PHYSICAL ACTIVITY, CARDIORESPIRATORY FITNESS AND METABOLIC SYNDROME IN ADOLESCENTS

ATIVIDADE FÍSICA, APTIDÃO CARDIORRESPIRATÓRIA E SÍNDROME METABÓLICA EM ADOLESCENTES

ACTIVIDAD FÍSICA, CAPACIDAD CARDIORRESPIRATORIA Y EL SÍNDROME METABÓLICO EN ADOLESCENTES

ORIGINAL ARTICLE
ARTIGO ORIGINAL
ARTÍCULO ORIGINAL

Raphael Gonçalves de Oliveira[1,2]
(Physical Education Professional)
Dartagnan Pinto Guedes[1]
(Physical Education Professional)

1. Universidade Norte do Paraná (UNOPAR), Londrina, Paraná, PR, Brazil.
2. Universidade Estadual do Norte do Paraná (UENP), Jacarezinho, Paraná, PR, Brazil.

Correspondence:
Universidade Estadual do Norte do Paraná (UENP), Centro de Ciências da Saúde. Alameda Padre Magno 841, Nova Alcântara, Jacarezinho, PR, Brazil. 86400-000.
rgoliveira@uenp.edu.br

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 (VO_{2max}), 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 VO_{2max} 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 VO_{2max} 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 findings indicate consistent and significant associations between longer recreational screen time, low VO_{2max} 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.

RESUMO

Introdução: Síndrome Metabólica (SMet) tem sido associada ao comportamento sedentário, baixos níveis de atividade física e de aptidão cardiorrespiratória. No entanto, em adolescentes, os resultados são conflitantes. Objetivo: Dimensionar a associação entre comportamento sedentário, prática de atividade física, aptidão cardiorrespiratória e SMet em uma amostra representativa de adolescentes. Métodos: A amostra foi composta por 1.035 adolescentes (565 moças e 470 rapazes), entre 12 e 20 anos de idade. Comportamento sedentário foi tratado mediante tempo de tela recreativo, enquanto informações equivalentes à prática de atividade física foram consideradas por intermédio do Physical Activity Questionnaire for Adolescents. Volume máximo de oxigênio ($VO_{2Máx}$), estimado por intermédio do PACER, foi empregado como indicador de aptidão cardiorrespiratória. SMet foi identificada através dos critérios da International Diabetes Federation. Resultados: Adolescentes de ambos os sexos identificados com SMet apresentaram significativamente maior tempo de tela recreativo e menor $VO_{2Máx}$ que seus pares não identificados com SMet. Escores equivalentes à prática de atividade física de adolescentes identificados e não-identificados com SMet foram estatisticamente similares. Probabilisticamente, adolescentes com elevado tempo de tela recreativo e baixo $VO_{2Máx}$ demonstraram, respectivamente, 79% [OR = 1,79; $IC_{95\%}$ 1,10 – 2,82] e 95% [OR = 1,95; $IC_{95\%}$ 1,20 – 3,09], com maiores chances de serem identificados com SMet. Conclusão: Os achados sinalizam para associações consistentes e significativas entre maior tempo de tela recreativo, baixos valores de $VO_{2máx}$ 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.*

RESUMEN

Introducción: El síndrome metabólico (SMet) se ha asociado con el comportamiento sedentario, los bajos niveles de actividad física y la aptitud cardiorrespiratoria. Sin embargo, en los adolescentes, los resultados son conflictivos. Objetivo: Dimensionar la asociación entre comportamiento sedentario, práctica de actividad física, aptitud cardiorrespiratoria y SMet en una muestra representativa de adolescentes. Métodos: La muestra fue constituida por 1.035 adolescentes (565 niñas y 470 Niños), entre 12 y 20 años de edad. El comportamiento sedentario fue tratado por el tiempo de pantalla recreativa, mientras que las informaciones equivalentes a la actividad física fueron consideradas por intermedio del Physical Activity Questionnaire for Adolescents. El volumen máximo de oxígeno ($VO_{2máx}$), estimado *a través del PACER, fue empleado como indicador de la aptitud cardiorrespiratoria. SMet fue identificado a través de los criterios de la International Diabetes Federation. Resultados: Los adolescentes de ambos sexos identificados con SMet presentaron significativamente mayor tiempo de pantalla recreativa y menor $VO_{2máx}$ que sus pares no identificados con SMet. Las puntuaciones equivalentes a la actividad física de adolescentes identificados y no identificados con SMet fueron estadísticamente similares. Probabilísticamente, los adolescentes con mayor tiempo de pantalla recreativa y $VO_{2máx}$ más bajo mostraron, respectivamente, el 79% [OR = 1,79; $IC_{95\%}$ 1,10 – 2,82] y 95% [OR = 1,95; $IC_{95\%}$ 1,20 – 3,09] más posibilidades de ser identificados con SMet. Conclusión: Los hallazgos señalan para asociaciones consistentes y significativas entre el mayor tiempo de pantalla recreativa, bajos valores de $VO_{2máx}$ y alta prevalencia de SMet, lo que sugiere intervenciones específicas que puedan auxiliar en la minimización de exposición a los riesgos cardiometabólicos desde las edades más tempranas.* ***Nivel de evidencia III; Estudios pronósticos - Investigación del efecto de característica de un paciente sobre el desenlace de la enfermedad.***

Descriptores: *Estilo de Vida Sedentario; Actividad Motora; Aptitud Física; Enfermedades Metabólicas; Jóvenes.*

DOI: http://dx.doi.org/10.1590/1517-869220182404174502 Article received on 01/16/2017 accepted on 04/07/2018

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[1]. In adults the prevalence of MetS is increasing in different geographic regions, being identified in approximately ¼ of the world population[2-4].

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[5]. However, as in adult populations, in young people, there is a clear tendency to an increase in the prevalence of MetS[6]. Recent studies indicate a prevalence of more than 10% among adolescents in some regions[7-9]. 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[10], and low level of physical activity[11] and physical fitness[12].

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 (VO_{2max} 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[13].

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 an increase of 10% in order to attend to eventual cases of data collection losses. Considering that the sample planning involved conglomerates, the effect of the sample design (deff) was defined as 1.5, 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[14]. 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 (rho = 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[15]. The result of the test was recorded with the number of completed stages, for later estimation of the maximum volume of oxygen (VO_{2max}), using the formula [16]:

$$VO_{2max}\ (ml/kg/min) = 0.353(\text{number of stages}) - 1.121(\text{age}) + 45.619$$

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)[17]. 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 < 40mg/dL; ≥ 16 years: boys < 40mg/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 VO_{2max} ($F = 21.824$; $p < 0.001$), 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 VO_{2max} ($F = 9{,}482$, $p < 0.001$) 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 VO_{2max} 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 VO_{2max} 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; $CI_{95\%}$ 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 VO_{2max} values (1st tertile) were considered to have a probability of 81% [OR = 1.81; $CI_{95\%}$ 1.12-2.86] of presenting two individual risk components together and approximately twice as likely to be identified with MetS [OR = 1.95; $CI_{95\%}$ 1.20-3.09] compared to adolescents with high VO_{2max} 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 VO_{2max}, 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.

		Age Groups		F Test		
		12 – 15 years	**16 – 20 years**	**Sex**	**Age**	**Interaction**
Recreational Screen Time (min/day)	Girls	228.56 ± 43.17	274.62 ± 51.75	3.336	11.693	8.468
	Boys	249.21 ± 51.62	307.83 ± 60.47	ns	p < 0.001	p < 0.001
Physical Activity Practice (score)	Girls	2.46 ± 0.49	2.03 ± 0.53	13.278	8.782	2.117
	Boys	3.19 ± 0.64	2.87 ± 0.51	p < 0.001	p < 0.001	ns
Estimated VO_{2max} (ml/kg/min)	Girls	36.37 ± 7.04	31.81 ± 9.53	21.824	9.482	7.552
	Boys	48.82 ± 8.48	42.26 ± 7.15	p < 0.001	p < 0.001	p < 0.001

Table 2. Comparison between recreational screen time, physical activity practice, cardiorespiratory fitness, and individual risk components and metabolic syndrome.

		Recreational Screen Time (min/day)		Physical Activity Practice (score)		Estimated VO_{2max} (ml/kg/min)	
		Girls	Boys	Girls	Boys	Girls	Boys
Waist Circumference*	≥ percentile 90	264.74 ± 54.16	305.32 ± 64.74	2.31 ± 0.56	3.13 ± 0.61	26.84 ± 7.12	39.07 ± 7.17
	< percentile 90	238.35 ± 46.84	250.76 ± 56.48	2.18 ± 0.48	2.88 ± 0.52	39.21 ± 8.95	52.95 ± 8.65
		p = 0.027	p < 0.001	ns	ns	p < 0.001	p < 0.001
Triglycerides	≥ 150 mg/dL	259.21 ± 51.93	291.77 ± 59.12	2.24 ± 0.47	3.06 ± 0.58	30.27 ± 7.74	43.74 ± 7.89
	< 150 mg/dL	244.52 ± 48.42	266.45 ± 53.85	2.27 ± 0.52	2.95 ± 0.53	35.98 ± 8.12	48.12 ± 8.25
		ns	ns	ns	ns	ns	ns
HDL-cholesterol**	< 40 mg/dL	267.68 ± 55.32	299.73 ± 60.83	2.36 ± 0.58	2.90 ± 0.50	29.15 ± 7.69	41.84 ± 7.68
	≥ 40 mg/dL	235.73 ± 40.97	257.19 ± 55.62	2.15 ± 0.44	3.11 ± 0.59	36.83 ± 8.37	48.36 ± 8.21
		p = 0.001	p = 0.021	ns	ns	p = 0.034	p = 0.041
Fasting glycemia	≥ 100 mg/dL	260.37 ± 50.06	293.41 ± 57.74	2.28 ± 0.53	3.04 ± 0.57	31.38 ± 7.88	42.75 ± 6.93
	< 100 mg/dL	243.94 ± 47.64	264.73 ± 52.34	2.22 ± 0.49	2.98 ± 0.53	35.01 ± 8.14	48.67 ± 8.15
		ns	ns	ns	ns	ns	ns
Blood Pressure	≥ 85 mmHg / ≥ 130 mmHg	263.65 ± 51.47	311.52 ± 65.92	2.09 ± 0.41	2.80 ± 0.49	27.84 ± 7.63	40.74 ± 7.58
	< 85 mmHg / < 130 mmHg	239.38 ± 43.52	246.78 ± 50.67	2.42 ± 0.61	3.21 ± 0.62	38.21 ± 8.22	49.81 ± 8.34
		p = 0.032	p < 0.001	p = 0.019	p = 0.008	p < 0.001	p = 0.011
Metabolic Syndrome	Yes	270.84 ± 52.74	303.59 ± 62.32	2.34 ± 0.53	3.05 ± 0.56	30.03 ± 7.46	41.03 ± 7.37
	No	232.53 ± 42.96	252.84 ± 55.37	2.16 ± 0.48	2.94 ± 0.54	37.94 ± 8.53	50.53 ± 8.40
		p < 0.001	p < 0.001	ns	ns	p = 0.021	p = 0.008

Analysis of covariance adjusted for age and body mass index. * Cut-off points for adolescents ≥ 16 years: boys ≥ 90 cm and girls ≥ 80 cm. ** Cut-off points for adolescents ≥ 16 years: boys < 40 mg/dL and girls < 50 mg/dL.

Table 3. Odds ratio and 95% confidence interval for the association between components of metabolic syndrome, recreational screen time, physical activity practice, and cardiorespiratory fitness in adolescents.

		Metabolic Syndrome Components		
		≤ 1 Component[1]	2 Components[1]	≥ 3 Components[1]
Recreational Screen Time	Low	Reference	Reference	Reference
	Moderate	1.40 (0.80 – 2.23)	1.51 (0.90 – 2.40)	1.62 (0.98 – 2.54)
	High	1.49 (0.88 – 2.37)	1.60 (0.97 – 2.53)	1.79 (1.10 – 2.82)
Physical Activity Practice	High	Reference	Reference	Reference
	Moderate	1.34 (0.83 – 2.11)	1.41 (0.88 – 2.22)	1.52 (0.93 – 2.42)
	Low	1.43 (0.90 – 2.18)	1.50 (0.94 – 2.31)	1.61 (0.98 – 2.49)
Estimated VO_{2max}	High	Reference	Reference	Reference
	Moderate	1.51 (0.89 – 2.44)	1.64 (0.97 – 2.63)	1.80 (1.06 – 2.82)
	Low	1.59 (0.91 – 2.60)	1.81 (1.12 – 2.86)	1.95 (1.20 – 3.09)

Values adjusted for sex, age, body mass index and other exposure variables involved in the regression models. [1] Including obligatorily high waist circumference, as proposed by the International Diabetes Federation.

Although adolescents with altered blood pressure were statistically less physically active, physical activity was not significantly associated with MetS.

Similar to the findings in the present study, Kang et al.[18] identified changes in three individual MetS-related risk components (elevated waist circumference, altered blood pressure, and increased triglycerides) in adolescents who reported longer recreational screen time, presenting a predisposition for a diagnosis of MetS that was twice as high. In addition, corroborating with the findings presented herein, Mark and Janssen[19] found progressively higher MetS prevalences according to the increase in recreational screen time of adolescents, being that recreational screen time ≥ 5 hours increased three times the chances of developing MetS.

In the present study, in average values, the recreational screen time of adolescents identified with MetS was approximately 4h 30min in girls and 5h in boys, while among adolescents not identified with MetS screen time was around 4h in both sexes. In order to propose recommendations to be adopted internationally, a committee of experts arbitrarily suggested a cut-off point for recreational screen time equivalent to ≤ 2 hours per day for cardiovascular risk reduction in adolescents[20]. However, subsequently, studies that used this cut-off point did not identify a significant association between recreational screen time and MetS[8,13,18,19], suggesting that, specifically for MetS, the cut-off point associated with 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[21-23]. Likewise, no statistical associations were observed between lower levels of physical activity practice and greater chances of identifying MetS[7-9,19,24]. 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[25,26]. These findings are confirmed by a meta-analysis that demonstrated the reliance on the use of accelerometers to identify significant associations between physical activity practice and MetS in young populations[13].

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[27]. 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[28], 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 VO_{2max} and significant associations between low cardiorespiratory fitness and a greater chance of identifying MetS[24,26,29]. Meta-analysis procedures indicated a strong association between cardiorespiratory fitness and MetS in adolescents, in which low VO_{2max} 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_{2max} (field or laboratory) or of the confounding variables considered[13].

The advantage of using cardiorespiratory fitness as a predictor of cardiometabolic risk refers to the fact that VO_{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[30]. 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[13] 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-A for the first time; c) estimation of VO_{2max} through the PACER test previously only used in a single study[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 different 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_{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).

REFERENCES

1. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. 2009;120(16):1640-5.
2. Vidigal FC, Bressan J, Babio N, Salas-Salvadó J. Prevalence of metabolic syndrome in Brazilian adults: a systematic review. BMC Public Health. 2013;13:1198.
3. Aguilar M, Bhuket T, Torres S, Liu B, Wong RJ. Prevalence of the metabolic syndrome in the United States, 2003-2012. JAMA. 2015;313(19):1973-4.
4. Ranasinghe P, Mathangasinghe Y, Jayawardena R, Hills AP, Misra A. Prevalence and trends of metabolic syndrome among adults in the asia-pacific region: a systematic review. BMC Public Health. 2017;17:101.
5. Friend A, Craig L, Turner S. The prevalence of metabolic syndrome in children: a systematic review of the literature. Metab Syndr Relat Disord. 2013;11(2):71-80.
6. Poyrazoglu S, Bas F, Darendeliler F. Metabolic syndrome in young people. Curr Opin Endocrinol Diabetes Obes. 2014;21(1):56-63.
7. Fam B, Amouzegar A, Arzhan S, Ghanbariyan A, Delshad M, Hosseinpanah F, et al. Association between Physical Activity and Metabolic Risk Factors in Adolescents: Tehran Lipid and Glucose Study. Int J Prev Med. 2013;4(9):1011-7.
8. Mehairi AE, Khouri AA, Naqbi MM, Muhairi SJ, Maskari FA, Nagelkerke N, et al. Metabolic syndrome among Emirati adolescents: A School-Based Study. PLoS One. 2013;8(2):e56159.
9. You MA, Son YJ. Prevalence of metabolic syndrome and associated risk factors among Korean adolescents: analysis from the Korean national survey. Asia Pac J Public Health. 2012;24(3):464-71.
10. Tanaka C, Reilly JJ, Huang WY. Longitudinal changes in objectively measured sedentary behaviour and their relationship with adiposity in children and adolescents: systematic review and evidence appraisal. Obes Rev. 2014;15(10):791-803.
11. Moraes AC, Guerra PH, Menezes PR. The worldwide prevalence of insufficient physical activity in adolescents; a systematic review. Nutr Hosp. 2013;28(3):575-84.
12. Malina RM. Physical fitness of children and adolescents in the United States: status and secular change. Med Sport Sci. 2007;50:67-90.
13. Oliveira RG, Guedes DP. Physical activity, sedentary behavior, cardiorespiratory fitness and metabolic syndrome in adolescents: systematic review and meta-analysis of observational evidence. PLoS One. 2016;11(12):e0168503.
14. Guedes DP, Guedes JERP. Medida da atividade física em jovens brasileiros: reprodutibilidade e validade do PAQ-C e do PAQ-A. Rev Bras Med Esporte. 2015;21(6):425-32.
15. Meredith MD, Welk GJ. Fitnessgram/Activitygram: test administration manual. 4th ed. Dallas, Texas: The Cooper Institute; 2013.
16. Saint-Maurice PF, Welk GJ, Finn KJ, Kaj M. Cross-Validation of a PACER Prediction Equation for Assessing Aerobic Capacity in Hungarian Youth. Res Q Exerc Sport. 2015;86(Suppl1):S66-73.
17. Zimmet P, Alberti KG, Kaufman F, Tajima N, Silink M, Arslanian S, et al. The metabolic syndrome in children and adolescents - an IDF consensus report. Pediatr Diabetes. 2007;8(5):299-306.
18. Kang HT, Lee HR, Shim JY, Shin YH, Park BJ, Lee YJ. Association between screen time and metabolic syndrome in children and adolescents in Korea: the 2005 Korean National Health and Nutrition Examination Survey. Diabetes Res Clin Pract. 2010;89(1):72-8.
19. Mark AE, Janssen I. Relationship between screen time and metabolic syndrome in adolescents. J Public Health (Oxf). 2008;30:153-60.
20. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. Pediatrics. 2011;128(Suppl 5):S213-56.
21. Bermúdez-Cardona J, Velásquez-Rodríguez C. Profile of Free Fatty Acids and Fractions of Phospholipids, Cholesterol Esters and Triglycerides in Serum of Obese Youth with and without Metabolic Syndrome. Nutrients. 2016;8(2):54.
22. Múnera NE, Uscátegui RM, Parra BE, Manjarrés LM, Patiño F, Velásquez CM, et al. Factores de riesgo ambientales y componentes del síndrome metabólico en adolescentes con exceso de peso. Biomedica. 2012;32(1):77-91.
23. Pan Y, Pratt CA. Metabolic syndrome and its association with diet and physical activity in US adolescents. J Am Diet Assoc. 2008;108(2):276-86.
24. Stabelini Neto A, Sasaki JE, Mascarenhas LP, Boguszewski MC, Bozza R, Ulbrich AZ, et al. Physical activity, cardiorespiratory fitness, and metabolic syndrome in adolescents: a cross-sectional study. BMC Public Health. 2011;11:674.
25. Nguyen TH, Tang HK, Kelly P, Van der PHP, Dibley MJ. Association between physical activity and metabolic syndrome: a cross sectional survey in adolescents in Ho Chi Minh City, Vietnam. BMC Public Health. 2010;10:141.
26. Ekelund U, Anderssen S, Andersen LB, Riddoch CJ, Sardinha LB, Luan J, et al. Prevalence and correlates of the metabolic syndrome in a population-based sample of European youth. Am J Clin Nutr. 2009;89(1):90-6.
27. Sirard JR, Pate RR. Physical activity assessment in children and adolescents. Sports Med. 2001;31(6):439-54.
28. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc. 2008;40(1):181-8.
29. McMurray RG, Bangdiwala SI, Harrell JS, Amorim LD. Adolescents with metabolic syndrome have a history of low aerobic fitness and physical activity levels. Dyn Med. 2008;7:5.
30. Steele RM, Brage S, Corder K, Wareham NJ, Ekelund U. Physical activity, cardiorespiratory fitness, and the metabolic syndrome in youth. J Appl Physiol (1985). 2008;105(1):342-51.