2023, Retos, 49, 1-8

Association between health-related physical fitness, extracurricular physical activities and body adiposity in with a representative sample adolescents from Florianópolis, Brazil
Asociación entre aptitud física relacionada con la salud, actividades físicas extraescolares y adiposidad corporal en una muestra representativa de adolescentes de Florianópolis, Brasil

*Jean Carlos Parmigiani De Marco, **Agnes Day Alves, *Isadora Gonzaga, *Mateus Augusto Bim, *Lorival José Carminatti, ***André de Araújo Pinto, *Thais Silva Beltrame, *Andreia Pelegrini
*State University of Santa Catarina (Brazil), **University of São Paulo (Brazil), ***State University of Roraima (Brazil)

Abstract. Objective: To identify associations between physical fitness, extracurricular physical activity, and body adiposity in a representative sample of adolescents from Florianópolis, Brazil. Methods: This cross-sectional, school-based study included 981 adolescents aged 14–18 years attending public schools in Florianópolis, Brazil. The dependent variable was body adiposity, calculated from the sum of triceps and subscapular skinfold thicknesses. Participation in extracurricular physical activity and health-related physical fitness components (flexibility, muscle strength and endurance, cardiorespiratory fitness) were independent variables. Results: The prevalence of high body adiposity was 27.1%, not differing between sexes (boys = 25,0%, girls = 29.4%). There was a negative association between body adiposity, cardiorespiratory fitness, and abdominal endurance in both sexes. The final model explained 58.2% of the variation in body adiposity scores in girls and 47.9% in boys. Negative associations of body adiposity with cardiorespiratory fitness (girls: $\beta = -0.752$, $p < 0.001$; boys: $\beta = -0.655$, $p < 0.001$) and abdominal endurance (girls: $\beta = -0.070$, $p = 0.021$; boys: $\beta = -0.077$, $p = 0.021$) were found in both sexes. Negative associations of body adiposity with extracurricular physical activity were observed in girls ($\beta = -0.078$, $p = 0.010$) and with grip strength ($\beta = -0.121$, $p < 0.001$) and flexibility ($\beta = -0.082$, $p = 0.015$) in boys. Conclusion: Regardless of sex, adolescent groups with low cardiorespiratory fitness and abdominal endurance were the most affected by high body adiposity. Furthermore, lower participation in extracurricular physical activity in girls and lower strength and flexibility in boys were associated with higher body adiposity.
Keywords: Adolescent. Body composition. Extracurricular physical activity. Kinanthropometry.

Resumen. Objetivo: Identificar las asociaciones entre aptitud física, actividad física extraescolar y adiposidad corporal en una muestra representativa de adolescentes de Florianópolis, Brasil. Método: estudio transversal, de base escolar, que incluyó a 981 adolescentes de 14 a 18 años, matriculados en escuelas públicas de la ciudad de Florianópolis-SC. La variable dependiente fue la adiposidad corporal, obtenida por la suma de dos pliegues cutáneos (tríceps + subescapular). Se consideraron variables independientes la participación en actividad física extraescolar y los componentes de aptitud física relacionados con la salud (flexibilidad, fuerza y resistencia muscular, aptitud cardiorrespiratoria). Resultados: La prevalencia de adiposidad corporal alta fue de 27,1%, sin diferencia entre sexos (niños= 25%, niñas= 29,4%). Hubo una asociación negativa entre la adiposidad corporal, la aptitud cardiorrespiratoria y la resistencia abdominal en ambos sexos. El modelo final explicó el 58,2% de la variación en los puntajes altos de adiposidad corporal en las niñas y el 47,9% en los niños. En ambos sexos se encontraron asociaciones negativas entre la aptitud cardiorrespiratoria (niñas: $\beta = -0.752$, p= <0.001; niños: $\beta = -0.655$, p< 0.001) y la resistencia abdominal (niñas: $\beta = -0.070$, p= 0.021; niños: $\beta = -0.077$, p= 0.021) con adiposidad corporal. Además, en las niñas se observaron asociaciones negativas entre la actividad física extraescolar ($\beta = -0,078$, p= 0,010), y en los niños la fuerza de prensión ($\beta = -0,121$, p< 0,001) y la flexibilidad ($\beta = -0,082$, p =0.015) con adiposidad corporal. Conclusión: En ambos sexos, los niveles más altos de aptitud cardiorrespiratoria y resistencia abdominal se asociaron con la adiposidad de la parte inferior del cuerpo. En las chicas la actividad extraescolar y en los chicos la fuerza y flexibilidad muscular se asociaron negativamente con la adiposidad corporal.
Palabras clave: Adolescente. Composición corporal. Actividad física extraescolar. Cineantropometría.

Fecha recepción: 17-11-22. Fecha de aceptación: 28-03-23
Andreia Pelegrini
andreia.pelegrini@udesc.br

Introduction

Obesity is a multifactorial chronic metabolic disorder characterized by excess body fat (Piqueras et al., 2021; WHO, 2022; Pinhas-Hamiel et al., 2022), predisposing the individual to chronic non-communicable diseases (WHO, 2022; Okunogbe et al., 2021). As one of the most common metabolic disorders worldwide, obesity represents a public health challenge with substantial economic impacts and increasing prevalence rates (Piqueras et al., 2021; WHO, 2022; Pinhas-Hamiel et al., 2022; Okunogbe et al., 2021).

Studies of pediatric populations observed a high prevalence of obesity in several countries (WHO, 2022; Pinhas-Hamiel et al., 2022), including Brazil, where prevalence rates ranging from 3.8% to 24% (Pelegrini et al., 2021) and from 2.2% to 44.4%, (Sbaraini et al., 2021) have been reported. These statistics are a cause for concern, given that obese children and adolescents are five times more likely to be obese in adulthood (Simmonds et al., 2016), which may generate outcomes such as diabetes, cancers, cardiometabolic and psychosocial comorbidities, as well as early mortality in midlife (Horesh et al., 2021; Jebeile et al., 2022).

Specifically in adolescents, obesity has been associated with low physical fitness, affecting mainly health-related physical components (Chen et al., 2022). In general, adolescents with obesity have lower performance in muscle strength and endurance, cardiorespiratory fitness (CRF) (Johansson et al., 2020; Brand et al., 2020; Dong et al., 2019), and flexibility tests (Chen et al., 2022; Thompson et al., 2021).

Research also demonstrates inverse associations and correlations of muscle strength and endurance (García-Hermoso et al., 2019; Palma, Parrací & Saa, 2022), as well as of changes in cardiorespiratory fitness levels in adolescence (García-Hermoso et al., 2020), with body adiposity in adulthood (García-Hermoso, 2019). Hence the recommendations for controlling obesity in adolescents through modifiable risk factors, such as by reducing physical inactivity (WHO, 2020; Zouhal et al., 2020; Mateo-Orcajada et al., 2022).

The levels of physical activity recommended for this age group can be achieved by participation in extracurricular sports and physical activity programs, which, according to data from several countries, have a positive association with physical activity level (Lee et al., 2018; Kokko et al., 2019; Miranda et al., 2020). Sports practice can promote improvements in body fat percentage (Oliveira et al., 2017).

Given the high and increasing levels of obesity in adolescents (Stierman et al., 2021; WHO, 2022; Pinhas-Hamiel et al., 2022; Kim & Kim, 2022), its negative effects on health (Horesh et al., 2021; Jebeile et al., 2022) and physical fitness (García-Hermoso et al., 2019; García-Hermoso et al., 2020), and the economic impacts of comorbidities associated with excess body weight (Okunogbe et al., 2021), it is necessary to deepen our knowledge about associations of body adiposity with health-related physical fitness components and practice of extracurricular physical activity (EPA). Therefore, this study aimed to investigate associations between health-related physical fitness, extracurricular physical activity, and body adiposity in a representative sample of adolescents from Florianópolis, Brazil.

Materials and methods

This is an epidemiological, cross-sectional, school-based study conducted as part of a larger research project entitled "Levels of physical activity, physical fitness, and health-related social behavior in adolescents: A study of secular trends," approved by the Human Research Ethics Committee at the Santa Catarina State University (UDESC, protocol No. 2,172,699). Adolescents of both sexes, aged 14 to 18 years, regularly enrolled in state public schools in Florianópolis, Santa Catarina State, Brazil, in 2017 were considered eligible for the study.

According to information provided by the State Secretariat of Education of Santa Catarina, there were 11,798 adolescents regularly enrolled in state public schools in Florianópolis in 2017. The sample size was calculated using the equation of Luiz & Magnanini (2000), with a confidence level of 1.96, tolerable error of 4%, and estimated prevalence of 50%. An additional 10% was added to the minimum sample size to account for losses during the data collection process. These parameters resulted in an a priori sample size of 943 schoolchildren. Because of the cluster sampling procedure adopted, the initial sample comprised 1,026 adolescents aged 14 to 18 years attending public high schools. For the study, schools with the highest number of high school students in each of the five regions of Florianópolis (Center, East, North, South, and Mainland) were selected.

Body adiposity was assessed by measuring triceps and subscapular skinfold thicknesses, according to the Canadian Society for Exercise Physiology (CSEP, 2004). Measurements were taken by using a scientific skinfold caliper (Cescorf, 0.1 mm resolution). Two measurements were collected non-consecutively from each site, and mean values were calculated. If the difference between measurements was greater than 5%, a third measurement was taken and the median value was used. The sum of the final values of each skinfold parameter was used to determine body adiposity, which was classified according to the cutoffs of the American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD, 1988). The AAHPERD protocol classifies body adiposity as low, normal, and high; however, in the current study, the results were dichotomized into normal (low and normal) and high.

Adolescents answered questions regarding sex (male and female) and age (complete years). Muscular endurance was assessed using an abdominal endurance test (ABD). Subjects were asked to lie in a supine position on a mat with their knees bent at 90°, their feet in contact with the floor, their arms at their sides, and their fingers stretched out toward the heels. The rhythm was set at 50 beats per minute using a metronome. The first beat referred to a rising movement and the next beat to the return to the initial position, repeated until the end of the test, for a maximum of one min. The test was interrupted if the subject felt uncomfortable, failed to maintain the cadence set by the metronome, or did not perform the technique correctly in more than two consecutive repetitions (CSEP, 2004).

Muscle strength was measured by a handgrip strength (HGS) test using a digital dynamometer (Jamar®, 0.1 kg resolution). The opening was adjusted so that the second joint of each finger fit the dynamometer handle (CSEP, 2004). Subjects were instructed to hold the dynamometer in line with the forearm at thigh level and slightly away from the body during the test, without touching the legs or any other object. Both hands were tested alternately, with two attempts for each hand. The highest measurements of each hand were summed to determine the total handgrip strength.

Flexibility was assessed by the sit-and-reach test, according to the modified protocol of Wells & Dillon (CSEP, 2004). A wooden bench with a scale ranging from 0 to 82 cm was used. Subjects placed the soles of their bare feet in contact with the bench at the 26 cm mark with the knees extended. The test consisted of sliding a cursor with the fingertips, reaching the maximum possible distance while remaining in contact with the cursor without forcing, maintaining the position for at least 2 s (CSEP, 2004). Subjects were allowed to perform the test twice. Attempts with flexed knees were disregarded. Results refer to the best performance in valid attempts.

2023, Retos, 49, 1-8

Cardiorespiratory fitness was measured by the bench test using the ergometer suggested by the modified Canadian Aerobic Fitness Test (mCAFT) (CSEP, 2004). The bench contains two steps, the first at a height of 18.4 cm and the second at a height of 20.3 cm. Prior to the test, the maximum heart rate (HR_{max}) of subjects was calculated using the equation $HR_{max} = 220 - Age$ (Karvonen et al., 1957). Heart rate was measured at eight stages by using a heart rate monitor (Polar). Each stage lasted 3 min and was followed by a 20 s interval. Subjects initiated the test with both feet on the ground in front of the bench, stepping on the first step and passing to the second step with both feet on the upper surface of the bench, and then returning to the starting position. For boys, the last two stages (7 and 8) are performed on the side of the bench which contains only one step (greater height). For girls, only the last stage (8) is performed in this manner, at a lower pace than the previous stage. Cadence was set by a song made available by CSEP (2004), which determines the moments of stepping on and off from the bench, with the speed increasing at each stage. If the subject failed to maintain the rhythm, reported pain or discomfort, or the heart rate exceeded 85% of HR_{max}, the test was interrupted. For male adolescents aged 15 to 19 years, the test started at stage 4, whereas, for female adolescents, the test started at stage 3 (CSEP, 2004). Oxygen consumption data for each test stage were used to calculate the maximal oxygen consumption (VO_2 max, mL kg^{-1} min^{-1}) using the equation developed by Weller et al. (1993) for mCAFT.

Extracurricular physical activity was assessed through the question, "Do you practice extracurricular physical activities/sports (other than physical education class)?" Response options were "yes" and "no." Habitual physical activity was estimated using the short version International Physical Activity Questionnaire (IPAQ) validated for Brazilian adolescents (Guedes et al., 2005). Information regarding practice of physical activity on the previous 7 days was collected and converted to daily minutes of moderate/vigorous intensity physical activity for analysis purposes.

Sexual maturation was staged based on pubic hair development, using figures adapted from Tanner (1962) by Adami & Vasconcelos (2008). The instrument consists of five figures depicting different stages of sexual maturation. After analyzing the figures, adolescents were asked to indicate the one that best corresponded to their current stage of development.

Statistical analyses were performed using IBM SPSS Statistics version 20.0. A 5% level of significance was adopted in all analyses. Mean, median, standard deviation, interquartile range, and frequency distribution (absolute and relative) were estimated for characterization of study participants. The normality of the data was assessed using the Kolmogorov–Smirnov test. Independent *t* or Mann–Whitney *U*-tests were used to investigate differences between sexes. Multiple linear regression analyses were conducted using the stepwise method to assess associations of body adiposity (dependent variable) with independent variables. Multiple linear regression models were adjusted for sexual maturation.

Results

The initial sample consisted of 1,026 adolescents. Of these, 34 were excluded because they were older than 18 years, seven did not have cardiorespiratory fitness data, three did not provide information about participation in extracurricular physical activity, and one did not complete the abdominal endurance test. Thus, the final sample comprised 981 adolescents.

Boys had higher means ($p < 0.05$) in most of the investigated variables, with the exception of sum of skinfolds and flexibility, which were higher in girls ($p < 0.05$). Whereas 57.2% of girls did not engage in extracurricular physical activity, most of the boys engaged in this practice (69.0%). The highest prevalence of sexual maturation was stage 4 (44.7%) in girls and stage 5 (57.1%) in boys (Table 1).

Table 1.
General characteristics of adolescents of both sexes. Florianópolis, SC (2017/18)

Variables	Female (n= 477)		Male (n= 504)		p-value
	$\bar{x}$ (SD)	Median (IR)	$\bar{x}$ (SD)	Median (IR)	
Age (years)	16,34 (0,96)	16,00 (16,00-17,00)	16,51 (1,01)	17,00 (16,00-17,00)	0,007†
Σ2SF (mm)	31,91 (12,64)	28,60 (22,83-37,93)	21,83 (11,76)	17,60 (14,50-24,93)	< 0,001†
MVPA (min/week)	344,04 (551,79)	180,00 (0,00-420,00)	599,67 (733,82)	360,00 (120,00-798,75)	< 0,001†
Flexibility (cm)	24,62 (9,33)	24,55 (18,35-31,53)	22,98 (8,82)	23,00 (16,45-28,99)	0,005*
ABD (rep)	20,32 (7,06)	25,00 (17,00-25,00)	23,62 (3,85)	25,00 (25,00-25,00)	< 0,001†
HGS (kg)	51,68 (11,10)	51,20 (43,90-57,95)	79,89 (17,01)	78,85 (68,25-90,45)	< 0,001*
CRF (VO2máx)	39,71 (3,40)	39,87 (37,77-41,54)	49,75 (4,63)	49,79 (46,87-52,85)	< 0,001†
	n (%)		n (%)		p-value
EPA					<0,001
Yes	204 (42,8)		348 (69,0)		
No	273 (57,2)		156 (31,0)		
Sexual maturation					<0,001
Stage 1	9 (1,9)		2 (0,4)		
Stage 2	19 (4,0)		4 (0,8)		
Stage 3	79 (16,6)		32 (6,3)		
Stage 4	213 (44,7)		178 (35,3)		
Stage 5	157 (32,9)		288 (57,1)		

$\bar{x}$: mean; SD: standard deviation; IR: interquartile range; mm: millimeter; min: minutes; cm: centimeters; rep: repetitions; kg: kilograms; Σ2SF: sum of two skinfolds (triceps+subscapularis); MVPA: moderate and vigorous physical activity, ABD: abdominal endurance; HGS: Hand Grip strength; CRF: cardiorespiratory fitness; EPA: extracurricular physical activity.
* Independent t test.
† Mann–Whitney U-test.

It was observed that 27.1% of adolescents had high body adiposity, with no difference between sexes (p = 0.132) (Figure 1).

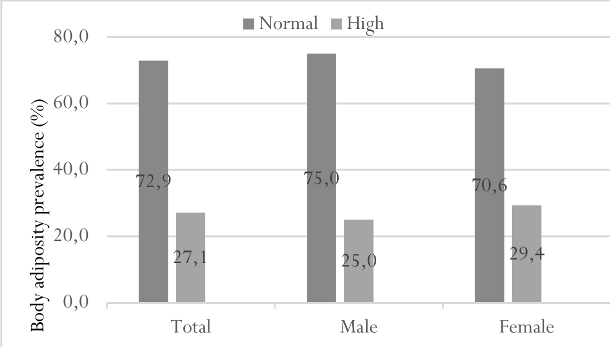

Figure 1. Body adiposity in adolescents of the total sample and stratified by sexes. Florianópolis, SC (2017/18).

For girls (Table 2), three explanatory models for body adiposity were proposed. The first model contained cardiorespiratory fitness, which explained 57.2% (β = -0.758, p < 0.001) of the variation in body adiposity. The second model included participation in extracurricular physical activity, which, together with cardiorespiratory fitness, explained 57.7% of the variation in body adiposity. The third model contained abdominal endurance, cardiorespiratory fitness, and extracurricular activity, explaining 58.2% of the variation in body adiposity. In the third model, cardiorespiratory fitness (β = -0.752, p < 0.001), participation in extracurricular physical activity (β = -0.078, p = 0.010), and abdominal endurance (β = -0.070, p = 0.021) were negatively associated with body adiposity, revealing that the lower the levels of cardiorespiratory fitness, abdominal endurance, and participation in extracurricular physical activity, the higher the body adiposity.

Table 2.
Association between body adiposity and independent variables in female adolescents. Florianópolis, SC (2017/18)

	B ± SE	($B_{95\%CI}$)	β	R²
Model 1				0,572
Constant	145,408 ± 4,887	135,806; 155,010		
CRF	-2,817 ± 0,112	-3,037; -2,597	-0,758*	
Model 2				0,577
Constant	146,347 ± 4,879	136,761; 155,934		
CRF	-2,819 ± 0,111	-3,038; -2,600	-0,758*	
EPA	-1,817 ± 0,764	-3,318; -0,316	-0,071**	
Model 3				0,582
Constant	147,663 ± 4,889	138,055; 157,270		
CRF	-2,795 ± 0,111	-3,014; -2,576	-0,752*	
EPA	-1,988 ± 0,764	-3,489; -0,486	-0,078**	
ABD	-0,125 ± 0,054	-0,019; -0,129	-0,070**	

Dependent variable: Body adiposity. CRF: cardiorespiratory fitness; EPA: extracurricular physical activity; ABD: abdominal endurance.
Analysis adjusted for sexual maturation.
* p< 0,001.
** p< 0,05.

For boys (Table 3), four explanatory models of body adiposity were constructed. In the first model, cardiorespiratory fitness (β = -0.664, p < 0.001) explained 44.5% of the variation in body adiposity. Grip strength was included in the second model, which together with cardiorespiratory fitness, explained 46.6% of the variation in body adiposity. The third model contained cardiorespiratory fitness, grip strength, and flexibility, explaining 47.4% of the variation in body adiposity. Finally, abdominal endurance was included in the fourth model (β = -0.077, p = 0.021), which together with cardiorespiratory fitness (β = -0.655, p < 0.001), grip strength (β = -0.121, p < 0.001), and flexibility (β = -0.082, p = 0.015), explained 47.9% of the variation in body adiposity. These findings indicate that, the lower the physical indicators, the higher the body adiposity.

Table 3
Association between body adiposity and independent variables in male adolescents. Florianópolis, SC (2017/18)

	B ± SE	($B_{95\%CI}$)	β	R²
Model 1				0,445
Constant	102,979 ± 5,109	92,941; 113,018		
CRF	-1,686 ± 0,085	-1,852; -1,519	-0,664*	
Model 2				0,466
Constant	111,821 ± 5,396	101,218; 122,423		
CRF	-1,725 ± 0,084	-1,889; -1,560	-0,679*	
HGS	-0,102 ± 0,023	-0,147; -0,057	-0,147*	
Model 3				0,474
Constant	112,290 ± 5,367	101,745; 122,834		
CRF	-1,700 ± 0,084	-1,865; -1,536	-0,669*	
HGS	-0,087 ± 0,023	-0,133; -0,041	-0,126*	
Flexibility	-0,119 ± 0,045	-0,207; -0,031	-0,089**	
Model 4				
Constant	115,633 ± 5,535	104,757; 126,508		0,479
CRF	-1,665 ± 0,085	-1,831; -1,498	-0,655*	
HGS	-0,084 ± 0,023	-0,130; -0,038	-0,121*	
Flexibility	-0,109 ± 0,045	-0,197; -0,022	-0,082**	
ABD	-0,235 ± 0,101	-0,434; -0,035	-0,077**	

Dependent variable: Body adiposity. CRF: cardiorespiratory fitness; HGS: hand grip strength; ABD abdominal endurance.
Analysis adjusted for sexual maturation.
* p< 0,001.
** p< 0,05.

Discussion

This study aimed to examine the associations of body adiposity with health-related physical fitness, and participation in extracurricular physical activity among adolescents. It was observed that 27.1% of adolescents had high body adiposity, with no difference between sexes (boys = 25,0% and girls = 29.4%). Our findings show that cardiorespiratory fitness was the variable that best explained the variation in body adiposity in both sexes (57.2% in girls and 44.5% in boys). Furthermore, in girls, participation in extracurricular physical activities and abdominal endurance also explain body adiposity. In boys, the explanatory variables were HGS, flexibility and abdominal endurance.

About one in four adolescents had high body adiposity. Such a prevalence is similar to that observed in study developed in a city of Espírito Santo, Brazil, where 27.4% of boys and 29.1% of girls had an inadequate fat percentage (Oliosa et al., 2019). Because of the comorbidities caused by the obesity epidemic (Piqueras et al., 2021), several studies have sought to monitor the prevalence of adiposity in children and adolescents over time. There has been an increase in prevalence in pediatric populations with advancing years (Sbaraini et al., 2021; Pinhas-Hamiel et al., 2022; Kim & Kim, 2022). Children who are overweight and obese are more likely to remain so in adolescence (Simmonds et al., 2016; Znovar et al., 2022), and 80% of obese adolescents tend to remain obese as adults (Simmonds et al., 2016). Such evidence points to the need for multidisciplinary strategies aimed at controlling high levels of adiposity to improve the health of the population (Aceves-Martins et al., 2022) and reduce the economic impacts of obesity treatment (Okunogbe et al., 2021).

Cardiorespiratory fitness was the main variable explaining the variation in body adiposity in both sexes. The worse the cardiorespiratory fitness, the higher the body adiposity. Similar results were observed in Spanish adolescents aged 13 to 17 years: lower cardiorespiratory fitness levels were associated with higher percentage of fat, as determined by bioelectrical impedance analysis (Garcia-Pastor et al., 2016). High cardiorespiratory fitness levels in childhood and adolescence are associated with lower body adiposity in adulthood (García-Hermoso et al., 2020). Furthermore, for each unit increase in VO_2 max, there is an 8%, 15%, and 27% decrease in three, four, and five or more anthropometric indicators of excess body fat, respectively (Gonçalves et al., 2018).

Although several studies found an association between cardiorespiratory fitness and body adiposity (Johansson et al., 2020; Brand et al., 2020; Dong et al., 2019), it is not possible to determine whether cardiorespiratory fitness is negatively affected by low levels of physical activity in adolescents with high body fat or if the opposite is true (Dong et al., 2019). However, Dobrowolska et al. (2022) described a positive correlation between fat-free mass and lung capacity, demonstrating that the higher the lung capacity, the higher the fat-free mass. The authors observed an inverse correlation between fat mass and lung capacity, that is, the higher the fat mass, the lower the lung capacity (Dobrowolska et al., 2022), which reveals the importance of body composition for cardiorespiratory fitness.

Ventilatory response to exercise progressively decreases as obesity (BMI) increases, as observed among adults who sought surgical centers for weight loss (Balmain et al., 2021). Therefore, it is suggested that the same can occur in adolescents with high adiposity levels. Respiratory gas exchange was found to be reduced during maximal exertion in obese adolescents (Marinus et al., 2017), a factor that may hinder cardiorespiratory fitness. Other factors that should be considered are the changes in running mechanics (Bowser & Roles, 2021) and the need for greater propulsion during running (Gonçalves et al., 2015) in overweight and obese children, resulting in overload and affecting cardiorespiratory fitness, given the greater difficulties in movement.

Abdominal muscle endurance was negatively associated with body adiposity in both sexes, corroborating the findings of Garcia-Pastor et al. (2016), who reported that adolescents with a higher proportion of body fat had lower muscle endurance. Similarly, negative associations between muscle strength and body adiposity were observed, in that boys and girls with higher body adiposity and waist circumference were more likely to have low muscle strength (Palacio-Agüero et al., 2020). It should be noted that, as for cardiorespiratory fitness, there is a prospective association between muscle fitness in adolescence and body adiposity in adulthood (García-Hermoso et al., 2019). The negative association between muscle fitness and body adiposity can be explained by the fact that excess fat causes several physiological changes that negatively affect muscle contractile function and ultimately reduce muscle performance (Talis et al., 2018).

Flexibility was also inversely associated with body adiposity in boys. These results corroborate studies carried out with adolescents aged 10 to 19 years in New York (Thompson et al., 2021) and with children and adolescents in China (Chen et al., 2022). Chen et al. (2022) identified that flexibility was least affected by high adiposity, highlighting that, during the test, individuals do not need to overcome resistance imposed by excess weight. Nevertheless, Thompson et al. (2021) theorized about the greater difficulty of adolescents with high body adiposity to lean forward during the test compared with adolescents with lower adiposity. Given the above, the real cause and effect of high body adiposity on flexibility in adolescents remains unknown, since the level of flexibility can also be attributed to the specificity of the daily activities of those evaluated. It is necessary to carry out more studies to understand how flexibility is influenced by high body adiposity.

In girls, there was an inverse association between body adiposity and participation in extracurricular physical activities, demonstrating the need for greater engagement in physical activity, as physical activity is a determinant of overweight and obesity (Dong et al., 2019). Practice of physical activity is essential in interventions aimed at controlling or reducing body adiposity in adolescents (Aceves-Martins et al., 2022), and adoption of regular physical exercise in youth, in addition to promoting improvements in body adiposity, contributes to healthy aging (Zouhal et al., 2020).

In general, the literature has shown that physically active adolescents have better body composition and higher cardiorespiratory fitness, flexibility, muscle strength, and endurance compared with insufficiently active peers (Mateo-Orcajada et al., 2022). Such evidence can be attributed to a possible dose–response association between regular physical activity and improvement in physical fitness. Physical activity promotes metabolic adaptations that cause greater energy expenditure, lipid oxidation, and, consequently, reduction in body fat (García-Hermoso et al., 2020; García-Hermoso et al., 2019). Nevertheless, it was not possible to confirm reverse causality among the investigated variables because of the cross-sectional nature of the present study. Therefore, it is recommended that physical activity not be limited to physical education classes, so that adolescents may reap the benefits promoted by regular practice. For this, adolescents may engage in sports (Kokko et al., 2019; Lee et al., 2018; Oliveira et al., 2017) or combined practice of resistance and aerobic exercises (WHO, 2020), as both can contribute to reducing body adiposity and promoting improvements in health-related physical fitness.

Some limitations of this study must be considered, such as the lack of objective data obtained with accelerometry to quantify the practice of physical activity performed by adolescents, and based on this, identify the frequency, duration and intensity of these activities. Another factor to be taken into account is the self-assessment of sexual maturation, which increases the risk of bias due to the difficulty that adolescents may have in identifying their maturational state. Furthermore, the results of the prevalence of body adiposity did not take into account the maturational state of adolescents, a factor that influences body composition during the development process. However, the representative number of adolescents from Florianópolis is a strength of this study. Students from all regions of the municipality were included in the sample.

Conclusion

Cardiorespiratory fitness and abdominal endurance were inversely associated with body adiposity in both sexes. Extracurricular activity (in girls) and muscle strength and flexibility (in boys) were negatively associated with body adiposity. These findings indicate the need for actions that promote regular physical activity, such as by providing appropriate places for sports and school interventions aimed at improving physical fitness and controlling body adiposity.

Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES) - Finance Code 001. And by the Santa Catarina State Foundation for Research and Innovation (FAPESC, grant number 2021tr950).

References

AAHPERD. (1988). *Physical Best*. Reston, VA: American Alliance for Health, Physical Education, Recreation and Dance.

Aceves-Martins, M., López-Cruz, L., García-Botello, M., Gutierrez-Gómez, Y. Y., & Moreno-García, C. F. (2022). Interventions to treat obesity in Mexican children and adolescents: systematic review and meta-analysis. *Nutrition reviews*, *80*(3), 544-560. https://doi.org/10.1093/nutrit/nuab041

Adami, F., & Vasconcelos, F. D. A. G. D. (2008). Obesidade e maturação sexual precoce em escolares de Florianópolis-SC. *Revista Brasileira de Epidemiologia*, *11*(4), 549-560. https://doi.org/10.1590/S1415-790X2008000400004

Balmain, B. N., Halverson, Q. M., Tomlinson, A. R., Edwards, T., Ganio, M. S., & Babb, T. G. (2021). Obesity blunts the ventilatory response to exercise in men and women. *Annals of the American Thoracic Society*, *18*(7), 1167-1174. https://doi.org/10.1513/AnnalsATS.202006-746OC

Bowser, B. J., & Roles, K. (2021). Effects of Overweight and Obesity on Running Mechanics in Children. *Medicine and Science in Sports and Exercise*. https://doi.org/10.1249/mss.0000000000002686

Brand, C., Reuter, C. P., Gaya, A. R., Mota, J., Duncan, M., Borfe, L., & Pollo Renner, J. D. (2021). Association between cardiorespiratory fitness and cardiometabolic risk factors in Brazilian children and adolescents: the mediating role of obesity parameters. *Paediatrics and International Child Health*, *41*(2), 93-102. https://doi.org/10.1080/20469047.2020.1838758

Canadian Society for Exercise Physiology [CSEP]. The Canadian Physical Activity, Fitness and Lifestyle Appraisal, CSEP's guide to health active living. 3nd ed. Ottawa, CSEP, 2004.

Chen, G., Chen, J., Liu, J., Hu, Y., & Liu, Y. (2022). Relationship between body mass index and physical fitness of children and adolescents in Xinjiang, China: a cross-sectional study. *BMC Public Health*, *22*(1), 1-11. https://doi.org/10.1186/s12889-022-14089-6.

Dobrowolska, A., Domagalska-Szopa, M., Siwiec, A., & Szopa, A. (2022). Association between Cardiopulmonary Capacity and Body Mass Composition in Children and Adolescents with High Body Weight: A Cross-Sectional Study. *Children*, *9*(5), 647. https://doi.org/10.3390/children9050647

Dong, Y., Lau, P. W., Dong, B., Zou, Z., Yang, Y., Wen, B., ... & Patton, G. C. (2019). Trends in physical fitness, growth, and nutritional status of Chinese children and adolescents: a retrospective analysis of 1·5 million students from six successive national surveys between 1985 and 2014. *The Lancet Child & Adolescent Health*, *3*(12), 871-880. https://doi.org/10.1016/S2352-4642(19)30302-5

García-Hermoso, A., Ramírez-Vélez, R., García-Alonso, Y., Alonso-Martínez, A. M., & Izquierdo, M. (2020). Association of cardiorespiratory fitness levels during youth with health risk later in life: a systematic review and meta-analysis. *JAMA pediatrics*, *174*(10), 952-960. http://jamanetwork.com/article.aspx?doi=10.1001/jamapediatrics.2020.2400

García-Hermoso, A., Ramírez-Campillo, R., & Izquierdo, M. (2019). Is muscular fitness associated with future health benefits in children and adolescents? A systematic review and meta-analysis of longitudinal studies. *Sports Medicine*, *49*(7), 1079-1094. https://doi.org/10.1007/s40279-019-01098-6

García-Hermoso, A., Ramírez-Vélez, R., & Saavedra, J. M. (2019). Exercise, health outcomes, and pædiatric obesity: A systematic review of meta-analyses. *Journal of Science and Medicine in Sport*, *22*(1), 76-84.

https://doi.org/10.1016/j.jsams.2018.07.006

Garcia-Pastor, T., Salinero, J. J., Sanz-Frias, D., Pertusa, G., & Del Coso, J. (2016). Body fat percentage is more associated with low physical fitness than with sedentarism and diet in male and female adolescents. *Physiology & behavior*, *165*, 166-172. https://doi.org/10.1016/j.physbeh.2016.07.016

Gonçalves, E. C. D. A., Nunes, H. E. G., & Silva, D. A. S. (2018). Clusters of anthropometric indicators of body fat associated with maximum oxygen uptake in adolescents. *PloS one*, *13*(3), e0193965. https://doi.org/10.1371/journal.pone.0193965

Gonçalves, E. CA, Augusto Santos Silva, D., & Gimenes Nunes, H. E. (2015). Prevalence and factors associated with low aerobic performance levels in adolescents: A systematic review. *Current Pediatric Reviews*, *11*(1), 56-70. https://doi.org/10.2174/1573396311666150501003435

Guedes, D. P., Lopes, C. C., & Guedes, J. E. R. P. (2005). Reprodutibilidade e validade do Questionário Internacional de Atividade Física em adolescentes. *Revista brasileira de medicina do esporte*, *11*(2), 151-158. http://dx.doi.org/10.5123/S1679-49742013000100012

Horesh, A., Tsur, A. M., Bardugo, A., & Twig, G. (2021). Adolescent and Childhood Obesity and Excess Morbidity and Mortality in Young Adulthood—a Systematic Review. *Current obesity reports*, *10*(3), 301-310. https://doi.org/10.1007/s13679-021-00439-9

Jebeile, H., Kelly, A. S., O'Malley, G., & Baur, L. A. (2022). Obesity in children and adolescents: epidemiology, causes, assessment, and management. *The Lancet Diabetes & Endocrinology*. https://doi.org/10.1016/S2213-8587(22)00047-X

Johansson, L., Brissman, M., Morinder, G., Westerståhl, M., & Marcus, C. (2020). Reference values and secular trends for cardiorespiratory fitness in children and adolescents with obesity. *Acta Paediatrica*, *109*(8), 1665-1671. https://doi.org/10.1111/apa.15163

Karvonen, J. J., Kentala, E. & Mustala, O. (1957). The effects of training on heart rate: a "longitudinal" study. Ann Med Exp Biol Fenn. 35: 307-315.

Kim, H. Y., & Kim, J. H. (2022). Temporal trends in the prevalence of metabolically healthy overweight and obesity in Korean youth: Data from the Korea National Health and Nutrition Examination Survey 2011-2019. *Journal of Korean Society of Pediatric Endocrinology*. https://doi.org/10.6065/apem.2142192.096

Kokko, S., Martin, L., Geidne, S., Van Hoye, A., Lane, A., Meganck, J., Scheerder, J., Seghers, J., Villberg, J., Kudlacek, M., Badura, P., Mononen, K., Blomqvist, M., Clercq, B. & Koski, P. (2019). Does sports club participation contribute to physical activity among children and adolescents? A comparison across six European countries. *Scandinavian journal of public health*, *47*(8), 851-858. https://doi.org/10.1177/1403494818786110

Lee, J. E., Pope, Z., & Gao, Z. (2018). The role of youth sports in promoting children's physical activity and preventing pediatric obesity: a systematic review. *Behavioral Medicine*, *44*(1), 62-76. https://doi.org/10.1080/08964289.2016.1193462

Luiz, RR, Magnanini MM (2000). A lógica da determinação do tamanho da amostra em investigações epidemiológicas. Cad. saúde coletiva. 2000; 8(2): 9-28.

Marinus, N., Bervoets, L., Massa, G., Verboven, K., Stevens, A., Takken, T., & Hansen, D. (2017). Altered gas-exchange at peak exercise in obese adolescents: implications for verification of effort during cardiopulmonary exercise testing. *The Journal of sports medicine and physical fitness*, *57*(12), 1687-1694. https://doi.org/10.23736/s0022-4707.16.06607-x

Mateo-Orcajada, A., González-Gálvez, N., Abenza-Cano, L., & Vaquero-Cristóbal, R. (2022). Differences in Physical Fitness and Body Composition Between Active and Sedentary Adolescents: A Systematic Review and Meta-Analysis. *Journal of Youth and Adolescence*, 1-16. https://doi.org/10.1007/s10964-021-01552-7

Miranda, M. M., Fernández, T. N., Guajardo, J. R., Eyraud, P. R., Palma, X., & Rodríguez, F. R. (2020). Relación entre la actividad física escolar y extraescolar en estudiantes de escuelas públicas chilenas. *Retos: nuevas tendencias en educación física, deporte y recreación*, (37), 393-399.

Okunogbe, A., Nugent, R., Spencer, G., Ralston, J., & Wilding, J. (2021). Economic impacts of overweight and obesity: current and future estimates for eight countries. *BMJ global health*, *6*(10), e006351. http://dx.doi.org/10.1136/bmjgh-2021-006351

Oliosa, P. R., Zaniqueli, D. D. A., Barbosa, M. C. R., & Mill, J. G. (2019). Relationship between body composition and dyslipidemia in children and adolescentes. *Ciencia & Saude Coletiva*, *24*, 3743-3752.

Oliveira, A., Monteiro, Â., Jácome, C., Afreixo, V., & Marques, A. (2017). Effects of group sports on health-related physical fitness of overweight youth: A systematic review and meta-analysis. *Scandinavian Journal of Medicine & Science in Sports*, *27*(6), 604-611. https://doi.org/10.1111/sms.12784

Palacio-Agüero, A., Díaz-Torrente, X., & Quintiliano Scarpelli Dourado, D. (2020). Relative handgrip strength, nutritional status and abdominal obesity in Chilean adolescents. *Plos one*, *15*(6), e0234316. https://doi.org/10.1371/journal.pone.0234316

Palma, B. E. P., Parrací, C. A. R., & Saa, P. A. C. (2022). Normative values of muscular and cardiorespiratory fitness and their relationship with anthropomet: Multicentre study. *Retos: nuevas tendencias en educación física, deporte y recreación*, (43), 818-825.

Pelegrini, A., Bim, M. A., Souza, F. U. D., Kilim, K. S. D. S., & Pinto, A. D. A. (2021). Prevalence of overweight and obesity in Brazilian children and adolescents: a systematic review. *Revista Brasileira de Cineantropometria & Desempenho Humano*, *23*. https://doi.org/10.1590/1980-0037.2021v23e8035

Pinhas-Hamiel, O., Hamiel, U., Bendor, C. D., Bardugo, A., Twig, G., & Cukierman-Yaffe, T. (2022). The Global Spread of Severe Obesity in Toddlers, Children and Adolescents–a Systematic Review & Meta Analysis. *Obesity Facts*. https://doi.org/10.1159/000521913

Piqueras Fiszman, P., Ballester, A., Durá Gil, J. V., Martinez-Hervas, S., Redón, J., & Real, J. T. (2021). Anthropometric indicators as a tool for diagnosis of obesity and other health risk factors: a literature review. *Frontiers in Psychology*, *12*, 2618. https://doi.org/10.3389/fpsyg.2021.631179

Simmonds, M., Llewellyn, A., Owen, C. G., & Woolacott, N. (2016). Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. *Obesity reviews*, *17*(2), 95-107. https://doi.org/10.1111/obr.12334

Sbaraini, M., Cureau, F. V., do Amaral Ritter, J., Schuh, D. S., Madalosso, M. M., Zanin, G., Goulart, M. R., Pellandda, L. C. & Schaan, B. D. (2021). Prevalence of overweight and obesity among Brazilian adolescents over time: a systematic review and meta-analysis. *Public Health Nutrition*, 1-27. https://doi.org/10.1017/S1368980021001464

Stierman, B., Ogden, C. L., Yanovski, J. A., Martin, C. B., Sarafrazi, N., & Hales, C. M. (2021). Changes in adiposity among children and adolescents in the United States, 1999–2006 to 2011–2018. *The American Journal of Clinical Nutrition*, *114*(4), 1495-1504. https://doi.org/10.1093/ajcn/nqab237

Tanner, J.M. (1962). *Growth at adolescence*. Oxford: Blackwell Scientific.

Thompson, H. R., Pavlovic, A., D'Agostino, E., Napier, M. D., Konty, K., & Day, S. E. (2021). The association between student body mass index and tests of flexibility assessed by the FITNESSGRAM®: New York City public school students, 2017–18. *PloS one*, *16*(12), e0262083. https://doi.org/10.1371/journal.pone.0262083

Weller, I. M., Thomas, S. G., Corey, P. N., & Cox, M. H. (1993). Prediction of maximal oxygen uptake from a modified Canadian aerobic fitness test. *Canadian Journal of Applied Physiology*, *18*(2), 175-188. https://doi.org/10.1139/h93-014

World Health Organization. *WHO Guidelines on Physical Activity and Sedentary Behaviour*. Geneva, Switzerland: World Health Organization; 2020. Retrieved from: https://www.who.int/publications/i/item/9789240015128

World Health Organization. *WHO European Regional Obesity Report 2022*. Copenhagen: WHO Regional Office for Europe; 2022. Retrieved from: https://apps.who.int/iris/bitstream/handle/10665/353747/9789289057738-eng.pdf

Zouhal, H., Ben Abderrahman, A., Khodamoradi, A., Saeidi, A., Jayavel, A., Hackney, A. C., Laher, I., Algotar, A. M. & Jabbour, G. (2020). Effects of physical training on anthropometrics, physical and physiological capacities in individuals with obesity: A systematic review. *Obesity reviews*, *21*(9), e13039. https://doi.org/10.1111/obr.13039