-33.47)[b]	<0.05*
2	5.44 (2.89-9.26)	8.13 (3.62-15.44)	3.45 (1.10-8.10)	0.25**
3	0.49 (0.02-2.41)	1.16 (0.06-5.6)	0	0.85**
Ford et al. (NCEP/ATPIII)				
1	28.71 (22.79-35.24)	30.23 (21.24-40.54)	27.58 (20.04-36.24)	0.68*
2	10.39 (6.72-15.19)	11.62 (6.06-19.75)	9.48 (5.08-15.88)	0.62*
Zimmet et al. (IDF)				
1	26.73 (20.97-33.16)	27.90 (19.21-38.07)	25.86 (18.51-34.4)	0.74*
2	3.46 (1.52-6.73)	5.81 (2.16-12.41)	1.73 (0.29-5.58)	0.23*

* Chi-square test.
** Fisher's test.
CI, confidence interval; SBP, Systolic blood pressure; DBP, diastolic blood pressure; WHO, World Health Organization; NCEP/ATP III, National Cholesterol Education Program, Adult Treatment Panel III; IDF, International Diabetes Federation; BMI, Body Mass Index; WC, waist circumference; HDL-c, high-density lipoprotein cholesterol.

Table 5. Agreement among different criteria adapted for the diagnosis of metabolic syndrome according to individual parameters and number of altered parameters in children and adolescents aged 10 to 17 years in Divinópolis, Minas Gerais, Brazil.

Criteria	WC/BMI	BP	FG	HDL-c	TG	1 altered parameter
WHO/NCEP ATP III	0.215	0.480	0.605	0.575	0.337	0.391
WHO/IDF	0.215	0.410	0.605	0.575	1	0.428
NCEP ATP III/IDF	1	0.293	1	1	0.337	0.7331

WC: waist circumference, BMI: body mass index, BP: blood pressure, FG: fasting glucose, HDL-c: High-density lipoprotein cholesterol, TG: triglycerides.

Overall agreement of the criteria used in this study was high only for one altered parameter when the NCEP/ATPIII and IDF criteria were compared. Agreement was moderate for glucose and HDL-c when WHO criteria were compared with NCEP/ATP III and IDF **(Table 5)**.

DISCUSSION

This study demonstrated that baseline characteristics of the population according to sex were statistically different for age and for MetS parameters such as blood pressure and triglyceride levels. The frequency of MetS according to WHO criteria was 1.16% for boys only. None of the girls presented with MetS. Low level of HDL-c was the most frequent metabolic alteration for all teenagers according to the NCEP/ATPIII and IDF criteria, while BMI was the most frequent one according to WHO criteria. There was moderate agreement between WHO and NCEP/ATPIII criteria in determining values above the normal range for mean blood pressure and fasting glucose. In evaluating WHO and IDF criteria, moderately increased blood glucose levels were also observed. The level of agreement for one altered individual parameter varied from poor (comparing WHO and NCEP/ATP/III) to high (comparing NCEP/ATPIII and IDF).

In the last decades, the prevalence of MetS in adult populations in developed countries has been around 20-25% [20]; this has been exceeded by the prevalence of MetS in developing countries, which varies between 25 and 45% [25]. These changes were expected to be found in the younger population, in which there is a low prevalence of MetS in normal-weight children and adolescents compared with obese ones [8]. Studies have demonstrated that the application of different criteria may substantially affect the estimated prevalence of MetS [15], which has caused difficulty and confusion in understanding its epidemiology [8]. Moreover, Burns et al. [26] assessed childhood predictors of MetS in adults and found that subjects with MetS during adulthood had higher BMI, blood pressure, and triglyceride levels during childhood, showing how important the frequency of individual parameters is at this age.

Despite lower cut-off points for hypertriglyceridemia and high blood pressure used by the NCEP/ATPIII criteria, in this study, MetS was found only in boys, according to WHO criteria. Few studies have demonstrated low or no occurrence of MetS in young people. In the study of children from Kuala Lumpur, Malaysia, MetS was absent in the group aged 9-12 years [27]. Similar to the present results, Turkish students aged 10-17 years had a MetS prevalence of 2.2% (1.5-3.1) [28]. Among schoolchildren and adolescents from Mérida (Mexico) aged 9-18 years, the prevalence of MetS was 2.2% and 1.8% according to the percentiles obtained by Cook-Merida and Cook-USA, respectively [29]. In Guatemalan children (aged 8-13 years) from public and private schools, the MetS prevalence was 2.0% with no significant difference between boys and girls [30]. When compared to other Brazilian studies, the present results are well below those found in the literature, as in the study of 12- to 19-year-old schoolchildren from public schools in Niteroi, State of Rio de Janeiro, where the prevalence of MetS was 13.8% and 2.4% for boys and girls, respectively [15]. For students from Maracai, State of São Paulo, aged between 10 and 16 years, the prevalence was 4.2% and 3% for boys and girls, respectively [14]. In the municipality of Recôncavo Baiano, State of Bahia, using the NCEP/ATPIII criteria adapted by Ferranti et al. [31], the prevalence was 12.8% in 7- and 14-year-old children.

The individual analysis of each MetS parameter demonstrated that decreased HDL-c blood levels were the most affected parameter in children and adolescents of both sexes, according to the NCEP/ATPIII and IDF criteria. Studies have shown the relationship of low levels of HDL-c and high level of triglycerides with physical inactivity. Schoolchildren and adolescents spend an average of fewer than two hours a week engaging in play and more than four hours a week watching TV, indicating a sedentary lifestyle [25].

Moreover, in this study, the high frequency of HDL-c alteration in girls could be associated with their high frequency of physical inactivity. Henry et al. [32] demonstrated that sociocultural barriers among adolescent girls lead to low levels of physical inactivity.

Alvarez et al. [15] showed a 41.6% prevalence of decreased HDL-c in adolescents from Niteroi, Rio de Janeiro. Seki et al. [14] observed a prevalence of 45.1% for low level of HDL-c in students from Maracai, Sao Paulo. Similar to these studies, Pitangueira et al. [31] noted low levels of HDL-c in 58.2% of students from Recôncavo Baiano. Iranian children and adolescents aged 10 to 19 years showed an HDL-c prevalence of 24.1%, according to the modified NCEP/ATPIII criteria, and there were no differences between boys and girls [33]. Low concentrations of HDL-c may also be related to high physical inactivity [34], a lifestyle factor identified in our study (33%). The difference in prevalence can be explained by the NCEP/ATPIII criteria, which recommend a cut-off point of "less than or equal to 40mg/dL," thereby increasing the frequency of low level of HDL-c among adolescents.

On the other hand, BMI was the most frequently altered individual parameter according to WHO criteria. In this case, excess of BMI by WHO criteria was seven times more frequently than excess of waist circumference by the NCEP/ATPIII and IDF criteria. Although this overestimation of obesity per se is not sufficient to infer a risk of MetS in children, this parameter does represent an important measure of adiposity. Nevertheless, the central obesity cut-off point used by the NCEP/ATPIII and IDF criteria represents a key component in the development of metabolic complications [35].

The use of different definitions for MetS has impaired comparisons across studies as significant discrepancies between criteria have been demonstrated. However, the moderate concordance predicts that, despite the different cut-off points, the tests show a certain degree of agreement regarding the determination of changing values for each risk factor. In the case of HDL-c, the cut-off point for WHO criteria is inferior to that of other criteria that consider it to be a major screening parameter. On the other hand, fasting blood glucose level according to WHO criteria may fail to detect patients at increased risk for this individual parameter. Finally, the criteria for high blood pressure should be evaluated with caution, since WHO and NCEP use figures for the percentiles, while the IDF criteria apply absolute values for defining the condition [29,36].

In conclusion, significant differences between the frequencies of individual MetS parameters in children and adolescents were found in the studied sample, depending on the criteria used. According to WHO criteria, MetS was found at a low frequency and only in boys, while the NCEP/ATPIII and IDF criteria did not diagnose MetS. The present findings suggest the need to reach a consensus on the cut-off points for risk factors and a single diagnostic definition of MetS in pediatric patients. It is important to improve the interpretation and comparison of data obtained from different populations and to standardize the recommended preventive and therapeutic practices.

NOTES

Financial support

Financial support was provided by the Federal University of São João Del-Rey (UFSJ), by the Minas Gerais Research Foundation (FAPEMIG), by the National Council for Scientific and Technological Development (CNPq), and by the University Extension Program of the Ministry of Education PROEXT/MEC/SESu. Thaís M. da Silva received support from the University Extension Program of the Ministry of Education PROEXT/MEC/SESu.

Conflicts of interest

The authors declare no potential conflicts of interest regarding the contents of this study.

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