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original article

Prevalence of metabolic syndrome and associated factors in 11- to 17-year-old adolescents

Prevalência de síndrome metabólica e fatores associados em adolescentes de 11 a 17 anos

Durcelina Schiavoni Bortoloti[1,3]
Juliana Pizzi[1]
Fernando Henrique Pavão[1]
Patricia Amaral Gurgel Velasquez[1]
Lediana Dalla Costa[1]
Rômulo Araujo Fernandes[2]
Edilson Serpeloni Cyrino[3]

Abstract – The adoption of health risk behaviors (low level of habitual physical activity and inadequate food and nutrient intake) has increased the prevalence of overweight/obesity, particularly among adolescents. Thus, the prevalence of disorders and metabolic diseases has increased in this population. The aim of this study was to identify the prevalence of metabolic syndrome (MS) and to analyze its association with sport participation and overweight in adolescents aged 11 to 17 years. A total of 683 adolescents (301 boys and 382 girls) were randomly selected to compose the sample. The prevalence of MS was established based on fasting glucose, triglycerides, high-density lipoprotein (HDL-c), waist circumference, and blood pressure according to the cut-offs recommended by the Brazilian Society of Cardiology (2005). Nutritional status, sport participation, socioeconomic status, and alcohol consumption were analyzed as risk factors associated with MS. The presence of one or more risk factors was identified in 39.5% and 22.5% of the sample, respectively. The most prevalent MS components were low HDL-c (44.7%), high systolic blood pressure (32.4%), and elevated triglycerides (18.6%). The presence of MS was associated with both overweight and the lack of participation in sport ($P < 0.05$). The results indicated an overall prevalence of MS of 5.4% in adolescent boys and girls. Furthermore, overweight and lack of sport participation were the main factors associated with MS.

Key words: Adolescents; Metabolic syndrome; Obesity; Sports.

Resumo – *A adoção de comportamentos de risco à saúde (reduzido nível de atividade física habitual, consumo inadequado de alimentos e nutrientes, entre outros) tem aumentado a prevalência de sobrepeso/obesidade, particularmente, em adolescentes. Assim, o número de disfunções e doenças metabólicas tem crescido nesta população. Portanto, o objetivo deste estudo foi identificar a prevalência de Síndrome Metabólica (SM) e analisar a sua associação com a prática esportiva e excesso de peso em adolescentes de 11 a 17 anos. Seiscentos e oitenta e três meninos (n = 301) e meninas (n = 382) foram selecionados aleatoriamente para comporem a amostra. A prevalência de SM foi estabelecida com base nos valores de glicose em jejum, triglicerídeos, lipoproteínas de alta densidade (HDL-c), circunferência de cintura e pressão arterial, de acordo com os pontos de corte recomendados pela Sociedade Brasileira de Cardiologia (2005). O estado nutricional, prática de esporte, nível socioeconômico e consumo de álcool foram analisados como fatores de risco associados a SM. A presença de um ou mais fatores de risco foi identificada em 39,5% e 22,5% da amostra, respectivamente. Os componentes da SM mais prevalentes foram HDL-c reduzida (44,7%), pressão arterial sistólica elevada (32,4%) e triglicérides elevado (18,6%). A presença de SM foi associada ao excesso de peso e a ausência da prática de esportes (P < 0,05). Os resultados indicaram uma prevalência total de SM na ordem de 5,4% em adolescentes de ambos os sexos. Adicionalmente, o excesso de peso e ausência da prática de esportes foram os principais fatores associados com a SM.*

Palavras-chave: *Adolescentes; Esportes; Obesidade; Síndrome metabólica.*

1 Universidade Paranaense. Instituto de Ciências Biológicas Médicas e da Saúde. Francisco Beltrão, PR. Brasil.

2 Universidade Estadual Paulista. Departamento de Educação Física. Presidente Prudente, SP. Brasil.

3 Universidade Estadual de Londrina. Centro de Educação Física e Esporte. Grupo de Estudo e Pesquisa em Metabolismo, Nutrição e Exercício. Londrina, PR. Brasil.

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INTRODUCTION

The morbidity and mortality profile of different populations has changed considerably in recent decades[1]. Thus, there is growing interest in different countries to investigate risk behaviors (inadequate eating habits, reduced habitual physical activity, and alcohol and tobacco consumption, among others) in children and adolescents of both genders in an attempt to provide data and measures for the development of public policies for disease prevention and health promotion in this population[2,3].

In this respect, the adoption of risk behaviors in childhood and adolescence[4] has been associated with the development of important metabolic disorders (abdominal obesity, high blood pressure, insulin resistance, glucose intolerance, and dyslipidemias). The combined manifestation of these disorders gives origin to the so-called metabolic syndrome (MS), a phenomenon that is well known in the adult population and is being identified early among adolescents.

Despite the lack of consensus regarding the criteria and cut-off values to be used for the diagnosis of MS in children and adolescents, researchers have identified an important prevalence of MS in these populations[5,6], especially among overweight and obese individuals[7,8]. This fact is a matter of concern since the rates of overweight/obesity have been growing over the years, particularly among Brazilian children and adolescents[9]. It is important to note that obesity is a leading cardiovascular risk factor, which shows a strong association with a series of comorbitidies[10].

Brazil is a country of continental dimensions with an enormous socioeconomic and cultural diversity among municipalities, states and regions. However, the number of studies in the literature investigating the prevalence of MS and its main determinants in Brazilian adolescents is sparse. Therefore, the objective of this study was to evaluate the prevalence of MS and its association with the lack of sport participation and excess weight in a representative sample of adolescents aged 11 to 17 years enrolled in public schools in the town of Francisco Beltrão, Paraná, Brazil. Our hypothesis was that the prevalence of MS will be relatively high (> 4%), especially among overweight adolescents who do not participate in sports.

METHODOLOGICAL PROCEDURES

Sample

The study was conducted at public elementary schools and high schools in the municipality of Francisco Beltrão, southwestern region of the State of Paraná, Brazil. The population of the municipality is approximately 80,000 inhabitants. For sample size calculation, a predictive equation was adopted to estimate population parameters, establishing a prevalence of MS of 4% according to values reported in international studies[11,12], a precision of 2.5%, statistical significance of 5% ($z = 1.96$), and a design effect of 2.0. Considering possible losses/refusals, 20% was added to the final calculation, which resulted in a minimum number of 566 adolescents.

For selection of the participants, all schools were first computed according to their geographic location (north, south, east, west, center, and periphery) and six schools (one per region) were selected randomly. At each school, the morning classes comprising the proposed age group (11 to 17 years: 6th grade of elementary school to 3rd year of high school) were selected randomly. All students of the selected classes were invited to participate in the study.

The following inclusion criteria were adopted during the selection process: 1) no frequent use of medications or treatment for some disease; 2) age of 11 to 17 years; 3) enrollment in the selected schools; 4) return of the free informed consent form signed by the parents or legal guardian and consent form signed by the participants. The present sample consisted of 683 adolescents (301 boys and 382 girls). The study was approved by the Ethic Committee of UNIPAR/CEPEH (Protocol No. 21714/2012) and was conducted according to the ethical principles for research involving humans adopted by the National Council on Ethics in Research (Conselho Nacional de Ética em Pesquisa - CONEP) and Resolution 196/96 of the Ministry of Health.

Anthropometry

Body mass was measured with a digital scale to the nearest 0.1 kg and height was measured with a stadiometer attached to the scale to the nearest 0.1 cm according to literature recommendations[13]. The body mass index (BMI) was established as the ratio between body weight (kg) and the square of the height (m^2). Waist circumference (WC) was determined with a non-elastic tape measure to the nearest 0.1 cm by a single examiner properly familiarized with the standard procedure described in the literature[14], with high reproducibility (intraclass coefficient = 0.95). For this study, WC was adopted as an indicator of abdominal obesity.

Blood pressure measurement

The systolic (SBP) and diastolic (DBP) blood pressure was measured with an Omron HEM-742 digital blood pressure monitor according to literature recommendations[15]. Two measurements were obtained on the right arm of the participant in the sitting position after 5 minutes of rest, with an interval of 2 minutes between measurements. When the differences between measurements were 10 mmHg or higher, a third measurement was obtained. The final blood pressure was calculated as the arithmetic mean of the two measurements. The technical error of measurement was 3.3% for SBP and 7.1% for DBP. The normative blood pressure levels of the National High Blood Pressure Education Program[15] were adopted for classification of the subjects. Adolescents exhibiting SBP or DBP values above the 90th percentile for sex and age were classified as having high blood pressure.

Blood collection

Blood was collected at the school itself in a room adapted for this purpose by three experienced nursing students and two laboratory technicians. The samples were collected in the morning after a 12-hour fast. Venous blood was collected in the elbow flexure into two vacuum tubes, one containing separator gel without anticoagulant and another containing fluoride for glucose measurement. Both samples were centrifuged for 10 minutes at 3000 rpm for the separation of serum and plasma. These samples were used to determine the concentrations of triglycerides, total cholesterol, high-density lipoprotein-cholesterol (HDL-c), and glucose in a biochemical autoanalyzer (Selectra 2-Vitalab). The assays were carried out at the Laboratory of Clinical Analysis, UNIPAR, Unidade de Francisco Beltrão, Paraná.

Diagnosis of metabolic syndrome

Metabolic syndrome was diagnosed according to the definitions recommended by the Brazilian Society of Cardiology[16] and of the National Cholesterol Education Program's Adult Treatment Panel III (NCEP-ATP III)[17], which consist of the presence of three or more of the following components: central obesity, elevated triglycerides, low HDL-c levels, high blood pressure, and high fasting glycemia.

Sport participation and excess weight

Habitual physical activity was evaluated using the questionnaire of Baecke et al.[18]. For this purpose, an examiner completed the questionnaire together with the students in the classroom. Specifically for this study, an important variable was used to identify changes in habitual physical activity in children and adolescents, i.e., the participation in sport[19]. Thus, for analysis, the subjects were asked whether they participated in sport activities (yes or no).

Excess weight was determined based on BMI using the cut-off values proposed by Conde and Monteiro[20], and the adolescents were classified as normal weight and excess weight (overweight or obesity). Finally, a polytomous variable of aggregation was created, which included sport participation and excess weight: i) no risk factor (sport participation and with normal weight, n = 218), ii) only lack of sport participation (n = 309), iii) only excess weight (n = 68), and iv) both (n = 88).

Confounding factors

In addition to the questionnaire of Baecke et al.[18], other questionnaires containing additional data about possible confounding factors were used. The questionnaire proposed by the Brazilian Association of Market Research Companies (Associação Brasileira de Empresas de Pesquisa - ABEP)[21] was used to verify the socioeconomic level. A question about the education level of the head of the household was also included. Alcohol consumption by the adolescents was evaluated using a food frequency questionnaire.

The confounding factors adopted for this study were: i) socioeconomic level of the household of the adolescent; ii) alcohol consumption evaluated with the food frequency questionnaire; iii) gender; iv) age; v) school unit (place of the school: center/periphery), and vi) education level of the household head.

Statistical analysis

The Mann-Whitney U test was used to compare numerical variables between genders. The prevalence of MS was determined by the analysis of frequency distribution. The chi-squared test (χ^2) was used to identify associations between MS components, the lack of sport participation, and excess weight. Multivariate models were developed by binary logistic regression to illustrate the magnitude of the associations (expressed as odds ratio [OR] and 95% confidence interval [$OR_{95\%CI}$]) between MS, lack of sport participation, and excess weight. For this purpose, a hierarchical system of entry of the confounding variables was created to fit the models (Model 1: not adjusted; Model 2: inclusion of sociodemographic variables of the adolescent; Model 3: inclusion of socioeconomic variables of the household; Model 4: inclusion of behavioral variables of the adolescent). The Hosmer-Lemeshow test was applied to evaluate the goodness-of-fit of the multivariate models (values > 5% indicate adequate goodness-of-fit). The IBM Statistical Package for the Social Sciences 17.0 (SPSS) for Windows (Chicago, IL, USA) was used for statistical analysis. A level of significance of 5% was adopted for all analyses.

RESULTS

Table 1 shows the general characteristics of the girls and boys. Significant differences were observed between genders; adolescent boys had higher SBP, WC and glucose ($p < 0.05$), while girls had higher triglyceride levels.

Table 1. General characteristics of the sample according to gender.

Variable	Girls (n = 382)	Boys (n = 301)	Total (n = 683)
Body weight (kg)	52.6 ± 11.9	56.4 ± 14.7	54.3 ± 13.3
Height (cm)	158.9 ± 7.6	164.3 ± 11.3	162.3 ± 9.8
BMI (kg/m^2)	20.73 ± 3.99	20.66 ± 4.04	20.70 ± 4.01
WC (cm)	69.2 ± 8.8	71.2 ± 9.3*	70.1 ± 9.1
SBP (mmHg)	113 ± 11	118 ± 14*	116 ± 13
DBP (mmHg)	66 ± 9	67 ± 10	66 ± 10
Glucose (mg/dl)	72 ± 8	75 ± 8*	74 ± 8
HDL-c (mg/dl)	48 ± 10	47 ± 10	47 ± 10
Triglycerides (mg/dl)	76 ± 36	71 ± 34*	74 ± 35

*p < 0.05 vs. girls. BMI = body mass index; WC = waist circumference; SBP = systolic blood pressure; DBP = diastolic blood pressure; HDL-c = high-density lipoprotein.

When the percentage of adolescents with inadequate levels of the different MS components were analyzed (Figure 1), the most prevalent components were reduced HDL-c (44.7%), high SBP (32.4%), elevated triglycerides (18.6%), high DBP (7%), and high WC (3.5%). The results showed that 37.9% of the adolescents did not have risk factors for MS, while one and two risk factors were identified in 39.5% and 17.2% of the sample, respectively. The prevalence of MS found in this study was 5.4%.

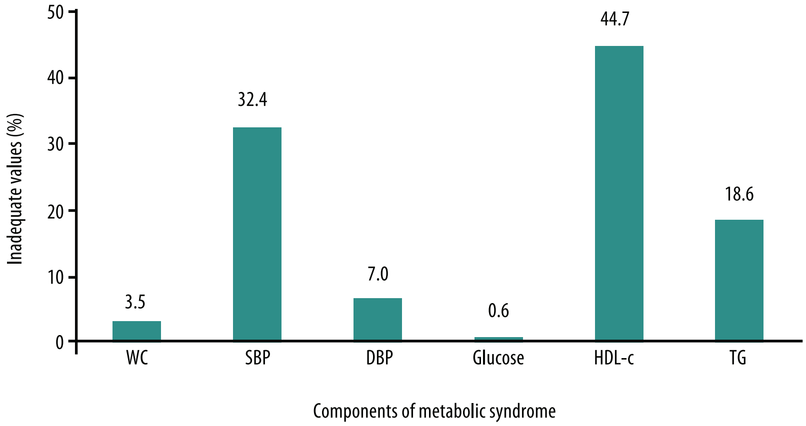

Figure 1. Percentage of adolescents with inadequate values of the different components of metabolic syndrome. WC = waist circumference; SBP = systolic blood pressure; DBP = diastolic blood pressure; HDL-c = high-density lipoprotein; TG = triglycerides.

Table 2 shows the association between MS components, lack of sport participation and excess weight. With respect to abdominal obesity, excess weight was a determinant in this association. The same was observed for SBP (p = 0.001) and triglycerides (p = 0.001). On the other hand, alterations in HDL-c (p = 0.052) or high DBP (p = 0.267) and glucose were not associated with excess weight or lack of sport participation.

Table 2. Association between excess weight, lack of sport participation and alterations in components of metabolic syndrome in the adolescents studied (n = 683).

	WC	SPB	DBP	Glucose	HDL-c	Triglycerides
Risk factor	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
None	1 (0.5)	57 (26.1)	18 (8.3)	2 (0.9)	95 (43.6)	32 (14.7)
Lack of sport participation	1 (0.3)	95 (30.7)	14 (4.5)	2 (0.6)	130 (42.1)	40 (12.9)
Excess weight	8 (11.8)	31 (45.6)	5 (7.4)	0 (--)	29 (42.6)	29 (42.6)
Both	14 (15.9)	38 (43.2)	11 (12.5)	0 (--)	51 (58)	26 (29.5)
Total	24	221	48	4	305	
$X^2_{p\text{-value}}$	0.001	0.001	0.267	---	0.052	0.001

WC = waist circumference; SBP = systolic blood pressure; DBP = diastolic blood pressure; HDL-c = high-density lipoprotein.

The models used to determine the magnitude of the associations between MS components, lack of sport participation and excess weight are shown in Table 3. Regardless of the possible confounding factors analyzed (socioeconomic level of the adolescent, alcohol consumption, gender, age, school unit, and education level of the household head), when compared to normal weight and physically active young people, adolescents with excess weight had a higher risk of developing MS (OR = 3.35 [$OR_{95\%CI}$ = 1.10 – 10.1]) than adolescents not participating in sport activities, but with normal weight. Thus, the combination of excess weight and lack of sport participation maximized the risk of developing MS (OR = 8.70 [$OR_{95\%CI}$ = 3.30 – 22.9]). Consequently, the inclusion of confounding factors did not result in saturation of the multivariate models.

Table 3. Association between excess weight, lack of sport participation and metabolic syndrome in the adolescents studied (n = 683).

Risk factor	n (%)	M1	M2	M3	M4
None	7 (3.2)*	1.0	1.0	1.0	1.0
Lack of sport participation	7 (2.3)	0.69 (0.24 – 2.02)	0.89 (0.30 – 2.64)	0.88 (0.29 – 2.59)	0.90 (0.30 – 2.66)
Excess weight	7 (10.3)	3.45 (1.16 – 10.2)	3.49 (1.15 – 10.5)	3.34 (1.10 – 10.1)	3.35 (1.10 – 10.1)
Both	16 (18.2)	6.69 (2.64 – 16.9)	8.23 (3.18 – 21.5)	8.37 (3.23 – 21.6)	8.70 (3.30 – 22.9)
Model fit**		$p = 1.0$	$p = 0.877$	$p = 0.781$	$p = 0.726$

*$X^2 = 0.001$. **Hosmer-Lemeshow test. Model 1 (M1) = not adjusted; Model 2 (M2) = adjusted for gender, age, and school unit; Model 3 (M3) = adjusted for gender, age, school unit, education level of the household head, and household socioeconomic condition; Model 4 (M4) = adjusted for gender, age, school unit, education level of the household head, socioeconomic condition, and alcohol consumption of the adolescent.

DISCUSSION

The main finding of the present study was the worrisome prevalence of MS (5.4%) among adolescents of both genders living in a small town in Paraná. Furthermore, the combination of excess weight and the lack of sport participation resulted in an 8-fold increase in the risk of developing MS. Although the prevalence of MS and its association with morbidity and mortality are well documented for the adult and elderly populations[22,23], the same does not apply to young people.

The prevalence of MS identified in this study was higher than the 4.2% reported in another study[12], but lower than the rates found in other international studies (9.2%)[24]. Although the adolescents studied were from a municipality with a low population density, the prevalence of MS was only slightly lower than that reported by Stabelini Neto et al.[8] for a sample of 601 adolescents living in three other cities of the State of Paraná (Curitiba, São Mateus do Sul, and Jacarezinho).

Part of the results found in this study corroborates the data of an interesting systematic review[7] on the prevalence of SM among adolescents aged 10 to 19 years. The authors analyzed 16 studies involving samples of different nationalities and observed that, despite the lack of consensus regarding the diagnosis of MS in adolescents, the studies analyzed indicated relatively high prevalence rates, especially among obese adolescents.

One of the main factors associated with the presence of MS in adolescents is increased body fat deposition. Within this context, obesity plays a key role in the stimulation of a variety of metabolic pathways that can induce inflammatory processes and consequently trigger alterations in one or more components of MS[10,25]. While obesity plays a fundamental role in the genesis of MS, our results show that its association with the lack of sport participation maximizes the risk of developing MS.

If on the one hand, a low level of physical activity is an important risk factor for body weight gain and the subsequent development of obesity, on the other hand physical exercise seems to affect MS components without necessarily reducing body fat[26]. Although high-intensity exercise programs can induce positive changes in HDL-c concentrations, the same does not appear to occur when the main purpose is to reduce body fat, since high-intensity exercises cannot be sustained for prolonged periods.

In addition to stimulating an increase in lipid oxidation, physical exercise increases vasodilatation, induces the release of anti-inflammatory agents, and improves the sensitivity of tissues to the action of insulin without affecting body fat stores[27]. These changes contribute to the prevention of cardiovascular diseases. Therefore, the absence of stimulation of the cited pathways may explain, at least in part, the synergistic action of excess weight and physical inactivity on increasing the risk of MS in adolescents.

Recent studies have shown that adults who were physically inactive in childhood and adolescents are at higher risk of developing arterial hypertension, dyslipidemias, and type 2 diabetes mellitus in adulthood[28]. Thus, although physical activities or sport participation and the adoption of sedentary behaviors are independent constructs[29], it is believed that the combination of sedentary and other health-risk behaviors is determinant for the development of MS. However, this hypothesis should be tested in longitudinal studies.

This study has some limitations. The lack of control of biological maturation may have partially affected the results, since some of the variables analyzed are influenced by maturation. In addition to biological aspects, the process of maturation can also influence social, emotional and behavioral aspects[30]. Another important limitation is the cross-sectional design adopted in this study, which permits analysis of the product but not of the process, a fact impairing the understanding of the metabolic profile found. Additionally, the use of indirect measures for the evaluation of sport participation and the classification of the nutritional status of the subjects may have partially influenced our results.

On the other hand, the type of sample stratification and the number of subjects of both genders used in the present study increase the power of generalization of the results. Since our results showed that the combination of excess weight and lack of sport participation maximizes the risk of developing MS, particularly among adolescents, the absence of public policies designed to promote lifestyle changes in the family and school environment tends to increase public health expenditure at increasingly earlier ages.

CONCLUSION

The present results showed an overall prevalence of MS of 5.4% among adolescent boys and girls. Furthermore, the combination of excess weight and lack of sport participation was the main factor associated with MS.

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Corresponding author

Durcelina Schiavoni Bortoloti
Rua: Julio Assis Cavalheiro, 2000 – Industrial
Francisco Beltrão – Paraná/Brasil
CEP: 86601-000
E-mail: dudaschiavoni@unipar.br