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Comparison of two diagnostic criteria for metabolic syndrome in adolescents and associations with subclinical atherosclerosis

Comparação de dois critérios de diagnóstico da síndrome metabólica em adolescentes e as associações com a aterosclerose subclínica

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ABSTRACT

Objective

To compare two diagnostic criteria for metabolic syndrome in adolescents and to assess associations with subclinical atherosclerosis.

Methods

A cross-sectional study with a quantitative approach was carried out with 512 adolescents from public schools aged between 15 and 19 years in a municipality in northeast Brazil. The diagnostic criteria used for the metabolic syndrome were the International Diabetes Federation and the National Cholesterol Education Program, Adult Treatment Panel III, adapted by COOK. Subclinical atherosclerosis was assessed through carotid intima-media complex thickness by ultrasound imaging.

Results

The diagnostic criteria for metabolic syndrome The National Cholesterol Education Program-Adult Treatment Panel III, adapted by COOK, identified a higher prevalence of young people with metabolic syndrome, 2.9%, was associated with subclinical atherosclerosis (p=0.02), had an of its components (elevated systemic blood pressure) associated with subclinical atherosclerosis (p=0.030), presented a higher percentage of positive predictive value (PPV=15%), compared to the International Diabetes Federation criteria. The concordance index between the two diagnostic criteria for metabolic syndrome was low (kappa of 0.28, p<0.001).

Conclusion

In adolescents, the criterion of the National Cholesterol Education Program – Adult Treatment Panel III adapted by COOK, was the criterion presented better evaluations and was the only one that was associated with the presence of subclinical atherosclerosis when compared to the criteria of the International Diabetes Federation.

Keywords: Adolescent. Atherosclerosis. Cardiovascular diseases. Metabolic diseases. Metabolic syndrome.

RESUMO

Objetivo

Comparar dois critérios de diagnóstico da síndrome metabólica em adolescentes e avaliar as associações com a aterosclerose subclínica.

Métodos

Estudo transversal, com abordagem quantitativa, desenvolvido em 512 adolescentes de escolas públicas com idade entre 15 e 19 anos em um município do Nordeste Brasileiro. Os critérios de diagnóstico utilizados para a síndrome metabólica, foram o International Diabetes Federation *e o* National Cholesterol Education Program - Adult Treatment *Panel III adaptado por COOK. A aterosclerose subclínica foi avaliada através da espessura do complexo médio-intimal da carótida por imagens de ultrassom.*

Resultados

O critério de diagnóstico para a Síndrome metabólica National Cholesterol Education Program – Adult Treatment *Panel III adaptado por COOK identificou maior prevalência de jovens com síndrome metabólica, 2,9%, apresentou associação com a aterosclerose subclínica (p=0,02), teve um dos seus componentes (pressão arterial sistêmica elevada) associado à aterosclerose subclínica (p=0,030), apresentou maior percentual de valor preditivo positivo (VPP=15%), em comparação ao critério do* International Diabetes Federation. *O índice de concordância entre os dois critérios diagnósticos para síndrome metabólica foi baixo (kappa de 0,28, p<0,001).*

Conclusão

Em adolescentes, o critério do National Cholesterol Education Program – Adult Treatment *Panel III adaptado por COOK foi o critério que apresentou melhores avaliações e foi o único que esteve associado à presença da aterosclerose subclínica, quando comparado ao critério do* International Diabetes Federation.

Palavras-chave: *Adolescente. Aterosclerose. Doenças cardiovasculares. Doenças metabólicas. Síndrome metabólica.*

INTRODUCTION

Metabolic Syndrome (MetS) is characterized by the simultaneous presence of at least three metabolic risk factors, among which the most prominent are: excessive abdominal fat accumulation, elevated blood pressure, insulin resistance, reduced HDL-cholesterol levels, and increased triglycerides [1].

MetS in adolescents is linked to a range of health problems that can compromise both immediate well-being and future health. Key consequences include an increased risk for early cardiovascular diseases, such as hypertension and atherosclerosis, in addition to a greater chance of developing type 2 diabetes still in youth. Liver alterations like hepatic steatosis are also common, along with hormonal and inflammatory imbalances that affect metabolism and growth [2,3].

Globally, the prevalence of MetS in adolescents shows a wide variation, ranging between 0.2% and 38.9%, and is most frequently identified in overweight or obese youth [3]. The *Estudo Nacional de Riscos Cardiovasculares em Adolescentes* (ERICA, Study of Cardiovascular Risks in Adolescents), conducted with 37,504 Brazilian students, identified an MetS incidence of 2.6% in adolescents; however, a large portion showed significant changes in some of the risk factors [4,5].

Currently, there is no solid consensus on the components, cutoff points, and a single diagnostic definition for MetS in adolescents. This lack of diagnostic consensus is concerning, as using different criteria can lead professionals to obtain distinct diagnoses and management approaches for the same patient. Furthermore, the use of multiple diagnostic criteria makes it difficult to identify a reliable number for the incidence and prevalence of MetS in national and international populations in this age group [2,6,7].

The diagnostic criterion of the International Diabetes Federation (IDF) [8,9] and the National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) [10] criterion adapted by Cook are suitable for application in adolescents [2].

As MetS is associated with Cardiovascular Disease (CVD) [5,11], it is essential to evaluate which of the two different diagnostic criteria for MetS in adolescents has a greater association with subclinical atherosclerosis, which is the initial process of CVD that can originate in childhood and progress into adulthood [12].

Subclinical atherosclerosis is characterized by the appearance of fatty streaks in the aortic intima, where non-obstructive atherosclerotic plaques promote functional alterations in vascular tone, related to the release of vasoactive mediators, affecting the production of nitric oxide by a dysfunctional endothelium [12-14].

This sequence of events can be evaluated in adolescence by measuring the Carotid Intima-Media Thickness (CIMT), which consists of measuring the thickness between the tunica intima and the tunica media of the artery using ultrasound imaging [5,15].

Thus, the objective of the present study was to compare two diagnostic criteria for MetS in adolescents, the IDF and the NCEPATPIII-COOK, and to evaluate them in relation to subclinical atherosclerosis, as understanding this relationship may help in choosing the MetS diagnostic criterion that best predicts the adolescent's true health status. This, in turn, can contribute to more appropriate health management and, consequently, to reducing the progression of cardiovascular and metabolic diseases.

METHODS

Cross-sectional study with a quantitative approach, conducted in the municipality of Campina Grande, in the state of Paraíba, Brazil, which was approved by the Research Ethics Committee of the Universidade Estadual da Paraíba (UEPB, State University of Paraíba) under opinion nº 0077.0.133.000-12.

The target population consisted of 9,294 adolescents, aged between 15 to 19 (incomplete years), who were enrolled in public high schools. For the sample size calculation, an estimated prevalence of 50% of cardiovascular risk factors was considered, with a sampling error of up to 5%, a design effect (Deff) of 1.5 (correction factor for simple random sampling by cluster), and an addition of 3% for possible losses or refusals.

Sampling was stratified, with proportional allocation, according to school size – small, medium, and large. The sampling unit was the classroom, and all students from the drawn classrooms who met the inclusion criteria, were present on the data collection day, and agreed to participate in the study, through written consent from themselves and/or their parents and/or guardians, according to the age group, were included in the research. To maintain the proportion of schools/students/classes, nine classes from small schools, eleven from medium-sized schools, and thirteen from large schools were randomly selected. The sampling was by clusters in two stages.

Regarding eligibility criteria, adolescents were included if aged between 15 and 19 years, 11 months and 29 days, and enrolled in public high schools in the study municipality. Exclusion criteria included adolescents presenting any of the following conditions: disease impairing physical activity, current pregnancy, use of medication altering lipid metabolism and/or glycemia [10].

Of the 583 adolescents included and contacted to participate in the research, seven were excluded after applying the exclusion criteria: two due to pregnancy, four due to corticosteroid use, and one for lower limb immobilization. A total of 64 losses were recorded due to adolescents being unable to undergo ultrasonography – either refusal of the exam or incomplete biochemical evaluation. Therefore, a total of 512 adolescents participated in the study.

On the day of the scheduled data collection for the 512 study participants, anthropometry, blood pressure measurement by trained researchers [16], and carotid ultrasound by a qualified physician were performed [17,18]. Blood samples were collected by an outsourced laboratory after 12 hours of fasting, either at the school or on a previously scheduled day. All procedures followed the recommendations of the Ministry of Health and the World Health Organization (WHO) [16,19-21].

Data collection training was carried out with researchers, followed by a pilot project in a randomly selected school and class, involving 12 students, who were not included in the study sample.

The presence of MetS was assessed according to two criteria, IDF [8] and NCEP-ATPIII adapted by Cook et al. [10], which use the same components, presented in the Chart 1.

Chart 1 – Diagnostic criteria for classification of metabolic syndrome in adolescents according to NCEP/ATP III-COOK and IDF.

Components	IIDF (10-16 years)	IIDF (>16 years)	NCEP/ATPIII-COOK, 2008 (adolescents)
Mandatory	Central obesity plus 2 criteria	Central obesity plus 2 criteria	At least 3 criteria
Adiposity definition	WC ≥90th percentile	WC ≥94cm (males) WC ≥80cm (females)	WC ≥90th percentile
Glycemic metabolism	Fasting glucose ≥100mg/dL	Fasting glucose ≥100mg/dL	Fasting glucose ≥110mg/dL
Dyslipidemia	Triglycerides ≥110mg/dL or HDL ≤40mg/dL	Triglycerides ≥150mg/dL or HDL <40 mg/dL (males) or <50mg/dL (females)	Triglycerides ≥110mg/dL or HDL <40mg/dL
Arterial hypertension	BP ≥90th percentile or use of antihypertensive drugs	SBP ≥130mmHg or DBP ≥85 mmHg or use of antihypertensive drugs	BP ≥90th percentile

Note: BMI: Body Mass Index; BP: Blood Pressure; HDL: High-Density Lipoprotein Cholesterol; IDF: International Diabetes Federation; IFG: Impaired Fasting Glucose; IGT: Impaired Glucose Tolerance; NCEP/ATP III: National Cholesterol Education Program/Adult Treatment Panel III; SBP: Systolic Blood Pressure; WC: Waist Circumference.

The ultrasound examination was performed with a portable device (Samsung/Medison, MySonoU5® model), equipped with a high-definition 7–12 MHz linear transducer, in B-mode, in accordance with the Mannheim Consensus [15] and the American Society of Echocardiography Consensus [22]. Measurement of the CIMT was carried out by a vascular physician trained in ultrasound examination. A second ultrasonographer evaluated 10% of the sample to calculate the inter-observer correlation coefficient, yielding a value of 0.8 (95% CI 0.651–0.887) (p<0.001).

The subject remained in the supine position with contralateral neck rotation. Longitudinal images of the common carotid artery were obtained, and the image in which the double-line pattern was most clearly defined was selected. Images were captured from both the right and left sides of the neck and evaluated remotely. Three manual measurements were performed approximately 1 cm from the bifurcation, and for the study the highest value found in each individual was considered [23]. A marked thickening was defined as values equal to or greater than 2 z-scores.

Statistical analysis was performed using IBM®SPSS® (version 20.0) with a significance level of 5%. Descriptive analysis was conducted for sample characterization, using absolute and relative frequency measures. The chi-square test was used to compare the following variables between sexes: nutritional status, physical activity, sedentary behavior, MetS and its components, as well as CIMT.

The association between the presence of MetS and sociodemographic variables, nutritional status, physical activity, and sedentary behavior was also assessed. Finally, the association of CIMT with MetS and its components was tested. For all associations, both the IDF [8] and the NCEP-ATPIII–COOK [10] criteria were applied.

Agreement between the two diagnostic criteria for MetS was assessed using the Kappa statistic. To identify the most accurate diagnostic criterion of MetS with the presence of CIMT, the positive predictive value (PPV = true positives / true positives + false positives) and the negative predictive value (NPV = true negatives / false negatives + true negatives) were calculated.

Adolescents were invited to read and sign the Free and Informed Assent Form which guaranteed their right not to participate or to withdraw at any time, as well as ensuring privacy, confidentiality, and anonymity of their information. In addition, parents and/or guardians signed the Free and Informed Consent Form, drafted in clear, simple, and objective language, authorizing data collection from their dependents.

RESULTS

The mean age of the adolescents who participated in the study was 16.8 years (±1.03 years). Regarding sex, 66.9% were female and 33.1% male. The analysis of nutritional status revealed that 18% of adolescents were overweight or obese. Physical inactivity was observed in 26.4% and sedentary behavior in 53.3% of cases, with girls being more inactive $p<0.001$ (33.2%) and sedentary $p=0.02$ (55.7%) (Table 1).

Table 1 – Metabolic syndrome and its components, assessed by two diagnostic criteria and distributed according to sex. Campina Grande, PB, Brazil. (n=512).
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Variables	Total [n (%)]	Sex		PR (95% CI)	*p*-value
		Male [n (%)]	Female [n (%)]		
Physical activity					
Inactive or insufficiently active	135 (26.4)	21 (12.4)	114 (33.2)	0.28 (0.17-0.47)	<0.001
Active	377 (73.6)	148 (87.6)	229 (66.8)		
Sedentary lifestyle					
≥2 hours	273 (53.3)	82 (48.5)	191 (55.7)	0.75 (0.51-1.08)	0.13
<2 hours	239 (46.7)	87 (51.5)	152 (44.3)		
WC (IDF)					
Altered	35 (6.8)	5 (3.0)	30 (8.7)	0.32 (0.12-0.83)	0.02
Normal	477 (93.2)	164 (97.0)	313 (91.3)		
HDL (IDF)					
Altered	332 (64.8)	100 (59.2)	232 (67.6)	0.69 (0.47-1.01)	0.06
Normal	180 (35.2)	69 (40.8)	111 (32.4)		
Blood glucose (IDF)					
Altered	-	-	-	-	-
Normal	512 (100)	169 (100)	343 (100)	-	-
Triglycerides (IDF)					
Altered	27 (5.3)	8 (4.7)	19 (5.5)	0.85 (0.36-1.98)	0.86
Normal	485 (94.7)	161 (95.3)	324 (94.5)		
SBP (IDF)					
Altered	30 (5.9)	22 (13.0)	8(2.3)	6.27(2.72-14.40)	<0.001
Normal	482(94.1)	147 (87.0)	335 (97.7)		
DBP (IDF)					
Altered	7 (1.4)	2 (1.2)	5 (1.5)	0.81 (0.15-4.22)	1.00*
Normal	505 (98.6)	167 (98.8)	338 (98.5)		

Table 1 – Metabolic syndrome and its components, assessed by two diagnostic criteria and distributed according to sex. Campina Grande, PB, Brazil. (n=512).
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Variables	Total [n (%)]	Sex		PR (95% CI)	*p*-value
		Male [n (%)]	Female [n (%)]		
MetS (IDF)					
Present	8 (1.6)	2 (1.2)	6 (1.7)	0.67 (0.13-3.37)	1.00*
Absent	504 (98.4)	167(98.8)	337 (98.3)		
DBP (NCEP)					
Altered	24 (4.7)	5 (3.0)	19 (5.5)	0.52 (0.19-1.42)	0.28
Normal	488 (95.3)	164 (97)	324 (94.5)		
SBP (NCEP)					
Altered	71 (13.9)	50 (29.6)	21 (6.1)	6.4 (3.70-11.2)	<0.001
Normal	441 (86.1)	119 (70.4)	322 (93.9)		
Blood glucose (NCEP)					
Altered	-	-	-	-	
Normal	512 (100.0)	169 (100.0)	343 (100.0)	-	-
Triglycerides (NCEP)					
Altered	88 (17.2)	25 (14.8)	63 (18.4)	0.77 (0.47-1.28)	-
Normal	424 (82.8)	144 (85.2)	280 (81.6)		
HDL (NCEP)					
Altered	338 (66.0)	131 (77.5)	207 (60.3)	2.26 (1.49-3.45)	0.31
Normal	174 (34.0)	38 (22.5)	136 (39.7)		
WC (NCEP)					
Altered	10 (2.0)	3 (1.8)	7 (2.0)	0.87 (0.22-3.40)	<0.001
Normal	502 (98.0)	166 (98.2)	336 (98)		
MetS (NCEP)					
Present	26 (5.1)	12 (7.1)	14 (4.1)	1.79 (0.81-3.97)	1.00*
Absent	486 (94.9)	157 (92.9)	329 (95.9)		
CIMT					
Altered	22 (4.3)	10 (5.9)	12 (3.5)	1.73 (0.73-4.10)	0.14
Normal	490 (95.7)	159 (94.1)	331 (96.5)		
Nutritional status					
Altered	92 (18.0)	27 (16.0)	65 (19.0)	0.81 (0.50-1.33)	0.20
Normal	420 (82.0)	142 (84.0)	278 (81.0)		

Note: *(*p* Fisher). CIMT: Carotid Intima-Media Thickness; DBP: Diastolic Blood Pressure; HDL: High-Density Lipoprotein Cholesterol; IDF: International Diabetes Federation; IFG: Impaired Fasting Glucose; MetS: Metabolic Syndrome; NCEP: National Cholesterol Education Program; SBP: Systolic Blood Pressure; WC: Waist Circumference.

Among the five components of MetS, triglycerides (17.2%), blood pressure (13.9%), and HDL (66.0%) were the most prevalent, especially when assessed by the NCEPATPIII-COOK criteria, compared to the IDF. The MetS was more prevalent in males (7.1%) (Table 1).

The behavior of MetS components between sexes showed that altered Waist Circumference (WC) was more prevalent among females $p<0.001$ (8.7%) and Systolic Blood Pressure (SBP) among males $p<0.001$ (13%), when assessed by the IDF criteria. Considering the NCEPATPIII-COOK criteria, SBP $p<0.001$ (29.6%) and low HDL $p<0.001$ (77.5%) were also more prevalent in males. The other variables showed similar patterns between sexes (Table 1).

MetS was diagnosed in 2.9% of the sample when using the IDF criteria, and in 11.2% when using NCEPATPIII-COOK. When present in adolescents, MetS diagnosed according to the NCEPATPIII-COOK criteria was associated with subclinical atherosclerosis ($p=0.02$) PR = 4.7 (1.47–15.15). The same was not observed when MetS was assessed by the IDF criteria $p=0.30$ PR = 3.29 (0.39–27.9). The CIMT occurred in 4.5% of cases (Table 2).

Table 2 – Sample characterization and metabolic syndrome assessed by two diagnostic criteria. Campina Grande/PB, Brazil. (n=512).

Variables	MetS (IDF)		PR (95% IC)	*p*-value	MetS (NCEP)		PR (95% IC)	*p*-value
	Altered [n (%)]	Normal [n (%)]			Altered [n (%)]	Normal [n (%)]		
Gender								
Male	2 (1.2)	167 (98.8)	0.67 (0.13-3.37)	1.00*	12 (7.1)	157 (92.9)	0.67 (0.13-3.37)	0.14
Female	6 (1.7)	337 (98.3)			14 (4.1)	329 (95.9)		
Physical Activity								
Inactive	1 (7%)	134 (99.3)	0.39 (0.05-3.24)	0.69*	3 (2.2)	132 (97.8)	0.35 (0.10-1.18)	0.11*
Active	7 (1.9)	370 (98.1)			23 (6.1)	354 (93.9)		
Sedentary lifestyle								
≥2 hours	4 (1.5)	269 (98.5)	0.87 (0.22-3.53)	1.00*	16 (5.9)	257 (94.1)	1.43 (0.63-3.20)	0.39
<2 hours	4 (1.7)	235 (98.3)			10 (4.2)	229 (95.8)		
Color								
Non-white	7 (1.8)	391 (98.2)	1.79 (0.22-14.7)	1.00*	21 (5.3)	377 (94.7)	1.35 (0.45-4.03)	0.80*
White	1 (1)	100 (99			4 (4.0)	97 (96.0)		
Maternal education								
≤8 years	2 (1.0)	206 (99.0)	0.56 (0.11-2.96)	0.70*	10 (4.8)	198 (95.2)	0.89 (0.40-2.00)	0.78
>8 years	5 (1.7)	293 (98.3)			16 (5.4)	282 (94.6)		
Social class								
C, D and E	0 (0)	24 (100)	1.02 (1.00-1.03)	1.00*	0 (0)	24 (100)	1.06 (1.03-1.08)	0.62*
A, B	8 (1.6)	480 (98.4)			26 (5.3)	462 (94.7)		
CIMT								
Altered	1 (4.5)	21 (95.5)	3.29 (0.39-27.9)	0.30*	4 (18.2)	18 (81.8)	4.7 (1.47-15.15)	0.02*
Normal	7 (1.4)	483 (98.6)			22 (4.5)	468 (95.5)		

Note: *(*p* Fisher). CIMT: Carotid Intima-Media Thickness; IDF: International Diabetes Federation; MetS: Metabolic Syndrome; NCEP: National Cholesterol Education Program.

CIMT was associated with one of the MetS components, namely systolic blood pressure when assessed by the NCEP/ATPIII-COOK diagnostic criteria (p=0.030); and showed no association when evaluated by the IDF criteria for MetS (Table 3).

Table 3 – Subclinical atherosclerosis assessed by carotid intima-media thickness and metabolic syndrome components evaluated by two diagnostic criteria. Campina Grande, PB, Brazil. (n= 512).

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Variables	Thickness		PR (95% CI)	*p*-value
	Present [n (%)]	Absent [n (%)]		
WC (IDF)				
Altered	2 (5.7)	33 (94.3)	1.38 (0.31-6.18)	0.66*
Normal	20(4.2)	457 (95.8)		
HDL (IDF)				
Altered	15(4.5)	317 (95.5)	1.17 (0.47-2.92)	0.91
Normal	7 (3.9)	173 (96.1)		
Blood glucose (IDF)				
Altered	-	-	-	-
Normal	22 (4.3)	490 (95.7)	-	-
Triglycerides (IDF)				
Altered	2 (7.4)	25 (92.6)	1.86 (0.41-8.40)	0.32*
Normal	20(4.1)	465 (95.9)		
SBP (IDF)				
Altered	3 (10.0)	27 (90.0)	2.7 (0.75-9.72)	0.13*
Normal	19 (3.9)	463 (96.1)		
DBP (IDF)				
Altered	1 (14.3)	6 (85.7)	3.8 (0.44-33.36)	0.19*
Normal	21 (4.2)	484 (95.8)		

Table 3 – Subclinical atherosclerosis assessed by carotid intima-media thickness and metabolic syndrome components evaluated by two diagnostic criteria. Campina Grande, PB, Brazil. (n= 512).

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Variables	Thickness		PR (95% CI)	*p*-value
	Present [n (%)]	Absent [n (%)]		
MetS (IDF)				
Present	1 (12.5)	7 (87.5)	3.29 (0.39-27.9)	0.30*
Absent	21 (4.2)	483 (95.8)		
DBP (NCEP)				
Altered	2 (8.3)	22 (91.7)	2.1 (0.47-9.68)	0.28*
Normal	20 (4.1)	468 (95.9)		
SBP (NCEP)				
Altered	7 (9.9)	64 (90.1)	3.1 (1.22-791)	0.030
Normal	15 (3.4)	426 (96.6)		
Blood glucose (NCEP)				
Altered	-	-	-	-
Normal	22 (4.3)	490 (95.7)	-	-
Triglycerides				
Altered	5 (5.7)	83 (94.3)	1.44 (0.51-4.02)	0.48
Normal	17 (4.0)	407 (96.0)		
HDL (NCEP)				
Altered	17 (5.0)	321 (95.0)	1.79 (0.65-4.93)	0.36
Normal	5 (2.9)	169 (97.1)		
WC (NCEP)				
Altered	2 (20.0)	8 (80.0)	6.02 (1.20-30.22)	0.06*
Normal	20 (4.0)	482 (96.0)		
MetS (NCEP)				
Present	4 (15.4)	22 (84.6)	4.7 (1.47-15.15)	0.020*
Absent	18 (3.7)	468 (96.3)		

Note: *(*p* Fisher). DBP: Diastolic Blood Pressure; HDL: High-Density Lipoprotein Cholesterol; IDF: International Diabetes Federation; IFG: Impaired Fasting Glucose; IGT: Impaired Glucose Tolerance; MetS: Metabolic Syndrome; NCEP: National Cholesterol Education Program; SBP: Systolic Blood Pressure; WC: Waist Circumference.

The two criteria for assessing MetS had an agreement of 19.2% $p<0.001$ but showed a low Kappa value of 0.28 (Table 4), demonstrating that they indeed diverge from each other.

In the presence of subclinical atherosclerosis, assessed by CIMT, the diagnostic criterion with the highest percentage of positive predictive value (15%) (disease present when the test is positive) was NCEP/ATP III-COOK, compared to the positive predictive value of IDF (13%). The negative predictive value (disease absent when the test is negative) was equal for both diagnostic criteria of MetS (96%).

Table 4 – Level of concordance between two diagnostic criteria for metabolic syndrome. Campina Grande, PB, Brazil. (n=512).

Variables	MetS (IDF)		*p*-value	Kappa
	Present [n (%)]	Absent [n (%)]		
MetS (NCEP)				
Present	5 (19.2)	21 (80.8)	<0.001	0.28
Absent	3 (6)	483 (99.4)		

Note: IDF: International Diabetes Federation; MetS: Metabolic Syndrome; NCEP: National Cholesterol Education Program.

DISCUSSION

Identifying the best diagnostic criterion for MetS in adolescents, and the one most strongly associated with subclinical atherosclerosis, is of fundamental importance, since early diagnosis and intervention may prevent the progression of cardiovascular diseases and consequently reduce mortality [1,12].

When assessing MetS components by sex, it was observed that WC was among the most prevalent criteria in females. The WC observed may be due to the higher physical inactivity noted in the female group. However, this fact may also be attributed to hormonal changes related to puberty, since during this phase girls exhibit greater fat accumulation compared to boys [24]. Studies conducted with adolescents have likewise found higher prevalence of WC in girls than in boys, stemming from the aforementioned factors [25,26].

Corroborating the findings of the present research, studies with young individuals, when comparing MetS components by sex, found higher prevalence of low HDL in males (31.5%) compared to females (13.0%) [26]. This divergence between sexes may be explained by the higher testosterone levels that progressively decrease HDL in males [14], and given that HDL is a protective factor against heart diseases, its reduction can lead to the accumulation of fat plaques in the arteries, thus increasing blood pressure [27].

Regarding the association of MetS components with subclinical atherosclerosis, it was observed that SBP, when assessed by the NCEP/ATP III-COOK criterion, was associated with the presence of CIMT. Another study also found an association of SBP with CIMT in adolescents in a cohort followed between 2019 and 2020, where elevated SBP at 5 years was predictive of greater CIMT thickness in adolescence [28,29]. This association may be explained by the synergism and multiplication of the set of anthropometric, physiological, and biochemical irregularities that constitute MetS and elevate the risk for atherosclerosis and consequent cardiovascular diseases [30-32]. It can also be explained by the reduction in distensibility caused by the hardening of the arteries, which favors the genesis and progression of atherosclerosis [16].

In the present study, the NCEP-ATPIII-COOK criterion showed higher MetS prevalence, association with subclinical atherosclerosis, and greater percentage of positive predictive value, thereby reinforcing that the NCEP/ATPIII-COOK criterion better identified SM in adolescents with subclinical atherosclerosis.

A systematic review and meta-analysis study evaluated original cross-sectional studies published between 2010 and 2021 and, upon performing an initial subgroup analysis, also identified a significantly different prevalence between the criteria ($p<0.00$) (95% Confidence Interval [CI]), where the NCEP ATP III showed a higher prevalence of MetS at 4.5%, when compared to the IDF at 2.6% [2].

Another study conducted with 232 adolescents from a public school in the city of Rio de Janeiro identified a higher percentage of metabolic syndrome in adolescents when evaluated by the NCEP-ATPIII criterion, compared to the IDF criterion. Thus, the percentages for obese adolescents were 40.4% with NCEP-ATPIII and 24.6% with IDF. For overweight adolescents, the values were 9.4% with NCEP-ATPIII and 1.9% with IDF [33].

This divergence may be because the IDF requires an altered WC and its association with at least two MetS components [32], unlike the NCEP/ATP III-COOK [10] which considers three of the following altered factors: WC, triglyceride, blood glucose, HDL, and BP, without requiring the mandatory presence of an altered WC. Another justification for this association may be due to the triglyceride cutoff point adopted by the NCEP/ATP III-COOK criterion being lower than the one adopted by the IDF in those over 16 years of age [7].

The diagnosis of MetS in adolescence represents a problematic issue due to the absence of an international consensus on its components and, especially, cutoff points. The lack of standardized diagnostic criteria creates gaps regarding the true magnitude of this disease and, above all, exposes adolescents to CVD as interventions are late, in the adult phase.

In the analysis of study results, particular attention is drawn to the large number of adolescents who were overweight or obese; physically inactive and/or sedentary. In boys, high SBP and low HDL generate a reflection on the health habits of adolescents and on what health practices can be adopted to minimize this problem with SBP and HDL.

This study has limitations for being cross-sectional, and therefore cannot analyze causality, atherosclerosis progression, or associations with cardiovascular events, which would be possible with a prospective design. Furthermore, the scarcity of studies addressing this topic in this age group hinders comparison with the findings of the present research.

CONCLUSION

The NCEP ATPIII-COOK criterion was the one that identified the highest prevalence of MetS among adolescents, was associated with subclinical atherosclerosis, and also presented one of its components (SBP) as being associated with subclinical atherosclerosis.

The two diagnostic criteria showed low agreement, demonstrating divergence between them, and the criterion that identified the greatest presence of disease when the test was positive was also the NCEP/ATPIII-COOK criterion.

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