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Cross-sectional Study

Asociación de resistencia abdominal con adiposidad corporal, actividad física y tiempo sentado en adolescentes

Association of abdominal endurance with body adiposity, physical activity and sitting time in adolescents

De Marco, Jean C.P.[1]; Bim, Matheus A.[1]; Souza, Fernanda U.[1]; Martins, Rafael[1]; Pinto, André A.[2]; Felden, Érico P.G.[1]; Pelegrini, Andreia[1]

[1]*State University of Santa Catarina, Florianópolis, SC, Brazil.*

[2]*State University of Roraima, Boa Vista, RR, Brazil.*

Correspondence to:
Author: Andreia Pelegrini
Institution: State University of Santa Catarina
Address: Pascoal Simone Street, 358 - Coqueiros, Florianópolis-SC/Brazil
Email: andreia.pelegrini@udesc.br

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ASSOCIATION OF ABDOMINAL ENDURANCE WITH BODY ADIPOSITY, PHYSICAL ACTIVITY AND SITTING TIME IN ADOLESCENTS

ABSTRACT

Objective: Identify possible associations of muscular endurance with body adiposity, physical activity, and sedentary behavior in adolescents. Methods: A cross-sectional study was conducted on a sample of 1773 adolescents (795 boys and 978 girls) aged 14 to 19 years from Florianopolis, Brazil. Abdominal endurance by the sit-up test proposed by the Canadian Physical Activity, Fitness and Lifestyle Assessment Approach. Body adiposity was estimated by the sum of triceps and subscapular skinfold thicknesses. Daily physical activity was estimated by the International Physical Activity Questionnaire - Short Form. Sedentary behavior was investigated using a self-report questionnaire, taking into account the time spent sitting on a weekday and a weekend day. Stepwise linear regression analysis was performed to identify the predictors of abdominal endurance. Results: Boys (16,43 years) were more active (94.85 min/day vs 84.30 min/day, $p < 0.001$) and had higher abdominal endurance (23.67 repetitions vs 21.31 repetitions, $p < 0.001$) than girls. Girls (16,27 years) had a longer sitting time (414.89 min/day vs 376.12 min/day, $p < 0.001$) and higher body adiposity (31.69 mm vs 21.44 mm, $p < 0.001$) than boys. As for predictors, body adiposity ($\beta = -0.207$) was the only variable associated with abdominal endurance in boys, whereas body adiposity ($\beta = -0.127$) and physical activity ($\beta = 0.099$) were associated with abdominal endurance in girls. Conclusion: In both sexes, high levels of body adiposity negatively affect abdominal endurance. On the other hand, in girls, high levels of physical activity have a positive influence on abdominal endurance.

Keywords: Physical fitness; Public Health; Pediatric exercise.

ASOCIACIÓN DE RESISTÊNCIA ABDOMINAL COM ADIPOSIDAD CORPORAL, ACTIVIDAD FÍSICA Y TEMPO SENTADO EM ADOLESCENTES

RESUMEN

Objetivo: Identificar posibles asociaciones de la resistencia muscular con la adiposidad corporal, la actividad física y el sedentarismo en adolescents. Métodos: Se realizó un studio tranversal en una muestra de 1773 adolescentes (795 niños y 978 niñas) de 14 a 19 años de Florianópolis, Brasil. Resistencia abdominal mediante la prueba de abdominals prouesta por el Enfoque Canadiense de Evaluación de Actividad Física, Condición Física y Estilo de Vida. La adiposidad corporal se estimó mediante la suma del grosor de los pliegues cutáneos del tríceps y del subescapular. La actividad física diaria se estimó mediante el Cuestionario Internacional de Actividad Física – Formulario abreviado. El comportamiento sedentario se investigó mediante un cuestionario de autoinforme, teniendo en cuenta el tiempo pasado sentado entre semana y fin de semana. Se realizó un análisis de regression lineal por pasos para identificar los predictors de la resistencia abdominal. Resultados: Los niños (16,43 años) fueron más activos (94,85 min/día vs 84,30 min/día, p < 0,001) y tuvieron mayor resistencia abdominal (23,67 repeticiones vs 21,31 repeticionae, p < 0,001) que las niñas. Las niñas (16,27 años) tuvieron mayor tiempo sentadas (414,89 min/día vs 376,12 min/día, p < 0,001) y mayor adiposidad corporal (31,69 mm vs 21,44 mm, p < 0,001) que los niños. En cuanto a los predictores, la adiposidad corporal ($\beta = -0.207$) fue la única variable asociada con la resistencia abdominal en los niños, mientras que la adiposidad corporal ($\beta = -0.127$) y la actividad física ($\beta = 0.099$) se asociaron con la resistencia abdominal en las niñas. Conclusión: En ambos sexos, los altos niveles de adiposidade corporal afectan negativamente la resistencia abdominal. Por otro lado, en las niñas, unos niveles elevados de actividad física influyen positivamente en la resistencia abdominal.

Palabras clave: Aptitud física; Salud pública; Ejercicio pediátrico.

INTRODUCTION

Muscular fitness is an important health indicator in pediatric populations, given that children and adolescents with adequate levels of this component have lower chances of developing cardiometabolic diseases in adulthood (García-Hermoso et al., 2019). Muscular fitness is a multidimensional component associated with the ability of muscles to generate strength, resist repeated contractions over time (muscular endurance), and perform dynamic actions in a short period of time (muscular power) (Artero et al., 2011).

Evidence indicates improvements in muscular endurance of adolescents worldwide up to 2000, declining from 2010 onward (Kaster et al., 2020). In Brazil, there was a 3.3% overall decrease in muscular endurance levels between 2008 and 2014 (Gaya et al., 2020). These findings are a cause for concern, as low levels of muscular endurance in youth tend to be maintained during adulthood (García-Hermoso et al., 2022).

In addition to understanding the levels of muscular endurance in a given population, it is necessary to identify which groups are most exposed to the lowest levels of muscular endurance in order to address underlying factors. The decline in muscular endurance in adolescents may be linked, for instance, to factors inherent to industrialization and digital age revolution. Knowledge of the factors influencing abdominal endurance may contribute to the development of more specific actions targeting the most exposed groups. Factors that may interfere with abdominal endurance include body adiposity (García-Hermoso et al., 2019; Tallis et al., 2018), physical activity (Kaster et al., 2020; Smith et al., 2019), and sedentary behavior (Smith et al., 2019). However, there are still gaps in the research literature that should be addressed in studies with adolescents.

Body adiposity has inverse associations with muscular fitness (García-Hermoso et al., 2019). High levels of body fat promove a series of physiological changes that affect the contractile function of muscles and the activity of proteins responsible for muscle contraction and relaxation, leading to a decrease in force produced by cross-sectional area and power produced by muscle mass (Tallis et al., 2018).

Physical activity can be an ally in the development of muscular endurance, especially when practiced vigorously (Kaster et al., 2020; Smith et al., 2019). Studies have shown that physical activity interventions during physical education classes (Oliveira et al., 2017) and extracurricular activities (Mendonça et al., 2022) promote improvements in abdominal muscular endurance. However, 57.9% of adolescents in a European study stated that they did not perform any muscle-strengthening activities (Bennie et al., 2022). This result may be related to psychological aspects, as adolescents with better self-efficacy are more likely to engage in strengthening activities (Smith et al., 2020).

A risk factor that should be considered is time spent in sedentary behaviors, which is directly related to cardiometabolic risk (Chaput et al., 2020). It should be noted, however, that studies have not yet been able to confirm the influence of sedentary behavior on abdominal endurance (Smith et al., 2019). Recently, an increase in time spent in sedentary behaviors and a decrease in physical activity have been observed (Kharel et al., 2022), factors that negatively influence muscular endurance. An Australian study found that a reduction in sedentary time can contribute to reducing health system costs, given that it decreases the chances of developing adverse conditions (Nguyen et al., 2022). Furthermore, in an isotemporal substitution study, it was observed that the replacement of 30 min of sedentary behavior by physical activity produces favorable changes in fitness in adolescents (Zang et al., 2022).

This study aims to identify possible associations of muscular endurance with body adiposity, physical activity, and sedentary behavior in adolescents.

METHODS

This is an observational, cross-sectional study conducted in 2007 and 2017/2018 in Florianópolis, SC, Brazil. The study was approved by the Human Research Ethics Committees at the Federal University of Santa Catarina (protocol No. 372/2006) and the State University of Santa Catarina (Protocol No. 2,172,699).

The study population consisted of adolescent students of both sexes, aged 14 to 19 years, enrolled in public schools in Florianópolis. The sample size calculation procedure is described in a previously conducted study (Pelegrini et al., 2018; Bim et al., 2021). According to school census data provided by the Santa Catarina State Department of Education, there were 12,741 adolescents enrolled in secondary schools in 2007 and 10,192 in 2017. The minimum sample size calculated for the surveys was 631 adolescents in 2007 and 624 adolescents in 2017, totaling 1255 adolescents so that the study sample was representative of the studied population.

Schools were selected based on their distribution in five municipal regions (continent, center, east, north, and south), according to the Municipal Health Secretariat. After geographical definition of city regions, the largest school of each region was selected. Then, the number of schools needed to compose total and proportional samples per region were estimated, and saturation sampling was performed. Classes were drawn until the necessary number of proportional samples was reached for each school. All students in drawn classes were invited to participate in the research.

The selected schools were contacted and informed about the study objectives and procedures. Authorization to conduct the research was obtained from schools. Written consent was obtained from the adolescents' parents/guardians. Adolescents who were 18 years and older signed the consent form themselves. Adolescents who presented physical or clinical conditions that prevented the performance of the physical tests, aged less than 14 years or over 19 years were not considered eligible to participate and were not included in the statistical analyses.

Data collection was carried out by trained researchers at locations indicated by the schools participating in the research, in the morning and afternoon shifts, according to a schedule of days and hours previously agreed with each school. Anthropometric measurements were taken individually in a separate room.

Variables

Abdominal endurance (dependent variable) was evaluated by an abdominal test. The subject was instructed to lie in dorsal decubitus on a mat, with the knees bent at 90°, feet on the mat, and arms extended along the side of the body, with hands and fingers extended toward the heels. The starting position was marked at the fingertip line, and the ending position was marked 10 cm away from the heels. Marking was done with a tape so that the subject could feel the relief of the tape by sliding their hands. One repetition was counted for each complete slide between the pre-marked 10 cm intervals. The pace of the test was set by a metronome at 50 beats per minute, with the first beat indicating the rising movement and the second the return to the starting position. This sequence was repeated until the conclusion of the evaluation, which lasted 1 min. The test ended after the completion of 25 repetitions, this being the maximum number required for the rater to be classified as excellent. The test was interrupted if the subject felt any discomfort, was unable to follow the metronome cadence, or performed the technique incorrectly in more than two consecutive repetitions (CSEP, 2004).

Height was measured using a metallic tape fixed to the wall with a recording resolution of 0.1 cm in the 2007 survey, and in the 2017/18 survey, a Sanny portable stadiometer was used, with a resolution of 0.1 cm (CSEP, 2004). Body mass was collected in the 2007 survey using a PLENNA® brand digital scale (100-gram resolution). In the 2017/18 survey, a Tanita digital scale was used (100-gram resolution) with values recorded in kilograms (KG) (CSEP, 2004). Skinfold measurements of subscapular and triceps regions[18] were used to estimate body adiposity. Measurements were taken with a Cescorf scientific skinfold caliper with a resolution of 0.1 mm. In the case of a 5% difference between two measurements, a third measurement was taken, and the median of all measurements was used (Marfell-Jones et al., 2006).

The level of physical activity was measured using the International Physical Activity Questionnaire - Short Form (IPAQ - SF), validated for Brazilian adolescents (Guedes et al., 2005). We collected information regarding the practice of physical activity in the last 7 days, referring to the frequency and duration of moderate and vigorous intensity physical activity. The daily average was calculated as the total time of physical activity divided by 7.

Sedentary behavior was determined as sitting time. This behavior was investigated by using the following questions: (a) "how much time in total do you spend sitting during a weekday?" and (b) "how much time in total do you spend sitting during a weekend day?" (Pardini et al., 2001). These questions were extracted from IPAQ for assessment of the daily sitting time of adolescents. To calculate daily sitting time, we applied the following equation: [(sitting time during a weekday × 5) + (sitting time during a weekend day × 2)]/7.

Sexual maturation was assessed by the Tanner scale (Tanner, 1962) in the 2007 survey (with six response options) and by the version adapted by Adami and Vasconcelos (Adami & Vasconcelos, 2008) in the 2017 survey (with five response options). The questionnaire was administered by a researcher of the same sex as the adolescent, and instructions were given on how to answer the worksheet. Adolescents received worksheets with five pubertal development images and were instructed to mark the number of the image that best resembled their pubic hair. The scale of 1 to 6 corresponds to the following stages: 1 and 2, prepubertal; 3 and 4, pubertal, 5 and 6; post-pubertal. For purposes of analysis and comparison, stage 6 was grouped with stage 5.

Statistical analysis

The data were tabulated using a Microsoft Excel spreadsheet. IBM SPSS Statistics version 20.0 was used for statistical analysis. Descriptive (mean and standard deviation) and inferential statistics were used. Data normality was verified using the Kolmogorov–Smirnov test. For comparisons between mean values, we applied the Mann–Whitney *U*-test. To identify the interrelationship between the independent variables, Spearman Correlation was used. Stepwise multiple linear regression was used to identify the predictors of abdominal endurance. Models were adjusted for sexual maturation. A significance level of 5% was adopted.

RESULTS

A total of 2172 adolescents participated in the study; however, 399 were excluded from the analysis for not presenting information on abdominal endurance testing (n = 374), sedentary behavior (n = 16), and physical activity (n = 2) or for being older than 19 years (n = 7). Therefore, the final sample consisted of 1773 adolescents.

Differences between sexes were found in all variables, with boys having higher age, body mass, height, daily physical activity, and abdominal endurance. On the other hand, girls showed higher triceps and subscapular skinfold thicknesses, sum of skinfold thicknesses, and daily sitting time.

Table 1. General characteristics of adolescents according to gender. Florianópolis, SC.

	Male	Female	p
N	795	978	0,001
Stature (m ± SD)	1,76 (0,07)	1,64 (0,07)	<0,001
Body Mass (kg ± SD)	65,76 (12,43)	56,38 (11,01)	<0,001
TRSK (mm ± SD)	10,67 (5,80)	17,19 (6,22)	<0,001
SESK (mm ± SD)	10,77 (6,52)	14,50 (6,61)	<0,001
∑2DC (mm ± SD)	21,44 (11,53)	31,69 (12,01)	<0,001
Physical activity (min/day ± SD)	94,85 (118,60)	64,41 (84,30)	<0,001
Sitting time (min/day ± SD)	376,12 (196,79)	414,89 (184,34)	<0,001
Abdominal (rep ± SD)	23,67 (3,63)	21,31 (5,90)	<0,001

m: meters; mm: milimeters kg: kilograms; TRSK: triceps skinfold; SESK: subscapular skinfold; ∑2DC: sum of two skinfolds (triceps + subscapular); min/day: minutes for day; rep: repetitions; SD: Standard Deviation.

In boys, the variable that best explained abdominal endurance was body adiposity. In girls, two models were generated, the first composed of body adiposity only and the second composed of body adiposity and physical activity. Whereas adiposity was negatively associated with abdominal endurance, physical activity was positively associated with the variable.

Table 2. Factors associated with abdominal resistance in adolescents.

	B ± SE	(B 95%CI)	β
Male[a]			
Model 1			
Constant	21,733 ± 0,696	20,367 – 23,098	
∑2DC	-0,083 ± 0,009	-0,102 – -0,065	-0,207
Female[b]			
Model 1			
Constant	20,369 ± 1,022	18,364 – 22,375	
∑2DC	-0,065 ± 0,016	-0,096 – -0,033	-0,130
Model 2			
Constant	20,015 ± 1,024	18,005– 22,024	
∑2DC	-0,063 ± 0,016	-0,094 – -0,032	-0,127
Physical activity	0,001 ± 0,000	0,000 – 0,002	0,099

[a] R^2= 0,028 for model 1.
[b] R^2= 0,028 for model 1; R^2= 0,038 for model 2
∑2DC: sum of two skinfolds (triceps + subscapular); B: Unstandardized coefficients; SE: Standard Error; β: Standardizes Coefficients.
Models adjusted for sexual maturation.

When analyzing the interrelation between the independent variables (data not shown), in boys, negative correlations were observed between the level of physical activity and body adiposity (rho= -0.102; p: <0.001) and with sitting time (rho= -0.184; p: <0.001). In girls, negative correlations were observed between physical activity level and sitting time (rho= -0.173; p: <0.001) and positive correlations between body adiposity and sitting time (rho= 0.067; p: <0.005).

DISCUSSION

This study investigated the association of abdominal endurance with body adiposity, physical activity, and sitting time in adolescents. It was found that, in both sexes, low body adiposity levels were predictive of high abdominal endurance, and, in girls, higher levels of physical activity predicted higher abdominal endurance.

Negative associations were observed between abdominal endurance and body adiposity. These data corroborate the results of Thivel et al. (2016), who found that children and adolescents with obesity performed worse in physical tests of muscular endurance, assessed through abdominal exercises, push-ups, and planks. However, the findings of a meta-analysis showed a moderate inverse association between muscular fitness and anthropometric parameters, with adolescents with worse muscular performance being more likely to have high levels of body adiposity when older (García-Hermoso et al., 2019). The authors highlighted that this inverse association is due to physiological aspects, such as the contribution of muscle mass to daily energy expenditure, as well as psycho-behavioral aspects, such as engagement in and satisfaction with physical activity (García-Hermoso et al., 2019).

Another factor to take into consideration regarding the association between these variables is the attenuating effect of obesity on muscle contraction capacity (Tallis et al., 2018). It is assumed that a greater concentration of adipose tissue in the trunk region may result in greater resistance to gravity and difficulty in performing movements, especially if abdominal muscles are not sufficiently strengthened. Joensuu et al. (2018), in a study with children and adolescents (9 to 15 years old), found that a 5 kg increase in fat mass was related to a reduction in the number of abdominal repetitions by 4 and 6 in boys and girls, respectively.

In girls, a positive association was found between physical activity practice and abdominal endurance, partially corroborating the results of a systematic review (Smith et al., 2019), in which associations between muscular endurance and physical activity were observed, especially at vigorous intensity. A similar result was observed in a study of the time trend of abdominal endurance in that performance was strongly related to vigorous physical activity in European countries (Kaster et al., 2020). Here, the fact that this association was found only in girls may be attributed to differences in behavioral factors related to regular physical activity. The overall prevalence of physical inactivity is higher in girls (84.7%) than in boys (77.6%) (Guthold et al., 2020). Furthermore, boys are more likely to meet the guidelines for muscle-strengthening activities than girls (Smith et al., 2020). Thus, boys more frequently partake in active behavior than girls, which may result in a more obvious impact on muscular endurance in girls engaging in routine physical activity.

Sedentary behavior had no association with muscular endurance, regardless of sex. This result is in agreement with literature data. A systematic review found no consistent associations between muscular endurance and sedentary behavior (Smith et al., 2019). It is worth noting that this is also the case for muscular strength and power tests (Smith et al., 2019). Thus, the extent to which high levels of sedentary behavior can negatively influence muscular aspects remains unknown. Recent evidence demonstrated an increase in sedentary behavior in pediatric populations after the coronavirus disease 2019 (COVID-19) pandemic compared with pre-pandemic levels (Kharel et al., 2022; Trott et al., 2022) and reductions in time spent on physical activity (Kharel et al., 2022), evidencing the need for studies seeking to identify how such behavioral changes may influence muscular endurance outcomes.

In addition to the associations observed with abdominal resistance, it is worth highlighting the interrelationships between the level of physical activity, sedentary behavior and body adiposity. Regarding body adiposity, it is noted that the improvement of physical activity levels and the reduction of sedentary behavior contribute to the control and/or reduction of adiposity in children and adolescents, in view of the greater caloric expenditure and less idle time (Kracht et al., 2023; Lister et al., 2023; García-Hermoso et al., 2023). When analyzing physical activity and sedentary behavior, weak negative associations are noted in youth, believing that such behaviors do not directly replace each other (Pearson et al., 2014). However, such associations become weak to moderate during adult life (Mansoubi et al., 2014), probably occurring due to the fact that the time in physical activity decreases and that of sedentary behavior increases with advancing age (Hayes et al., 2019; Vanhelst et al., 2023). Nevertheless, high levels of physical activity have shown to eliminate the increased risk of death provided by the time spent sitting. (Ekelund et al., 2019).

A limitation of the present study is the use of a self-report questionnaire to assess physical activity, given the risk of sampling bias. However, the questionnaire was validated for the current target audience and is widely used in epidemiological research because of its low cost and ease of application. Furthermore, the results of the present study cannot be extrapolated to all adolescents in the country, as Brazil has a vast territory, encompassing different cultures. The results also cannot be extrapolated to populations of students from private schools, as the study participants were from public schools. As strengths, we can mention the representativeness of the data on adolescents from the capital of Santa Catarina, Brazil. The results may contribute to the understanding of how body adiposity, physical activity, and sedentary behavior may influence muscular endurance, which is a marker of good health.

CONCLUSIONS

It can be concluded that boys and girls with high body adiposity have lower abdominal endurance. Girls with higher levels of physical activity have higher abdominal endurance. This makes it necessary to develop actions aimed at making adolescents and their families aware of behavioral aspects related to nutritional education and the practice of physical activity. As well as the expansion and improvement of public spaces intended for the practice of physical activity, in addition to initiatives that provide physical education professionals who can guide adolescents regarding the physical practices developed. So that from this it is possible to improve abdominal endurance by improving levels of physical activity and control and/or reduction of body adiposity in adolescents.

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