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Overweight/Obesity and Physical Fitness Among Children and Adolescents

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Background: Physical fitness is strongly associated with several positive health indicators among adolescents. However, its association with body mass index status is inconsistent. The aim of this study was to explore the association between overweight/obesity and physical fitness among children and adolescents. ***Methods:*** The design consisted of a cross-sectional study comprising 519 Brazilian students age 7 to 15 years. BMI status was assessed according to sex- and age-specific growth charts. Physical fitness was assessed using 8 tests: sit-and-reach, stationary long jump, 1-minute curl-up, modified pull-up, medicine-ball throw, 9-minute run, 20-m run, and 4-m shuttle-run. ***Results:*** Prevalence of overweight and obesity was 24% and 12%, respectively. Boys performed better than girls in all tests, except flexibility. Normal weight students performed better than overweight and obese students in all tests, except the sit-and-reach and the medicine-ball throw. Cardiorespiratory fitness had the strongest association with BMI status. The prevalence of obese subjects classified as "most fit" was less than 10%. ***Conclusions:*** Higher values of body mass index were associated with declines in physical fitness, independent of age. The majority of obese children and adolescents and almost a half of those overweight were classified in the third tertile of physical fitness (least fit).

Keywords: motor activity, exercise, body mass index, students, health promotion

Physical fitness is associated with lower prevalence of cardiovascular disease risk factors, reduces total and abdominal adiposity, improves mental and bone health, increases academic performance in young people, and protects against all-cause mortality.[1–3] Among school-age children, there is evidence that physical fitness is more strongly related to metabolic risk than physical activity.[4] A study with Brazilian scholars identified that moderate-to-vigorous physical activity explained only 4% to 8% in VO_2max variability.[5] Therefore, knowledge on physical fitness and its predictors needs to be deepened.

Unfortunately, there is evidence suggesting that aerobic fitness, but not anaerobic performance, has declined worldwide in the last decades among children and adolescents.[6] Sometimes, such declines come accompanied by body mass index (BMI) increases.[7–10] Overweight and obesity have risen in the last decades among young people.[11,12] One of the most feasible explanations for this phenomenon consists in the decline of fitness, produced primarily by decreases in physical activity levels.[13] Overweight/obesity and low physical fitness are 2 different factors interrelated in the same pathway, and changes in one may cause changes in the other. Furthermore, physical fitness in youth tends to track moderately into adulthood.[14,15]

Estimates from the United States indicate that the prevalence of physical fitness test administration in 2000 was 65% across all school levels.[16] In Brazil, there is no scientific data concerning this issue, but physical education in school settings is worsening and drastically needs improvement. This is supported by a Brazilian study which indicated that the intensity level of physical education classes is not sufficient to improve fitness.[17]

Although there are many studies associating BMI with physical activity, few have investigated the relationship between BMI status and physical fitness, particularly among school-age subjects. Most existing studies used only 1 or 2 fitness tests. Some studies suggest that obese and overweight teenagers have low physical fitness levels in comparison with their normal weight peers.[18–20]

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The aim of the current study was to explore the association between overweight/obesity and physical fitness among children and adolescents.

Methods

This is an epidemiological study with a cross-sectional design, which was conducted as part of a national project aimed at assessing the fitness profile of Brazilian children and adolescents. This project is entitled “Projeto Esporte Brasil (Sports Brazil Project)—PROESP” and was released in 2002 by the Ministry of Sports. Further details on the project can be found elsewhere.[21,22] The study protocol was approved by the Ethics Committee of the Federal University of Pelotas. Besides the consent of each school, parents or guardians signed individual consent forms authorizing participants to be tested.

The study took place in the Southern city of Rio Grande (population 200,000). The sample was randomly selected in 2 stages. First, 10 schools (out of 90 with elementary education) were randomly selected, including stratification by type of school (public and private) and location (urban and rural). To maintain the proportionality existent in the city, 8 public and 2 private schools were selected, as well as 3 rural and 7 urban schools. Afterward, classes in each sampled school were randomly selected. When the school had only 1 classroom per grade level, this was included. When there were 2 or more, 1 classroom from each grade level at every school was randomly sampled. This process used a probability proportionate to the number of students in each grade level in Rio Grande.

Approximately 70 students from each grade level (ranging from 1st to 8th) at each school were included in the study. The initial idea of the project was to select about 100 students from each grade level. Nonetheless, it is worth mentioning that the reduced sample did not affect the results, as all the associations had enough power to be detected. To be eligible for the study participants had to be enrolled in the 2004 school year and between 7 to 15 years old. A few students that were 6 years old or over 15 years old were tested but excluded from the analysis. Missing data were caused by the following reasons: a) physical disability, b) parents did not sign the consent term, c) refuse to be assessed, or d) absence in the day of the evaluations. No sample replacement was done.

Data collection was carried out by a team consisting of 3 Physical Education teachers and 3 university students. All of these data collectors were provided standardized trainings on how to perform all measures and physical tests. A pilot study, including approximately 100 students, was conducted in a school which was not included in the final sample. Throughout the fieldwork, the students were informed on testing procedures at least 1 day before measures and physical tests were administered. During testing, the researchers provided students with all relevant information concerning the measures and physical tests. Measurements were collected, whenever possible, during physical education classes. Fieldwork was carried out between September and November 2004.

Body measures assessed were: weight (in kg, with a precision of 0.1 kg); height (in cm, with a precision of 0.1 cm); and wingspan (in cm, with a precision of 0.1 cm), which corresponds to the extension of arms outstretched. BMI status was then calculated according to the World Health Organization’s growth reference for school-age children and adolescents.[23] This criterion classifies subjects age 5 to 19 years, according their z-scores of BMI for sex and age. A z-score less than –2 corresponds to “thinness”; a z-score between –2 and +1 means that the subject is considered “normal weight”; a z-score above 1 but lower than 2 corresponds to “overweight”; and a z-score higher than 2 means that the subject is “obese.”

With regards to physical fitness, 8 tests were administered in the same day: sit-and-reach, long jump, stationary long jump, 1-minute curl-up, modified pull-up, medicine-ball throw, 9-minute run, 20-meter run, and 4-meter shuttle-run. All students were required to participate in these physical activity measurements at the same time to stay on task. Thus, while a group of students were involved with a certain test, other groups performed other tests. Table 1 presents a summary description of the procedures applied in each test, as well as the main physical component involved in each one.

Data were entered in Excel by 2 individuals, and afterward they were transferred to Stata 9.2, where a check for range and consistency was done. Analyses included descriptive statistics (means and SD) of anthropometric measures and physical fitness tests, stratified by sex. Linear regression analysis was used to calculate the determinant coefficients (R^2) of BMI status upon each test performance. One-way analysis of variance was used, with Bonferroni post hoc, to test differences in the physical fitness indicators according to the categories of BMI status. After this, a multiple regression model, including age (in years), school type (public or private) and geographic region (urban or rural) was used, to adjust the effect of BMI status on outcomes for confounding.

With the purpose of analyzing the distribution of physical fitness as a single variable according to the categories of BMI status, a principal component analysis was done. This is a technique of data reduction,[24,25] in which the single physical fitness component resulted explained more than a half (55%) of the variability of all tests administered. All analyses were done separately by sex. They were not stratified by age groups because the effects of BMI status on physical fitness did not vary according to age (p-values for interaction were all greater than 0.1).

Results

Overall, 527 children and adolescents were included in the study. Of these, 2 subjects were excluded due to missing values for BMI, and 6 were excluded from the analyses because they were classified in the “thinness” category. Thus, the final sample was composed by 519

Table 1 Description of the Procedures Used in Each Physical Fitness Test Administered, and the Main Physical Component Involved in Each One

Physical fitness test
Sit-and-reach (flexibility)
Subjects should be seated with their legs joined and outstretched. The sole of their feet must be supported in a standardized wood box (Well Box), measuring 30.5 cm × 30.5 cm × 30.5 cm, with an extension of 23.0 cm for the support of the upper limbs above it. Through an inflection of trunk, they should reach, with rings fingers (arms joined and hands superposed), the maximal distance (in a metric scale of 50 cm) upon the box they could reach.
Stationary long-jump (muscular power of lower limbs)
Still stand-up, the subject should took propulsion, by inflection of their knees, and jump ahead the maximal distance he/she was able. One attempt was allowed before the main one.
1-min curl-up (muscular resistance)
Subjects should lie in the floor, with their knees inflected in an angle of 90°, feet in contact with the floor and supported by an appraiser, and arms crossed over their trunk. The movement consists of a hip inflection, up to the elbows touch thighs, and return to the initial position. Subjects were encouraged to do the maximal repetitions they were able in 1 minute. Only correct movements were counted.
Modified pull-up (strength of upper limbs)
Subjects should lie in the floor, with their legs jointed and outstretched. Their hands should hold a bar, supported by a wood framework, with their arms fully outstretched. The movement consists in an inflection of the elbows (without hip inflection) up to their face touch the bar. Only correct movements were counted.
Medicine-ball throw (muscular power of upper limbs)
Subjects should be seated with the backside of their trunk in touch with a wall. They should hold a medicine-ball with their hands (abreast of chest) and throw it ahead over the maximal distance they could. It was not allowed inflection their hip, nor withdraw their trunk from the wall. The distance (in cm) from the wall to the first place that ball entered in contact with floor was measured.
9-minute run (cardiorespiratory fitness)
Subjects were encouraged to run the maximal distance they were able in 9 minutes. Walking was also allowed to those that got very tired. Subjects should run around a track measuring, by convention, 9 m of width and 18 meter of length. Almost always, this track consists of the sports court of school. Since this test left subjects exhausted, generally this was the last test to be administered. Number of tours around the track was counted, and after the test, it was converted in meters.
20-meter run (speed)
In a track (often of concrete) measuring 20 meter of length, subjects should course it in the maximal velocity they could. Time spend (seconds and hundredth) by each subject was registered.
4-meter shuttle-run (agility and coordination)
Subjects should shift, in the fastest time they were able, in a square area delimited by 4 cones on each corner (4 m apart each other). They should touch each cone, in a commuting with movements in zigzag. Time spend (seconds and hundredth) by each subject was registered.

students age 7 to 15 years. Out of these, 91% studied in urban schools, 87% studied in public schools and 52% were males. The mean age was 11.4 years (SD = 2.1), with 28% of the students age 7 to 9 years, 47% age 10 to 12 years, and 25% age 13 to 15 years.

The mean sex- and age-specific BMI z-score was 0.6 (SD = 1.2), ranging from –2.5 to 4.8, with no difference between boys and girls ($P = .6$). The mean BMI z-score decreased with age ($P < .001$). Almost two-thirds (64.6%; 95% CI: 60.4–68.7) of the subjects were classified as normal weight, almost a quarter (23.7%; 95% CI: 20.0–27.4) were overweight, and 11.7% (95% CI: 9.0–14.5) were obese. There were no significant differences in the prevalence of overweight and obesity between boys and girls.

Table 2 presents the description of the sample stratified by sex, according to anthropometric indicators and physical fitness. Boys performed better in all tests, with the exception of the sit-and-reach test, where girls performed better. Mean values were similar to median values for most tests, with the exception of the modified pull-up where the mean clearly exceeded the median.

As can be observed in Figure 1, BMI had the highest determinant coefficient (R^2) among all variables (66% among boys and 60% among girls) . The physical test that explained most of the variability of BMI status was the 9-minute run, with $R^2 = 20\%$ among boys and $R^2 = 11\%$ among girls. Height, wingspan, sit-and-reach and medicine-ball throw were not associated with BMI status ($R^2 = 0$).

Table 2 Description of the Sample According to Anthropometric and Physical Fitness Indicators

	Boys (n = 270)		Girls (n = 249)		
Measure/test	**Mean (SD)**	**Median (P25–P75)**	**Mean (SD)**	**Median (P25–P75)**	***P****
Weight (kg)	43.5 (13.2)	41 (34–51)	41.8 (12.2)	40 (32–50)	0.12
Height (cm)	147.8 (14.1)	147 (138–159)	144.9 (12.8)	146 (135–155)	0.01
BMI (kg/m^2)	19.5 (3.6)	18.7 (16.9–21.4)	19.5 (3.4)	19.1 (17.1–21.4)	1.0
Wingspan (cm)	149.7 (15.3)	149 (139–161)	145.8 (13.3)	147 (134–156)	0.002
Sit-and-reach (cm)	18.7 (7.5)	19 (13–24)	22.3 (8.0)	23 (18–27)	<0.001
Long jump (cm)	142 (31)	140 (123–160)	118 (23)	118 (103–132)	<0.001
1-minute curl-up (repetitions)	30.7 (8.7)	31 (26–36)	23.5 (8.3)	24 (19–29)	<0.001
Modified pull-up (repetitions)	5.4 (4.9)	4 (1–8)	1.7 (2.6)	0 (0-3)	<0.001
Throw of medicine-ball (m)	2.7 (0.9)	2.5 (2.0–3.2)	2.1 (0.6)	2.1 (1.7–2.5)	<0.001
9-minute run (m)[a]	1255 (247)	1296 (1080–1404)	1022 (183)	1026 (918–1134)	<0.001
20-meter run (seconds)	4.0 (0.5)	4.0 (3.6–4.3)	4.4 (0.4)	4.3 (4.1–4.7)	<0.001
4-meter shuttle-run (seconds)	6.6 (0.7)	6.5 (6.1–7.0)	7.3 (0.7)	7.3 (6.8–7.8)	<0.001

[a] Test with higher number of missing values (7% among boys and 6% among girls).

* One-way analysis of variance comparing means values of boys and girls.

Table 3 presents the distribution of anthropometric and physical fitness indicators for boys and girls, according to BMI status. For both sexes, there were no statistical differences between categories of BMI status and: height ($P = .6$), wingspan ($P = .8$), sit-and-reach ($P = .8$) and medicine-ball throw test ($P = .9$). Among boys, performance in the long jump, 9-minute run and 20-m run tests were better for overweight boys compared with obese ones (20%, 20% and 3% higher, respectively, in each test), and among normal weight boys compared with overweight and obese (28%, 33% and 10% higher, respectively). In the 1-minute curl-up, there were no differences among normal weight and overweight boys, but these 2 groups performed better than the obese group (37% higher). Overweight and obese boys did not significantly differ in their modified pull-up scores, but normal weight boys performed twice as many repetitions than their peers. In the shuttle-run test, those categorized as having a normal weight performed better than those categorized as obese (8% higher score). In the multiple regression model (data not shown), adjusting for age, school type and geographic region, long jump and 20-m run results were no longer different among normal weight and overweight boys, but remained better than boys categorized as obese (17% and 3% higher for each test, respectively). Moreover, performance in the medicine-ball throw was slightly better (12% higher) among overweight and obese boys compared with normal weight boys. Other results remained similar to those observed in the unadjusted analyses.

Among girls, overweight students performed better than the obese (15% higher performance), and those categorized as normal weight were better than the other 2 groups in the 9-minute run test (23% higher than the obese and 7% higher than the overweight students). Overweight and obese girls did not differ in the long jump and modified pull-up tests; however, normal weight girls performed better in these tests (7% higher than overweight and 19% higher than obese students in the long jump test; twice and 10 times higher, respectively, in the pull-up test). In the 1-minute curl-up and 20-m run tests, normal weight and overweight girls obtained similar scores, but had better scores than girls categorized as obese (38% and 41% better, respectively). In the shuttle-run, normal weight students performed 7% better than obese students. In the multiple regression model (data not shown), long jump values among overweight girls were not statistically different from the other groups, but the results for those with normal weight remained better than the obese (13% higher). Like with boys, performance in the medicine-ball throw was slightly better (7% higher) among overweight (but not obese) girls in comparison with those categorized as normal weight. Other results remained similar to those obtained in the unadjusted analyses.

The distribution of the single physical fitness variable, generated by means of a principal component analysis, according to the categories of BMI status, is illustrated in the Figure 2. The likelihood of being "most fit" compared with "least fit" was 1.63 among the normal weight group, 0.61 among the overweight, and 0.13 among the obese students. Although approximately a quarter (24%) of the normal weight students was classified as "least fit," this proportion was almost twice and 3 times higher, respectively, among those overweight or obese. The prevalence of obese subjects classified as "most fit" was less than 10%, while among normal and

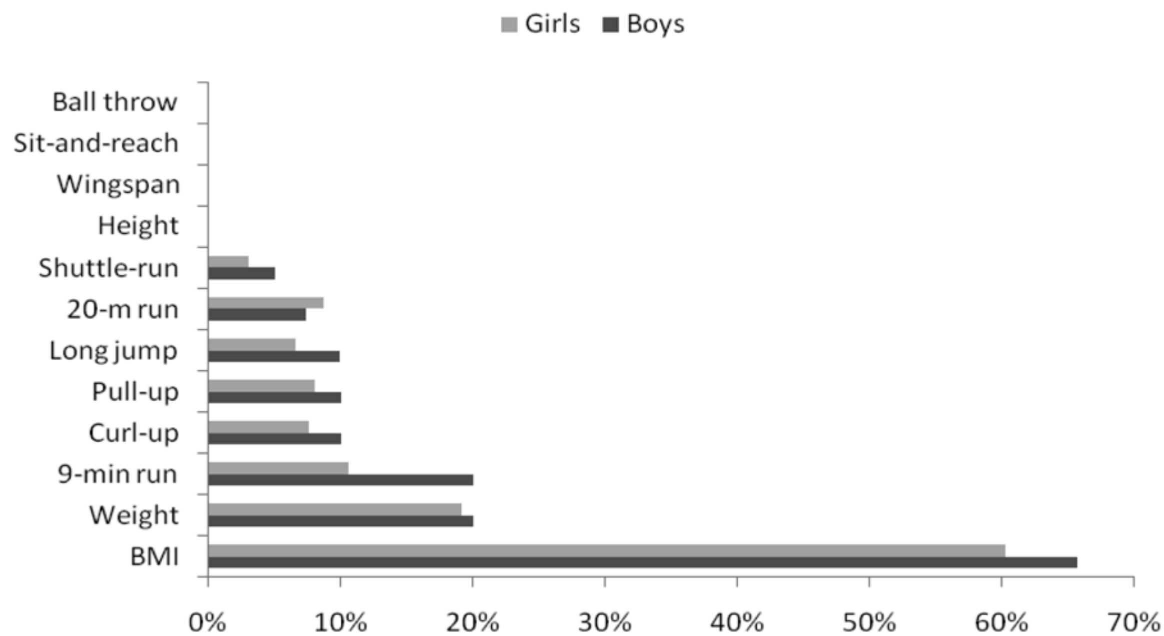

Figure 1 — Determinant coefficients (R^2) of the measures/motor tests administered upon the body mass index status (normal, overweight, obese).

Table 3 Distribution of Anthropometric and Physical Fitness Indicators According to Body Mass Index Status (n = 519)

	Boys (n = 270)				Girls (n = 249)			
	Normal	Overweight	Obese		Normal	Overweight	Obese	
Measure/test	Mean* (SD)	Mean* (SD)	Mean* (SD)	*P***	Mean* (SD)	Mean* (SD)	Mean* (SD)	*P***
Weight (kg)	39.6[a] (10.5)	47.0[b] (15.6)	56.9[c] (12.9)	<0.001	38.5[a] (10.3)	44.5[b] (10.5)	55.8[c] (15.3)	<0.001
Height (cm)	148.3 (14.3)	147.4 (14.1)	146.3 (13.0)	0.72	145.3 (13.0)	143.8 (11.9)	144.7 (14.2)	0.72
BMI (kg/m^2)	17.6[a] (1.8)	21.2[b] (2.0)	26.1[c] (3.5)	<0.001	17.9[a] (2.1)	21.2[b] (2.0)	26.1[c] (2.9)	0.001
Wingspan (cm)	150.1 (15.5)	149.9 (15.4)	147.5 (14.1)	0.66	146.1 (13.7)	145.1 (12.1)	145.9 (14.0)	0.87
Sit-and-reach (cm)	18.9 (7.2)	17.9 (8.3)	19.4 (7.5)	0.57	21.8 (7.8)	23.9 (8.6)	22.1 (6.9)	0.22
Stationary long jump (cm)	149[c] (30)	138[b] (28)	116[a] (34)	<0.001	122[b] (25)	113[a] (18)	103[a] (15)	<0.001
1-minute curl-up (repetitions)	31.9[b] (7.9)	31.3[b] (8.3)	23.1[a] (10.1)	<0.001	24.7[b] (7.8)	23.1[b] (8.3)	16.8[a] (8.7)	<0.001
Modified pull-up (repetitions)	6.5[b] (5.0)	3.8[a] (4.0)	2.2[a] (3.9)	<0.001	2.3[b] (2.9)	1.0[a] (1.6)	0.2[a] (0.6)	<0.001
Medicine-ball throw (m)	2.7 (0.9)	2.8 (1.0)	2.7 (0.8)	0.86	2.1 (0.6)	2.1 (0.6)	2.0 (0.5)	0.46
9-minute run (m)	1326[c] (226)	1196[b] (232)	996[a] (161)	<0.001	1059[c] (180)	987[b] (161)	862[a] (160)	<0.001
20-meter run (seconds)	3.9[a] (0.5)	4.0[b] (0.6)	4.3[c] (0.4)	<0.001	4.3[a] (0.4)	4.4[a] (0.4)	4.7[b] (0.4)	<0.001
4-meter shuttle-run (seconds)	6.5[a] (0.6)	6.7 (0.8)	7.0[b] (0.7)	<0.001	7.2[a] (0.7)	7.3 (0.7)	7.7[b] (0.6)	0.01

* Post hoc test of Bonferroni (to compare means difference): a < b < c ($P < .05$).

** One-way analysis of variance.

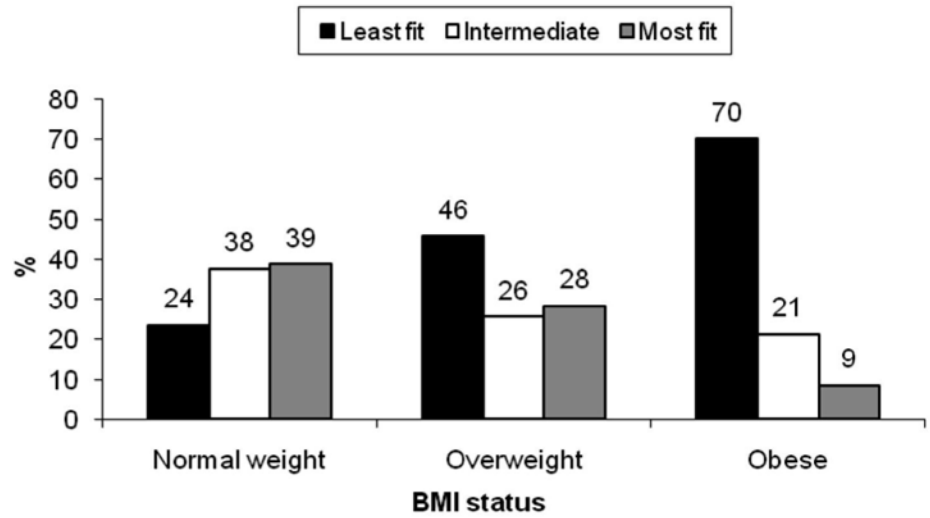

Figure 2 — Physical fitness distribution (divided into thirds), according to the categories of body mass index (BMI) status.

overweight groups this proportion was, respectively, around 4 and 3 times higher. These results were similar for boys and girls.

Discussion

There are few studies worldwide investigating physical fitness performance according to BMI status. To the authors' knowledge, this is the first study in Brazil on this issue. Some strengths of the current study should be considered. First, the sample was randomly selected (without reposition of nonparticipants), minimizing the likelihood of selection bias. Studies using replacement may oversample fit adolescents, who take part regularly in physical education classes. Second, the sampling procedures guaranteed a sample which was representative of all children and adolescents attending elementary schools of the city (public and private, rural and urban). Third, the objective measure of BMI and the use of a well-known criterion to classify students according to BMI status,[23] reduced the likelihood of misclassifying the exposure variable. Fourth, the variety of physical fitness tests applied allowed investigators evaluating the effect of BMI status on several physical abilities.

Some limitations should also be considered. First, it was not possible to enumerate the exact number of losses in the study, because the information on the number of students per class was based on a list of students sent by school directors, which reflects enrollment numbers at the beginning of the scholar year. Nevertheless, some of the students dropped out of school and were counted with those that were absent during data collection. Fortunately, the number of students who refused to participate in the data collection was low (fewer than 5%). These losses and refusals did not affect the statistical power of the analysis and, as they were not replaced, the authors believe this did not produce a selection bias.

Second, because socioeconomic status may confound the associations between BMI status and physical fitness, 2 variables were used in the adjusted model as proxies: type of school (public or private) and geographic region of school (urban or rural). An individual-based socioeconomic variable however would have been the preferred proxy for adjustment purposes. Third, although BMI can be considered a valid indicator to discriminate the excess of body fat mass in children and adolescents,[26] a BMI measure actually encompasses either the fat mass and the fat-free mass. Therefore, it is not possible to argue that the excess of weight is due from an excess of fat mass. Fourth, the reduced number of underweight individuals (n = 6) did not allow analyzing the physical fitness results for this group.

The lack of data regarding biological maturation indicators also can be considered as a limitation. However, when age was tested as a proxy of the pubertal status, that variable did not demonstrate an interaction effect on the association between BMI status and physical fitness. Another point that deserves to be highlighted is the absence of data on the reliability of the administered tests, although much of them are widely applied among young persons. Finally, the cross-sectional study design did not allow inferring temporal relationship or a causal association between BMI status and physical fitness.

In this study, the prevalence of children and adolescents above normal weight was high (35.4%; 95% CI: 31.3–39.6). Another study including a representative sample of Brazilian adolescents age 10 to 19 years, conducted in 1989 found a prevalence of weight excess (overweight and/or obesity) of 7.7% by using the same cut-off points of the current study.[27] Another study comparing data from 1974 to 1997 confirmed an increasing trend of overweight among Brazilian children and adolescents.[12] A recent review of literature revealed that the prevalence of overweight among school-age children increased worldwide, mainly in economically developed countries and in urbanized populations.[11]

In this present study, boys performed better than girls on all physical fitness tests, with the exception of sit-and-reach, in which girls were better. A literature review indicates that boys are about 25% more fit than girls and are 15% to 25% more physically active.[28] Higher flexibility indexes among females in comparison with males are also consistent with the literature.[29] Obese adolescents performed worse in all physical tests requiring propulsion or lifting of the body mass (long jump, curl up, pull-up, 9-minute run, 20-m run and 4-m shuttle run), in comparison with the adolescents classified as normal weight. For most of these tests, overweight students performed better than the obese ones, but worse than students classified as normal weight. These findings are supported by many researches that have explored the relationship between BMI status and physical fitness in youth.[19,30–32] One of these studies showed a marked inverse J-shaped curve of BMI along with physical fitness.[19] In the current study, however, it was not possible to estimate the effect of those categorized as underweight because they were not included in the analyses.

Flexibility scores (measured through sit-and-reach test) did not vary by BMI status, as observed by other studies with children and adolescents.[31,32] The unique test in which overweight and/or obese students performed better than the normal weight students (after adjusted analysis) was the medicine-ball throw. Similar results were observed in another study that used the same test.[19] Other research with Flemish youths verified that obese students show greater strength on handgrip than their counterparts.[30]

The physical test more strongly related to BMI status for both sexes was the 9-minute run test. Among boys, BMI status explained about 20% of the variability in this test, and among girls, about 10%. Cardiorespiratory fitness is also shown to have a linear significant positive association with fat free mass in adolescent girls.[33] In another study, BMI was inversely associated with aerobic capacity, explaining about 14% and 12% of its variability for boys and girls, respectively.[34]

In conclusion, although in some tests there were no significant differences in the scores between normal weight and overweight categories (stationary long jump, 20-m run, and 1-minute curl-up), obese students performed worse in almost all tests (except sit-and-reach and medicine-ball throw). Overweight (along with obese) students performed worse than those classified as normal weight in 2 tests (modified pull-up and 9-minute run). These differences were sharper among boys than girls, and the effect of BMI status on physical fitness was independent of age. In addition, the majority of obese children/adolescents and almost half of those overweight were classified in the third tertile of physical fitness (least fit).

A series of recommendations have been developed based on these results. If those above normal weight (overweight and obese) have higher absolute muscular strength/power than their counterparts, then physical activities that primarily involve these abilities should be promoted to these groups. This might be considered because these persons are more likely to perform these activities well and compare more favorably to their normal weight peers. Another practical recommendation is for Physical Education teachers to administer physical fitness tests more frequently during their physical education classes.

Future researches could focus on points not well investigated yet. For example, it is important to address how biological and behavioral factors may explain the effect of overweight/obesity in some physical fitness components and not in others. Besides this, longitudinal studies are required to determine the impact of physical fitness on overweight/obesity. Finally, other investigations assessing physical fitness performance among underweight children and adolescents in relation to their peers are needed.

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