

Association between health-related physical fitness and body mass index status in children

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Abstract

The purpose of this study was to investigate the association between body mass index (BMI) status and physical performance in Brazilian children. The analyzed sample was composed of 978 children of both sexes (518 boys and 460 girls), aged 7 to 11 years. BMI and skinfolds were measured, and three motor tests were applied (flexibility, cardiorespiratory fitness, and muscular strength/endurance). In both sexes, overweight/obese children presented poor performance in all motor tests, except flexibility. In general, overweight/obese children have an increased odds ratio (OR) to present poor physical performance (boys: OR = 3.64 for cardiorespiratory fitness, OR = 1.94 for muscular strength/endurance, OR = 1.52 for flexibility; girls: OR = 5.03 for cardiorespiratory fitness and OR = 2.62 for muscular strength/endurance). In conclusion, for both sexes, a poor physical performance in the tests measuring cardiorespiratory fitness and muscular strength/endurance was associated with the presence of overweight/obesity.

Keywords

Motor tests, obesity, physical performance

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Introduction

Obesity is characterized by excessive body fat (Flynn et al., 2006), and its development is associated with biological, genetic, and behavioral variables (Agras et al., 2004). The fast rate of increase in obesity over the last few decades has concerned health professionals (Wang and Dietz, 2002), as obesity is an important biological risk factor for the development of chronic diseases (CDs) (Falaschetti et al., 2010; Lawlor et al., 2010), associated with risk of low cardiorespiratory fitness (Artero et al., 2010; Dumith et al., 2010; Mak et al., 2010), increases the 'years of life lost', and hence public health care costs (Fontaine et al., 2003; Wang and Dietz, 2002). Thus, obesity is indicated as an important public health challenge.

Obesity and its associations with physical activity level (PAL) and lower physical fitness have been analyzed in pediatric populations (Giugliano and Carneiro, 2004; Joshi et al., 2012; Ortega et al., 2008). Prior studies have shown that both PAL and obesity track from childhood and adolescence to adulthood (Deshmukh-Taskar et al., 2006; Fernandes and Zanesco, 2010). Therefore, it is a common belief that maintenance of adequate health-related physical fitness protects against the development of CD in adulthood (Chen et al., 2002; Fernandes and Zanesco, 2010; Wedderkopp et al., 2004). Furthermore, studies have shown that obese youths are less physically active and have lower fitness than nonobese youths (Coelho-e-Silva et al., 2013; Ekelund et al., 2002; Shang et al., 2010). Thus, promoting an active lifestyle and hence adequate health-related physical fitness among children and adolescents is an important challenge to health professionals due to the harmful consequences of childhood obesity and lower fitness levels on health in adulthood.

However, in developing nations, such as Brazil, there are limited data about the existence of this association among children. Thus, the purpose of the present study was to investigate the association between body mass index (BMI) status and health-related physical fitness in Brazilian children.

Methods

Sample

This is a cross-sectional study using the database of a mixed longitudinal study entitled 'Growth Analysis and Related Fitness Physical Health in High School Level Socioeconomic' (2002–2005), and a secular trend study called 'Secular Trend in Physical Growth Indicators and Related Physical Fitness Health in School' (2010 and 2011). Thus, the information refers to the subjects assessed at a single time (cross-sectional data). All measurements were performed by trained evaluators. The data were collected in a private school located in the center of Londrina, Brazil (approximately 500,000 inhabitants), which includes approximately 15% of all children of the city.

Exclusion criteria were: (a) the child refused to participate, (b) non-parental consent, (c) some physical problem that prevented temporarily or definitively the student to be submitted to the administration of motor tests, and (d) no classes on the day of data collection. The sample of 736 children was estimated taking into account an overweight prevalence of 13.9% (Wang and Dietz, 2002), absolute error of 2.5%, and a significance of 5%. A total of 1068 children were measured for the study, however, after exclusions, the sample composed of 978 children (518 boys and 460 girls), with age ranging from 7 to 11 years.

Chronological age was established through the procedures indicated by Ross and Marfell-Jones (1982). Informed written consent was obtained from the participants and their parents before participating in the study, and the study protocol was approved by the ethics committee of the Londrina State University.

Anthropometry

Weight and height were determined following the guidelines described by Gordon et al. (1988). Weight was measured, with the child standing, wearing a T-shirt and shorts without shoes, to the nearest .1 kilogram, using a precalibrated digital FILIZOLA scale that was recalibrated at each different location. Height was determined while the child was standing without shoes, to the nearest .1 centimeter, using a stadiometer. Weight and height were also used to calculate BMI, expressed as weight (kilogram) divided by height (square meter). The sex- and age-cutoffs for BMI proposed by Cole et al. (2000) were utilized to classify the BMI status. Skinfold measurements (triceps and subscapular) were taken from the right side of the body, by only one researcher, using a Lange skinfold caliper (range: 0–60 mm × 1 mm; Cambridge Scientific Industries Inc., Cambridge, Massachusetts, USA) according to known procedures (Harrison et al., 1988). The median of three measurements taken in rotational form was used to represent the value for the triceps and subscapular sites. For both skinfolds, the observed intraclass correlation (reliability) was .95 and the standard error was less than ± 1.0 mm.

Health-related physical fitness

Health-related physical fitness was assessed through three motor tests. The participants performed a 'sit-and-reach' test (flexibility), followed by 'sit-ups' (muscular strength and endurance), and a 'nine-minute run/walk' test (cardiorespiratory fitness). The sit-and-reach test was performed by the participants according to known procedures (American Alliance for Health, Physical Education, Recreation and Dance, 1984). The participants were each given three trials, and the best value was used as the test score. All participants received verbal encouragement from the investigators in order to achieve maximum performance. In each test, the sex-and-age specific cutoffs of Physical Best proposed by the American Alliance for Health Physical, Education, Recreation, and Dance (1984) were adopted to indicate satisfactory or unsatisfactory performance.

Statistical analyses

The data were stored and analyzed using the Statistical Package for Social Sciences (SPSS for Windows Version 17.0). Normality was checked and rejected using the Kolmogorov–Smirnov test. Thus, median values and interquartile range were adopted as descriptive statistics. The Mann–Whitney U test was used when comparing differences in physical characteristics between sexes, while the Kruskal–Wallis test was used to analyze indicators of the health-related physical fitness in relation to BMI status stratified in boys and girls. The association between nutritional status and physical performance was assessed by the χ^2 test, and the magnitude of this association was expressed by multiple logistic regression (odds ratio (OR) and 95% confidence interval (95% CI)), which was adjusted by chronological age. The statistical significance was set at $p < .05$.

Results

The physical characteristics of the sample are shown in Table 1. For both sexes, there were no statistical differences in the variables: age ($p = .896$), weight ($p = .123$), or height ($p = .470$). However, boys presented higher values of BMI than girls ($p = .039$). The prevalence of overweight was around 20% for boys and girls, and obesity was 10% for boys and 6% for girls.

Table 2 presents the scores of the health-related physical fitness according to the BMI status. In general, for both sexes, obese children presented higher subcutaneous fat and lower muscle

Table 1. Physical characteristics of Brazilian children aged 7–11 years by sex.^a

Variables	Boys (n = 518) Median (IR)	Girls (n = 460) Median (IR)	Mann–Whitney p value
Age (years)	8.5 (2.2)	8.6 (2.4)	.896
Weight (kg)	30.7 (12.3)	29.8 (11.4)	.123
Height (cm)	133.0 (13.4)	132.0 (14.1)	.470
BMI (kg/m ²)	17.3 (4.1)	17.1 (3.6)	.039
BMI Status (n (%))			
Healthy weight	367 (70.8)	340 (73.9)	.092 ^b
Overweight	99 (19.1)	91 (19.8)	
Obesity	52 (10.0)	29 (6.3)	

Note: BMI: body mass index; IR: interquartile range.

^aValues are reported as median (interquartile range).

^b χ^2 test for linear trend.

Table 2. Indicators of the health-related physical fitness in Brazilian children aged 7–11 years by sex and BMI status.^a

	Healthy BMI Median (IR)	Overweight Median (IR)	Obesity Median (IR)	Kruskal–Wallis p value
Boys (n = 518)	(n = 367)	(n = 99)	(n = 52)	
Age (years)	8.3 (2.2)	8.9 (1.9)*	8.6 (1.7)	.001
∑SF (mm)	17.0 (6.5)	32.0 (11.5)*	42.7 (14.1)*†	.001
SRT (cm)	27.0 (8.0)	25.0 (7.0)	24.5 (9.0)	.087
SUT (rep)	32.0 (10.0)	31.0 (11.0)	25.5 (12.0)*†	.001
CFT (m)	1350.0 (302.0)	1265.0 (275.0)*	1115.0 (190.0)*†	.001
Girls (n = 460)	(n = 340)	(n = 91)	(n = 29)	
Age (years)	8.7 (2.4)	8.2 (2.4)	8.1 (2.4)	.642
∑SF (mm)	20.5 (9.5)	33.0 (13)*	45.0 (15)*†	.001
SRT (cm)	29.0 (8.0)	29 (10)	27 (8)	.587
SUT (rep)	31.0 (11.0)	27 (10)*	23 (13)*†	.001
CFT (m)	1215.0 (239.0)	1130 (140)*	1075 (220)*†	.001

Note: IR: interquartile range; ∑SF: sum of triceps and subscapular skinfolds; SRT: sit-and-reach test; SUT: sit-ups test; CFT: cardiorespiratory fitness test; BMI: body mass index. Values are reported as median (interquartile range).

^aLevels of significance for the BMI status differences based on the Kruskal–Wallis test.

*p < .05 versus healthy BMI; †p < .05 versus overweight.

strength and endurance than those of healthy weight. However, in boys ($p = .087$) and girls ($p = .587$), there were no differences for flexibility, according to the BMI status.

Unsatisfactory performance in the flexibility test was higher in overweight/obese boys ($p = .035$ (Figure 1, (a))), but this pattern was not identified in girls ($p = .200$ (Figure 1, (b))). Independent of sex, decreased performance in muscle strength was higher in overweight/obese children ($p = .001$ for both). Boys presented lower rates of unsatisfactory performance in muscle endurance; on the other hand, in both boys and girls, BMI was strongly associated with lower performance in the running test ($p = .001$ for both).

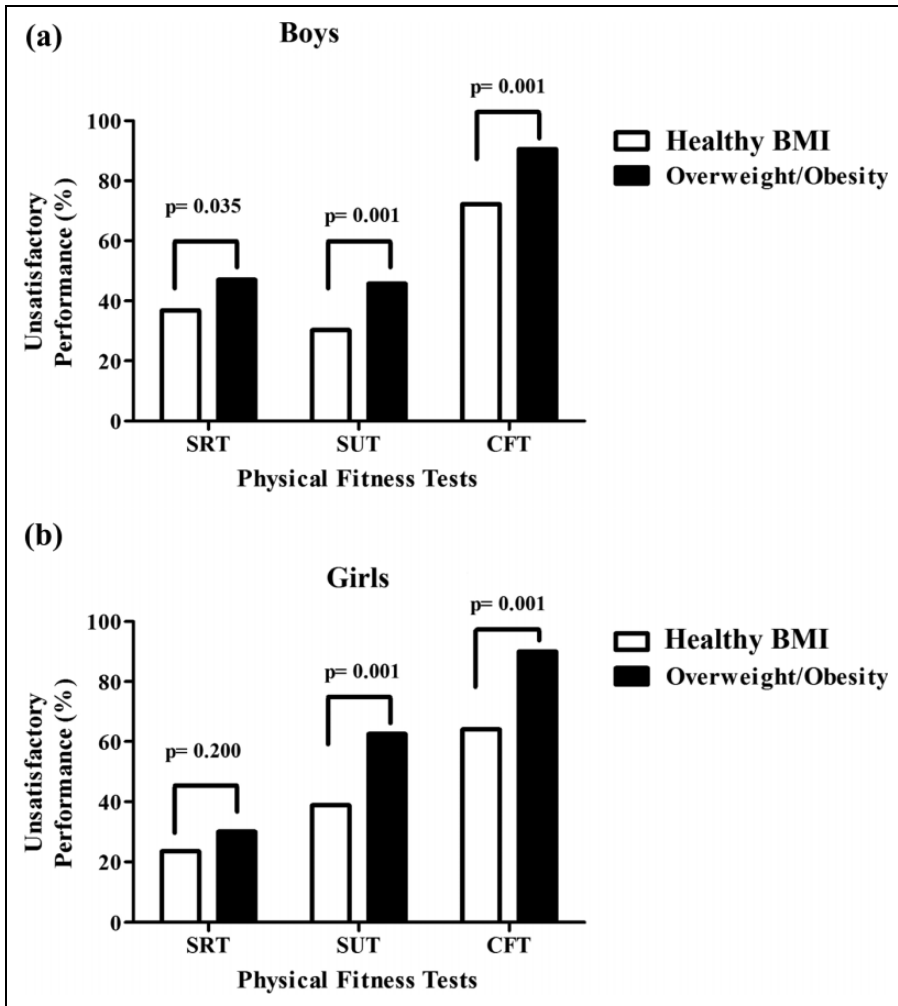


Figure 1. Association between health-related physical fitness and nutritional status in Brazilian boys (a) and girls (b) children aged 7–11 years. SRT: sit-and-reach test; SUT: sit-ups test; CFT: cardiorespiratory fitness test; BMI: body mass index.

Children considered overweight/obese were significantly more likely to demonstrate low health-related physical fitness (cardiorespiratory fitness: OR = 3.6 for boys and 5.0 for girls, muscular strength/endurance: OR = 1.9 and 2.6 for boys and girls, respectively; flexibility: OR = 1.5 only for boys), compared to their peers with healthy BMI (Figure 2(a) and (b)).

Discussion

This was a cross-sectional study, in which a large sample of children and adolescents was analyzed and a strong association was identified between overweight and lower performance in health-related physical fitness.

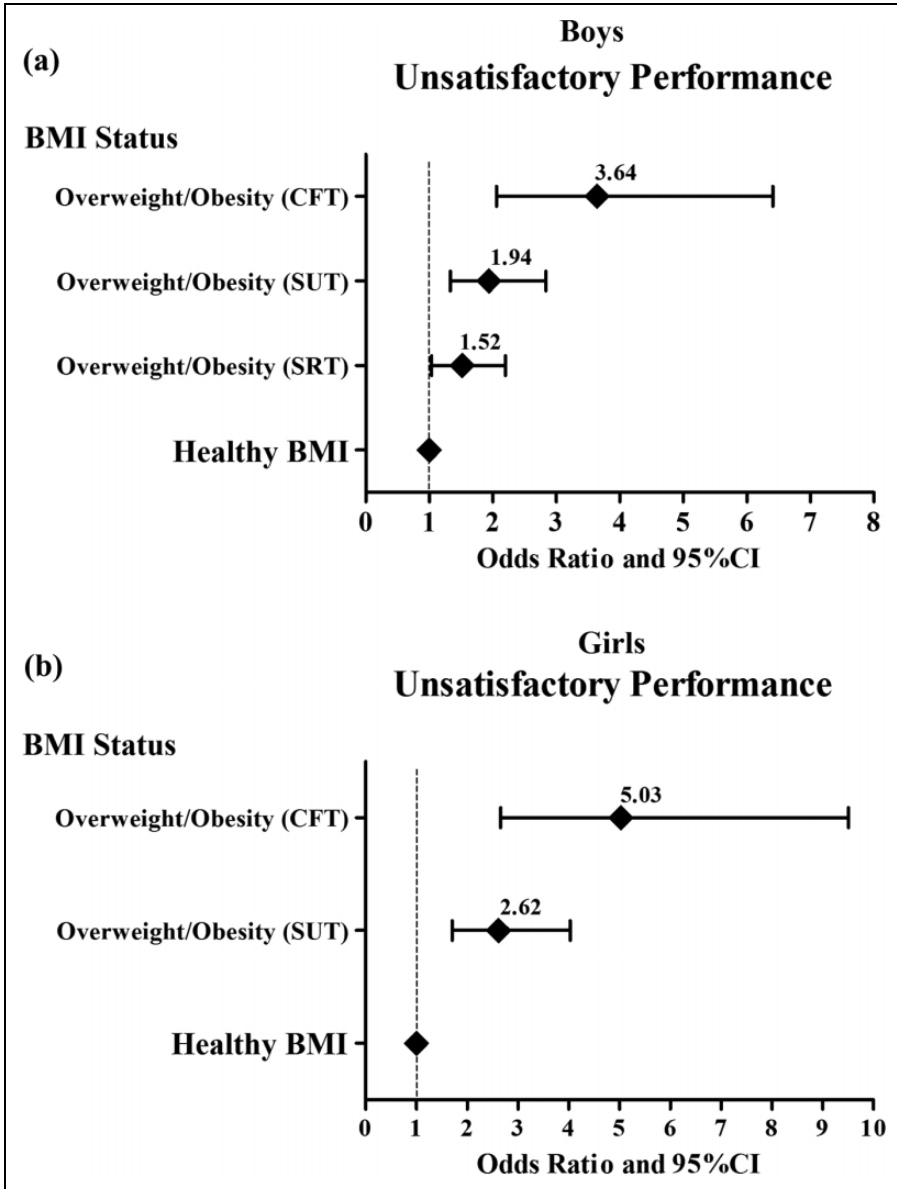


Figure 2. Logistic regression for association between BMI status and health-related physical fitness in Brazilian boys (a) and girls (b) children aged 7–11 years. SRT: sit-and-reach test; SUT: sit-ups test; CFT: cardiorespiratory fitness test; BMI: body mass index.

Recent evidence has reinforced the beneficial effects of promoting a physically active lifestyle from childhood (Moreira et al., 2011). It is well documented that PAL tracks from childhood to adulthood and if initiated at an early age is associated with a lower occurrence of obesity and CDs in adulthood, such as arterial hypertension and type 2 diabetes mellitus (Fernandes and

Zanesco, 2010). Corroborating with the harmful effects of pediatric obesity and ratifying the necessity for its prevention through physical activity practice, BMI values at seven-year-old are strongly related to values of blood pressure, blood glucose, and cholesterol presented in young adulthood (Sinaiko et al., 1999).

In our study, overweight/obese children presented decreased muscle strength and cardiorespiratory fitness, a harmful effect that was observed independent of sex. Prior studies have reported that obese children present poor performances in all indicators of health-related physical fitness, except flexibility (Artero et al., 2010; Kim et al., 2005; Tokmakidis et al., 2006). Among pediatric populations, health-related physical fitness is an important indicator of physical health (Chen et al., 2002; Ortega et al., 2008), and its relationship with obesity is an unhealthy effect previously documented only in developed nations. The poor performances of overweight children cannot be attributed exclusively to the increased difficulty of body locomotion and muscular injuries caused by the excessive weight (Wearing et al., 2006). In fact, the above-mentioned relationship could be affected by confounders such as PAL because in adolescents there is an inverse relationship between physical activity and body fat as well as a positive relationship between physical activity and cardiorespiratory fitness (Gutin et al., 2005).

In this regard, Stodden et al. (2008) presented a model that seeks to explain the relationship between obesity, physical activity, and physical fitness, focused on the acquisition and development of motor skills. This model considers a dynamic and reciprocal relationship between obesity and four other factors (physical activity, motor skill competence, perceived motor competence, and physical fitness).

If on one hand, there is a positive spiral of involvement and perception of high competence of motor skills, greater physical activity and higher levels of physical fitness and health, promoting a state of healthy weight; on the other, the negative spiral points to a cessation of physical activity with low competence and perception of motor skills, less physical activity, and poor physical fitness and health, leading to weight gain and obesity. Therefore, the relationship between obesity and physical fitness is characterized as highly complex since the variables involved can compromise these interpretations (Stodden et al., 2008).

In fact, in the present study, more than 90% and 40% of the obese children presented unsatisfactory performances in cardiorespiratory fitness and muscular strength/endurance, respectively. However, in both sexes, nonobese children also presented high rates of unsatisfactory performance, higher rates than those observed in previous studies (Dumith et al., 2010; Huang and Malina, 2002).

It is worth mentioning that, in the case of flexibility evaluated by the sit-and-reach test, performance was not affected by overweight/obesity in either sex, a result that has also been observed in other studies (Malina et al., 1995; Tokmakidis et al., 2006). One possible explanation for this behavior lies in the fact that physical activities involving flexibility, unlike those of endurance, agility, and explosive power, are not significantly affected by overweight and are thus equally attractive to both eutrophic and overweight children and adolescents (Fogelholm et al., 2008).

Another consideration is that the test used as an indicator of flexibility (sit-and-reach), used internationally for epidemiological studies, has some limitations such as the fact that it verifies the flexibility of the hip region and this is dependent on leg length proportions (sitting height), added to which, there is little evidence of the validity of this test in this population (Castro-Piñero et al., 2010).

Our results suggest a possible influence of overweight/obesity on the physical health of children; however, due to the cross-sectional design it is not possible to establish a causal relationship,

that is, inadequate physical fitness may cause obesity or obesity may lead to low physical fitness. Thus, further longitudinal studies are necessary to fill this gap in the literature. Additionally, the fact that only a private school was selected to participate in the study is presented as a potential limitation since such results cannot be extrapolated to young people studying in public schools in the same municipality.

Conclusion

In summary, our data analyzed the relationship between BMI status and health-related physical fitness in a large sample of children and indicated that there was a significant association between overweight and lower performance in indicators of health-related physical fitness in our sample.

The results suggest that children are encouraged to increase their participation in physical education classes and institutions such as clubs, association communities that may provide extracurricular activities, such as physical exercise programs, sports organized, and recreational activities to this population, seeking appropriate levels of physical fitness related to health. In this sense, government actions should be developed to deal with the effects related to the increase of overweight in children, otherwise in the future, the impact on public spending as a result of CDs would be a major public health problem in Brazil.

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Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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