ABSTRACT

Introduction: Metabolic Syndrome (MetS) has been associated with sedentary behavior, low levels of physical activity and of cardiorespiratory fitness. However, in adolescents the results are conflicting. Objective: To measure the association between sedentary behavior, physical activity, cardiorespiratory fitness and MetS in a representative sample of adolescents. Methods: The sample consisted of 1,035 adolescents (565 girls and 470 boys) between 12 and 20 years of age. Sedentary behavior was treated through recreational screen time, while information equivalent to physical activity was considered through the Physical Activity Questionnaire for Adolescents. The maximal oxygen uptake (VO2max), estimated through PACER performance, was used as an indicator of cardiorespiratory fitness. MetS was identified using the criteria of the International Diabetes Federation. Results: Adolescents of both sexes identified with MetS had significantly longer recreational screen time and lower VO2max than their unidentified MetS peers. Scores equivalent to the level of physical activity undertaken by adolescents identified and not identified with MetS were statistically similar. Probabilistically, adolescents with high recreational screen time and low VO2max had, respectively, 79% [OR = 1.79; 95% CI 1.10 – 2.82] and 95% [OR = 1.95; 95% CI 1.20 – 3.09] greater odds of being identified with MetS. Conclusion: The finds indicate consistent and significant associations between longer recreational screen time, low VO2max values and high prevalence of MetS, which suggests specific interventions designed to help minimize cardiometabolic risk exposure from a very early age. Level of Evidence III; Prognostic Studies - Investigating the Effect of a Patient’s Characteristics on the Disease Outcome.

Keywords: Sedentary Lifestyle; Motor Activity; Physical Fitness; Metabolic Diseases; Youths.

RESUMEN

Introducción: Síndrome Metabólica (SMet) ha sido asociado con el comportamiento sedentario, bajos niveles de actividad física y de aptitud cardiorespiratoria. No en cambio, en los adolescentes, los resultados son conflictivos. Objetivo: Dimensionar la asociación entre comportamiento sedentario, práctica de actividad física, aptitud cardiorespiratoria y SMet en una muestra representativa de adolescentes. Métodos: La muestra fue compuesta por 1,035 adolescentes (565 niñas y 470 Niños) en edad entre 12 y 20 años. Comportamiento sedentario fue tratado mediante tiempo de tela recreativo, mientras que la información equivalente a la práctica de actividad física se consideró por medio del Physical Activity Questionnaire for Adolescents. Nivel máximo de oxígeno (VO2max), estimado a través del PACER, fue empleado como indicador de aptitud cardiorespiratoria. SMet fue identificada a través de los criterios de la International Diabetes Federation. Resultados: Adolescentes de ambos los sexos identificados con SMet presentaron de manera significativa mayor tiempo de tela recreativo y menor VO2max que sus pares no identificados con SMet. Escores equivalentes a práctica de actividad física de adolescentes identificados y no-identificados con SMet fueron estatisticamente similares. Probabilísticamente, adolescentes con elevado tiempo de tela recreativo y bajo VO2max demostraron, respectivamente, 79% [OR = 1.79; 95% CI 1.10 – 2.82] y 95% [OR = 1.95; 95% CI 1.20 – 3.09], con mayores chances de serem identificados con SMet. Conclusión: Os achados sinalizam para associações consistentes e significativas entre maior tempo de tela recreativo, baixos valores de VO2max e elevada prevalência de SMet, o que sugere intervenções específicas que possam auxiliar na minimização de exposições aos riscos cardiometabólicos desde as idades mais precoces. Nível de Evidência III; Estudos Prognósticos – Investigação do efeito de característica de um paciente sobre o desfecho da doença.

Descritores: Estilo de Vida Sedentário; Atividade Motora; Aptidão Física; Doenças Metabólicas; Jovens.
INTRODUCTION

Metabolic Syndrome (MetS) is characterized by a conglomeration of risk factors that, when altered, significantly increase the chances of developing cardiovascular diseases and type II diabetes mellitus. The identification of MetS occurs when three of five risk factors are present: excess abdominal fat, high blood pressure, reduced high-density lipoprotein cholesterol (HDL-cholesterol), high fasting glycemia, and triglycerides. In adults the prevalence of MetS is increasing in different geographic regions, being identified in approximately ¼ of the world population. At younger ages, the prevalence of MetS is naturally lower and may vary according to age, diagnostic criteria, geographical location of the data collection, and nutritional status of the investigated subjects. However, as in adult populations, in young people, there is a clear tendency to an increase in the prevalence of MetS. Recent studies indicate a prevalence of more than 10% among adolescents in some regions. In this case, an aggravating factor is the fact that environmental indicators associated with a greater chance of the onset and development of MetS become more frequent at this age, such as the greater time spent in sedentary activities, and low level of physical activity and physical fitness.

A systematic review and meta-analysis showed that the chance of identifying MetS in adolescents increased significantly in situations of high sedentary behavior (screen time > 2 hours / day on weekends), insufficient physical activity (< 300 min / week - moderate-vigorous intensity), and lower cardiorespiratory fitness (VO2max, values equivalent to the lower tertile). However, subgroup analysis showed no association between MetS and self-reported physical activity. Sedentary behavior and MetS did not present significant associations when considering screen time on days of the week, while cardiorespiratory fitness, although it was configured as the only variable to demonstrate an independent association with MetS, was included in few studies in the meta-analysis, provoking the need for further studies in this area.

Therefore, the objective of the present study was to assess the association between sedentary behavior, physical activity, cardiorespiratory fitness, and MetS in adolescents.

METHODS

A descriptive cross-sectional survey was carried out at the school base of the city of Jacarezinho, Paraná, Brazil. Data collection extended from August to November 2014. The intervention protocols used were approved by the Research Ethics Committee of the University of Paraná - UNOPAR (1.302.963). All participants signed a Free and Informed Consent Form.

The reference population included adolescents of both sexes, between 12 and 20 years of age, enrolled in middle school (6th to 9th grade) and high school (1st to 3rd year) of public and private schools. According to information from the Secretary of Education of the State of Paraná, in the 2014 school year, this population was estimated to be approximately 6,000 adolescent students. The sample size was established assuming a 95% confidence interval, a sampling error of three percentage points, and a minimum sample of one thousand adolescents was initially estimated. However, the final sample used in the treatment of information was composed of 1,035 adolescents (565 girls and 470 boys).

Regarding subject selection, probabilistic sampling for clusters was used, taking as a reference sex, year of study, and shift in which the adolescent was enrolled in each stratum of the school structure (public and private). From a universe of eight schools, three public schools and two private schools participated in the study, which were randomly selected. The criteria adopted to exclude some adolescents drawn for the study were: (a) refusal to participate in the study; (b) non-confirmation by signing the Informed Consent Form; (c) a health problem that temporarily or permanently prevented participation in the study; (d) using any type of medication that could induce changes in study variables; (e) being subjected to some type of specific diet; (f) pregnancy; and (g) not attending school on the scheduled day to start data collection. In these cases, a new draw was carried out to recover any sample losses.

Sedentary behavior was addressed through structured screen time issues (watching TV and using a computer, video game, tablet, and smartphone for activities unrelated to schoolwork) in the previous week. A predefined time scale was provided for the response, on which the adolescents indicated their options from alternatives of the amount of time spent in these activities. The issues considered TV time and use of computer, video game, tablet, and smartphone separately on weekdays and weekends (Saturday and Sunday). Recreational screen time was defined by the combined use of all screen devices considered, through weighted average involving the data of weekdays and weekends.

The practice of physical activity was identified through the Physical Activity Questionnaire (PAQ), translated, adapted, and validated for Brazilian youth. In the study the PAQ-A version was used, specific for adolescents. Originally, the PAQ-A for Brazilian adolescents presented satisfactory test-retest reproducibility (ICC = 0.88), internal consistency (α = 0.76), and correlation with moderate-to-vigorous physical activity estimated by accelerometry (r = 0.54). Each PAQ-A item presents a five-point response scale, which allows establishment of a score equivalent to the level of physical activity practice, computed by means of the arithmetic mean of the eight items that make up the questionnaire. Thus, the physical activity score can vary linearly from one (1) to five (5) points.
Cardiorespiratory fitness was treated using the Progressive Aerobic Cardiovascular Endurance Run (PACER), according to the procedures presented by the FitnessGram Program. The result of the test was recorded with the number of completed stages, for later estimation of the maximum volume of oxygen (VO2max), using the formula:

\[
\text{VO2max (ml/kg/min)} = 0.353 \times (\text{number of stages}) - 1.121 \times (\text{age}) + 45.619
\]

MetS was identified by analyzing the blood content of plasma lipids (triglycerides and HDL-cholesterol) and blood glucose, resting blood pressure (systolic and diastolic), and abdominal fat accumulation (waist circumference), according to criteria proposed by the International Diabetes Federation (IDF). In this case, MetS is defined by the presence of a high waist circumference (< 16 years: both sexes ≥ Percentile 90; ≥ 16 years: boys ≥ 90 cm and girls ≥ 80 cm) and at least two other compromised components: increased triglycerides (≥ 150 mg/dL), reduced HDL-cholesterol (< 16 years: both sexes < 40 mg/dL; ≥ 16 years: boys < 40 mg/dL and girls < 50 mg/dL), high fasting blood glucose (≥ 100 mg/dL), and altered blood pressure (systolic ≥ 130 mmHg or diastolic ≥ 85 mmHg).

Doses of plasma lipids and glycemia were performed by collecting blood samples through venipuncture, after 10-12 hours of fasting, according to conventional laboratory techniques. The systolic and diastolic blood pressure levels were measured by the auscultatory method using a mercury sphygmomanometer, with the adolescent sitting after a minimum of 5 minutes of rest. Two measures were taken and the average value of both measures considered for calculation purposes. Measurements of waist circumference were determined at the midpoint between the last rib and the iliac crest, using an inextensible anthropometric measurement tape.

Statistical analysis

Statistical analysis was performed using SPSS software, version 22. For the analysis of continuous variables, we used the procedures of descriptive statistics (mean ± standard deviation). Considering that the treated data presented normal distribution, the comparisons between sexes (girls and boys) and age groups (12 to 15 years and 16 to 20 years), regarding sedentary behavior, physical activity practice, and cardiorespiratory fitness were performed through analysis of two-way variance with interaction, followed by Scheffe’s multiple comparison test.

Comparisons between information equivalent to sedentary behavior, physical activity, and cardiorespiratory fitness, and individual components of MetS (waist circumference, triglycerides, HDL-cholesterol, blood glucose, and blood pressure) were performed separately by sex using covariance analysis with adjustments for age and body mass index (BMI). In order to size the associations between the exposure variables (sedentary behavior, physical activity, and cardiorespiratory fitness) stratified by distribution of tertiles (1st tertile = low, 2nd tertile = moderate, 3rd tertile = high) and the outcome variable and its components, odds ratio (OR) values were calculated through binary logistic regression with adjustments for sex, age, BMI, and other exposure variables involved in the regression models.

RESULTS

The presence of MetS was identified in 4.5% of the sample, being statistically higher in boys (5.2% versus 3.9%) and in older adolescents (4.9% versus 4.2%). Statistical information equivalent to the exposure variables that characterize the sample selected for the study are provided in table 1. The boys were statistically more physically active (F = 13.278, p < 0.001), with higher VO2max (F = 21.824; p < 0.001), while the screen time did not differ significantly between the sexes. In relation to age, younger adolescents reported significantly lower screen time (F = 11.693, p < 0.001), and significantly higher physical activity (F = 8.782, p < 0.001) and VO2max (F = 9.482, p < 0.001) than older adolescents.

Comparisons between exposure variables (sedentary behavior, physical activity practice, and cardiorespiratory fitness) and individual components of risk and MetS are presented in table 2. Adolescents with altered blood pressure were statistically less active (p = 0.019 and p = 0.008 for girls and boys, respectively). Significantly higher recreational screen time and lower VO2max were observed in girls and boys with high waist circumference, reduced HDL-cholesterol, and altered blood pressure. In both sexes, changes in triglyceride levels and glycemia did not result in significant differences in the exposure variables. Additionally, in adolescents identified with MetS, recreational screen time was significantly higher (p < 0.001 in both sexes) and VO2max lower (girls: p = 0.021 and boys: p = 0.008), which was not the case for the practice of physical activity.

The odds ratio values for the association between MetS components and the exposure variables are shown in table 3. Adolescents who reported high recreational screen time (third tertile) showed 79% [OR = 1.79; CI95% 1.10-2.82] more chance of being identified with MetS (≥ 3 components) than their peers who demonstrated low screen time (1st tertile). In the case of cardiorespiratory fitness, adolescents with low VO2max values (1st tertile) were considered to have a probability of 81% [OR = 1.81; CI95% 1.12-2.86] of presenting two individual risk components together and approximately twice as likely to be identified with MetS [OR = 1.95; CI95% 1.10-3.40] compared to adolescents with high VO2max values (3rd tertile). The practice of physical activity reported by adolescents did not present a significant association with the identification of individual components of risk related to MetS.

DISCUSSION

The present study investigated the association between sedentary behavior, physical activity practice, cardiorespiratory fitness, and MetS in adolescents. The results showed that longer recreational screen time, an indicator related to sedentary behavior, and lower values equivalent to VO2max, an indicator related to cardiorespiratory fitness, significantly increased the chances of identifying MetS in adolescents of both sexes.

Table 1. Mean values, standard deviation, and F statistic equivalent for information associated with recreational screen time, physical activity practice, and cardiorespiratory fitness.

<table>
<thead>
<tr>
<th></th>
<th>Age Groups</th>
<th>F Test</th>
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<tr>
<td></td>
<td>12 – 15 years</td>
<td>16 – 20 years</td>
<td>Sex</td>
<td>Age</td>
<td>Interaction</td>
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<tr>
<td>Recreational Screen Time (min/day)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Girls</td>
<td>228 ± 43.17</td>
<td>274 ± 51.75</td>
<td>3.336</td>
<td>11.693</td>
<td>8.468</td>
</tr>
<tr>
<td>Boys</td>
<td>249 ± 51.62</td>
<td>307 ± 60.47</td>
<td>ns</td>
<td>p &lt; 0.001</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Physical Activity Practice (score)</td>
<td></td>
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<tr>
<td>Girls</td>
<td>2.46 ± 0.49</td>
<td>2.03 ± 0.53</td>
<td>13.278</td>
<td>8.782</td>
<td>2.117</td>
</tr>
<tr>
<td>Boys</td>
<td>3.19 ± 0.64</td>
<td>2.87 ± 0.51</td>
<td>p &lt; 0.001</td>
<td>p &lt; 0.001</td>
<td>ns</td>
</tr>
<tr>
<td>Estimated VO2max (ml/kg/min)</td>
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<tr>
<td>Boys</td>
<td>48.82 ± 8.48</td>
<td>42.26 ± 7.15</td>
<td>p &lt; 0.001</td>
<td>p &lt; 0.001</td>
<td>p &lt; 0.001</td>
</tr>
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</table>
changes in three individual MetS-related risk components (elevated waist circumference, subsequently, studies that used this cut-off point did not identify a greater risk should be higher than 2h/day.

Regarding the practice of physical activity, there were no significant associations between PAQ-A scores and MetS identification. In this regard, to our knowledge, this is the first study that used PAQ-A to address possible associations between physical activity and MetS. However, when consulting the literature in the area, it was verified that studies involving other types of questionnaires also did not find significant differences in the practice of physical activity of adolescents identified and not identified with MetS. Likewise, no statistical associations were observed between lower levels of physical activity practice and greater chances of identifying MetS. On the other hand, it should be noted that studies that identified a significant association between low levels of physical activity practice and a greater chance of identifying MetS used the accelerometry technique as a measure of physical activity. These findings are confirmed by a meta-analysis that demonstrated the relevance of the use of accelerometers to identify significant associations between physical activity practice and MetS in young populations.

The use of self-reported procedures to treat the practice of physical activity in adolescents tends to present bias, considering difficulties existing at this age to recall and report with fidelity the intensity, frequency, and duration of activities performed. A previous study showed that information related to the practice of self-reported physical activity by young people tends to overestimate the most intense activities and underestimate the less intense activities, which may have influenced the dimensioning of the association between physical activity practice and MetS observed in the present study.

Regarding cardiorespiratory fitness, other studies also showed that adolescents identified with MetS tend to present statistically lower VO2max and significant associations between low cardiorespiratory fitness and a greater chance of identifying MetS. Meta-analysis procedures indicated a strong association between cardiorespiratory fitness and MetS in adolescents, in which low VO2max quadrupled the chances of diagnosis of this outcome. In addition, association between cardiorespiratory fitness...
and MetS occurred regardless of the type of test used to estimate the VO\textsubscript{2max} (field or laboratory) or of the confounding variables considered\textsuperscript{13}.

The advantage of using cardiorespiratory fitness as a predictor of cardiometabolic risk refers to the fact that VO\textsubscript{2max} is a naturally more stable physiological indicator, requiring specific stimulus for a certain period of time to present changes. Different from what happens, for example, with the practice of physical activity, which can demonstrate high intra-subject variability in a short period of time, such as from one day to another, especially in the young population\textsuperscript{10}. With respect to the 20-meter multi-stage test, such as the one used in the present study, this is a viable alternative to identify adolescents at greater risk of MetS, presenting the advantage of being able to be administered to a large quantity of subjects simultaneously, in a short time, and at low cost.

As study strengths, given the gaps identified in a recent systematic review and meta-analysis\textsuperscript{11} involving the association between sedentary behavior, physical activity practice, cardiorespiratory fitness, and MetS in adolescents, the present study presents important contributions: a) recreational screen time typically dichotomized (≤ 2h/day) in different studies without significant association with MetS, was treated here by tertiary distribution; b) association between physical activity practice and MetS was dimensioned through the PAQ-F for the first time; c) estimation of VO\textsubscript{2max} through the PACER test previously only used in a single study\textsuperscript{24}, in order to assess the association between cardiorespiratory fitness and MetS in adolescents, was considered again here.

Among possible limitations, it is necessary to take into account the transversal nature of the data collection, which does not allow establishment of a causal reference between the variables of exposure and outcome. Another limitation is the degree of veracity of the adolescents’ answers regarding screen time and physical activity, considering that the information presented in the questionnaires is self-reported. Finally, since, to date, there is no universally accepted diagnostic criterion for MetS for the young population, we chose the criterion proposed by the IDF; however, at this age the available criteria may generate significantly different prevalences of MetS.

CONCLUSION

Evidence found in the study pointed out that the practice of physical activity, identified through PAQ-A self-reported information, did not present a statistical association with MetS. However, consistent and significant associations were observed between longer recreational screen time, which represents higher sedentary behavior, lower values equivalent to VO\textsubscript{2max}, an indicator of impairment of cardiorespiratory fitness, and a high prevalence of MetS, suggesting specific interventions that may help in the minimization of exposure to cardiometabolic risks from the earliest ages.

All authors declare no potential conflict of interest related to this article.

AUTHORS’ CONTRIBUTIONS: Each author contributed individually and significantly to the development of this article. RGO (0000-0003-0904-9305)*: writing the article, reviewing and performing the data collection; DPG (0000-0002-7367-2276)*: data analysis, article review and intellectual concept of the article and the design of the research project. *ORCID (Open Researcher and Contributor ID).

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