Physical fitness and associations with anthropometric measurements in 7 to 15-year-old school children

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Abstract

Objective: To analyze associations between health-related physical fitness and the anthropometric and demographic indicators of children from three elementary schools in Botucatu, SP, Brazil.

Methods: The sample for this cross-sectional study was composed of 988 students, recruited from the second to ninth grades (an age range of 7 to 15 years). The children underwent anthropometric assessment (weight, height, waist circumference and tricipital and subscapular skin folds) and were tested for health-related physical fitness (flexibility: sit and reach test; abdominal strength/resistance: 1-minute abdominal test; and aerobic resistance: 9-minute running/walking test). Data were analyzed using descriptive statistics plus Student's t test, the chi-square test or Fisher's exact test and logistic regression with a significance level of 5%.

Results: The physical fitness levels observed were significantly influenced by age (all levels), sex (abdominal strength/resistance), obesity (all levels), body adiposity (flexibility, abdominal strength/resistance) and abdominal adiposity (abdominal strength/resistance and aerobic resistance). Females were more prone to be unfit in abdominal strength/resistance. Both obesity and excessive abdominal adiposity predisposed children to be unfit in abdominal strength/resistance and aerobic resistance. Excess body adiposity increased the likelihood of poor trunk flexibility.

Conclusions: Unhealthy physical fitness levels were related to female sex, obesity and excessive abdominal adiposity. Implementing programs designed to effect lifestyle changes to achieve physical fitness and healthy nutrition in these schools would meet the objectives of promoting healthy body weight and increased physical fitness among these schoolchildren.

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Introduction

Health-related physical fitness is a series of measures of physical and physiological characteristics that define the risk of premature development of diseases or morbidity and which are associated with a sedentary lifestyle,[1] or are those components of physical fitness that are affected by routine activity and are related to health status.[2]

The importance of having healthy levels of the components of health-related physical fitness (cardiorespiratory fitness,

muscle strength/resistance, body composition and flexibility) lies in their relationship with reducing the incidence of chronic diseases and with improving performance, which is why the physical fitness that comes from regular physical activity is beneficial for children.[3]

Growing concern about the harmful effects of childhood unfitness and its results in adulthood has meant that the number of studies investigating the physical fitness

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of children is increasing.[4] Additionally, diagnosing poor physical fitness levels is one possible strategy for detecting metabolic disorders.[5]

Despite consensus about its epidemiological importance, the physical fitness of Brazilian children has been investigated rarely and those studies that have been conducted are limited to regional samples.

One of the findings of these studies is a high percentage of unfitness in both sexes in certain health-related fitness levels. Both boys and girls were found to be unfit, especially so for abdominal strength/resistance and aerobic resistance, and when these results are broken down by sex, the boys are fitter in terms of theses components.[4,6]

With relation to flexibility, girls normally score better than boys; in other words sex is once more one of the variables associated with this component.[4,7]

Both sexes exhibited significant variations in abdominal and aerobic resistance, beginning from 10 to 14 years of age in boys and from 12 to 14 in girls.[8] These data suggest that age group can also be considered to be predictive of physical fitness.

Other associations, including with anthropometric measurements, are also being investigated in order to identify possible indicators of unfitness. Studies have detected a significant negative correlation between both body mass index (BMI) and waist circumference (WC) with abdominal strength/resistance and aerobic resistance,[4,9,10] and also between body adiposity and cardiorespiratory fitness.[11,12]

Considering that physical fitness testing and anthropometric assessment are preparatory steps for lifestyle-changing interventions, the objective of this study is to analyze associations between health-related physical fitness and demographic and anthropometric indicators in children from three schools from the city of Botucatu, SP, Brazil.

Methods

This was a cross-sectional study for which data were collected in 2007. A total of 988 schoolchildren (522 boys and 466 girls) aged 7 to 15 were recruited from three different elementary schools (2nd to 9th grade) with three different administration systems (municipal, philanthropic and private); all located in Botucatu. Exclusion criteria were limiting medical conditions or disabling motor disorders that precluded completion of the physical tests or refusal to participate in the study.

Data collection was conducted by Physical Education professionals and trained nutritionists from the multidisciplinary team at the Centro de Metabolismo em Exercício e Nutrição (CeMENutri), affiliated to the Public health department at the Faculdade de Medicina de Botucatu.

Health-related physical fitness components were tested in accordance with the Manual de Aplicação de Medidas e Testes, Normas e Critérios de Avaliação,[2] and results were classified by age and sex. The categories "very poor" and "poor" were collapsed together to make a "poor" category and "good," "very good" and "excellent" were collapsed into a "good" category. The fitness components assessed were: flexibility (sit and reach test), abdominal strength/resistance (1-minute abdominal test) and aerobic resistance [9-minute running/walking test, using a Garmin Forerunner® 305 GPS watch (Garmin International, USA)].

The anthropometric assessment comprised measures of body weight, height, WC and tricipital and subscapular skin folds, in accordance with World Health Organization guidelines.[13] Body weight was measured on a stand-on anthropometric scale (Filizola®, Filizola S.A., Brazil), and height was measured with a portable stadiometer (Seca®, Germany), taking the mean of three consecutive measurements for analysis and with the children unshod and wearing light clothing. The children's BMIs were then calculated and compared to the National Center for Health Statistics' BMI charts for age and sex.[14] Overweight was defined as a BMI greater than or equal to the 85th percentile, on the NCHS chart, and obesity was defined as a BMI greater than or equal to the 95th percentile. These cutoff points are those defined by the World Health Organization.[13] All percentiles and z scores were calculated using Epi-Info® (Centers for Disease Control and Prevention, USA) version 3.2 (2004).

Waist circumference was measured at the midpoint between the last rib and the iliac crest, with the child standing and after complete exhalation, using a non-stretch measuring tape marked off in millimeters (Sanny®, American Medical do Brasil, Brazil). The reference values are given in percentiles for age and sex, as proposed by McCarthy et al.[15] and values above the 90th percentile were defined as unhealthy.

Tricipital skin folds (TSF) and subscapular skin folds (SESF) were measured three times on the right side of the body using an adipometer (Lange®, Beta Technology Incorporated, Cambridge, USA) and the mean of all three measurements was used for analysis (TSF measured on the right upper arm, midway between the acromion and the olecranon, and the SESF is measured two fingers below the low point of the right scapula). Body adiposity was then estimated using the equation and sex-specific reference values proposed by Lohman,[16,17] based on summing the two skinfold measurements, with girls ≥ 25% and boys ≥ 20% classified as having moderately elevated body fat.

A descriptive analysis was performed, calculating frequencies and percentages of categorical variables (sex, BMI, WC, body fat percentage, flexibility, abdominal strength/resistance and aerobic resistance), mean and standard deviation for quantitative variables [age, weight,

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height (stature), BMI, WC, body fat percentage, flexibility, abdominal strength/resistance and aerobic resistance] and percentage distributions for flexibility, abdominal strength/resistance and aerobic resistance for both sexes.

The means of quantitative variables were compared between sexes using Student's *t* test (symmetrical distribution) or analogue test (asymmetrical distribution).

The classifications proposed for flexibility, abdominal strength/resistance and aerobic resistance were analyzed for associations with sex, BMI, WC and body fat percentage using the chi-square test or Fisher's exact test. Ordinal logistic regression models were then constructed using the proportional odds method and taking the variables observed adjusted for age.

For all tests, the significance level adopted was 5% or the corresponding p value. Analyses were performed using SAS for Windows (SAS, USA) version 9.1.3.

The school principals, parents and guardians of the schoolchildren and also children over the age of 11 signed a free and informed consent form designed to conform to the Brazilian Ministry of Health's Resolution 196/96 on research involving human beings as an obligatory prerequisite for beginning the study protocol. The study was approved by the Research Ethics Committee at the Faculdade de Medicina de Botucatu on 6 July 2009, under protocol OF.287/2009-CEP.

Results

The sample (n = 988) had a majority of males (52.9%) and mean age was 9.7±2.4 years (Table 1).

Classification by BMI showed that the majority had healthy weights (63.8%). A total of 32.8% of the sample were overweight (15.9% were overweight and 16.9% were obese), and just 3.4% were underweight. Unhealthy WC was detected in 42.5% of the sample and excess body fat in 45.4%. Of the anthropometric indicators, only body fat percentage differed between the sexes, being greater among the girls (Table 1).

According to the reference classification, the fitness component with the greatest prevalence of poor performance was abdominal strength/resistance (52.9%), followed by aerobic resistance (42.4%) and flexibility (28.4%). These figures pass the 25th percentile of the sample distribution (Table 2) by 30.2, 17.4 and 5.9%, respectively. In contrast, 37.7, 20.4 and 10% of the children had good levels of fitness for flexibility, abdominal strength/resistance and aerobic resistance, respectively.

The boys had greater abdominal strength/resistance and aerobic resistance than the girls. The girls had greater trunk flexibility in the sit and reach test (Table 1).

Table 3 lists the results of the tests of association between the flexibility, abdominal strength/resistance and aerobic resistance results and the demographic and anthropometric indicators. A Table 4 shows the proportional odds logistic regression models adjusted for age.

These schoolchildren's flexibility was only associated with body fat percentage (p = 0.018). This interaction affected children whose body fat percentage was excessive, having a 55% greater likelihood of having unhealthy flexibility levels, when compared with children with normal body fat percentages. It was also possible to observe that schoolchildren with overweight/obesity exhibited approximately 1.8 times greater chance of having good flexibility when compared with those with healthy weights.

Table 1 - Anthropometric characteristics and physical fitness levels of children from three elementary schools in Botucatu, Brazil, broken down by sex

Characteristics	Overall		Boys		Girls		
	Mean ± SD	n	Mean ± SD	n	Mean ± SD	n	p
Age (years)	9.7±2.4	988	9.8±2.4	522	9.7±2.4	466	0.6660
Weight (kg)	38.9±13.8	986	39.1±14.5	520	38.7±12.9	466	0.6504
Height (stature) (m)	1.4±0.15	982	1.4±0.15	516	1.4±0.14	466	0.7045
BMI (kg/m^2)	18.9±3.8	982	18.9±3.9	516	19.0±3.8	466	0.6050
WC (cm)	64.9±9.9	981	65.3±10.6	516	64.5±9.1	465	0.2521
Body fat percentage	21.8±7.6	980	19.5±7.6	515	24.4±6.8	465	< 0.0001
Flexibility (cm)	24.1±6.8	946	23.0±7.0	500	25.4±6.4	446	< 0.0001
Abdominal strength/resistance (rep/min)	23.9±8.7	945	26.1±8.3	499	21.6±8.6	446	< 0.0001
Aerobic resistance (m)	1,209.6±213.8	932	1,271.1±221.4	493	1,140.5±181.9	439	< 0.0001

BMI = body mass index; rep/min = repetitions per minute; SD = standard deviation; WC = waist circumference.

Table 2 - Percentiles for flexibility, abdominal strength/resistance and aerobic resistance of children from three elementary schools in Botucatu, Brazil

Sex/variables	Percentile						
	5	**10**	**25**	**50**	**75**	**90**	**95**
Boys							
Flexibility (cm)	10	13	19	24	28	31	33
Abdominal strength/resistance (rep)	12	15	21	26	31	36	39
Aerobic resistance (m)	903	989	1,122	1,269	1,419	1,530	1,634
Girls							
Flexibility (cm)	14	16	22	26	30	33	35
Abdominal strength/resistance (rep)	5	10	17	23	27	32	35
Aerobic resistance (m)	840	907	1,039	1,131	1,260	1,380	1,445

rep = repetitions.

Abdominal strength/resistance was associated with sex, BMI, WC and body fat percentage. Girls, obese children and those with WC greater than that considered healthy were, respectively, 45, 57 and 41% more likely to be classified as having poor abdominal strength/resistance when compared with boys, children with healthy weight and those with healthy WC measurements. Schoolchildren with moderately excessive body fat percentages also had

an approximately 1.6 times greater chance of having good abdominal strength/resistance.

Aerobic resistance also exhibited interactions with all of the indicators investigated. Schoolchildren with overweight/obesity and with WC greater than considered healthy had, respectively, 52, 68 and 56% greater chances of being unfit in terms of aerobic resistance when compared with those with healthy weights and those with healthy WC. Only the

Table 3 - Associations between health-related physical fitness levels and demographic and anthropometric indicators of children from three elementary schools in Botucatu, Brazil

Indicators	Flexibility				Abdominal strength/resistance				Aerobic resistance			
	Good n (%)	Reasonable n (%)	Poor n (%)	p	Good n (%)	Reasonable n (%)	Poor n (%)	p	Good n (%)	Reasonable n (%)	Poor n (%)	p
Sex												
Male	191 (20.2)	164 (17.3)	145 (15.3)	0.7370	119 (12.6)	137 (14.5)	243 (25.7)	0.0072	61 (6.6)	230 (24.7)	201 (21.6)	0.0330
Female	165 (17.4)	157 (16.6)	124 (13.2)		74 (7.8)	115 (12.2)	257 (27.2)		32 (3.4)	213 (22.9)	194 (20.8)	
BMI												
Underweight	13 (1.4)	11 (1.1)	8 (0.9)	0.9392	7 (0.8)	10 (1.1)	15 (1.6)	< 0.0001	6 (0.7)	14 (1.5)	12 (1.3)	< 0.0001
Healthy weight	219 (23.3)	210 (22.4)	166 (17.7)		143 (15.2)	169 (18.0)	283 (30.2)		80 (8.7)	315 (34.1)	194 (21)	
Overweight	63 (6.7)	47 (5.0)	44 (4.7)		27 (2.9)	45 (4.8)	82 (8.7)		4 (0.4)	64 (6.9)	80 (8.7)	
Obese	58 (6.2)	53 (5.6)	47 (5.0)		16 (1.7)	27 (2.9)	114 (12.1)		3 (0.3)	50 (5.4)	101 (11)	
WC												
Below normal	5 (0.5)	4 (0.4)	3 (0.3)	0.8170	2 (0.2)	4 (0.4)	6 (0.7)	< 0.0001	2 (0.2)	7 (0.8)	3 (0.3)	< 0.0001
Healthy	205 (21.9)	179 (19.1)	142 (15.2)		129 (13.8)	159 (17)	239 (25.6)		75 (8.1)	288 (31.3)	156 (17)	
Above normal	142 (15.2)	136 (14.6)	120 (12.8)		59 (6.3)	88 (9.4)	249 (26.6)		13 (1.4)	148 (16.1)	228 (24.8)	
Body fat percentage												
Normal	206 (21.9)	179 (19.1)	126 (13.4)	0.0181	127 (13.5)	142 (15.1)	243 (25.9)	< 0.0001	77 (8.3)	284 (30.7)	146 (15.8)	< 0.0001
Moderately excessive	70 (7.4)	55 (5.9)	51 (5.4)		37 (3.9)	57 (6.1)	81 (8.7)		9 (1)	83 (9)	81 (8.8)	
Excessive	77 (8.2)	86 (9.2)	89 (9.5)		28 (3)	53 (5.7)	170 (18.1)		6 (0.7)	76 (8.2)	162 (17.5)	

BMI = body mass index; WC = waist circumference.

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Table 4 - Proportional odds logistic regression models adjusted for age, for the health-related physical fitness of children from three elementary schools in Botucatu, Brazil

Characteristics	Flexibility	Abdominal strength/resistance	Aerobic resistance
Age	0.94 (0.88-0.99)	0.83 (0.77-0.88)	0.69 (0.64-0.75)
Sex			
Male	1.0	1.0	1.0
Female	0.94 (0.72-1.22)	0.55 (0.41-0.73)	0.79 (0.60-1.08)
BMI			
Healthy weight	1.0	1.0	1.0
Underweight	0.75 (0.33-1.67)	0.89 (0.39-2.06)	0.33 (0.13-0.83)
Overweight	1.82 (1.09-3.04)	0.79 (0.46-1.36)	0.48 (0.27-0.85)
Obese	1.89 (1.02-3.52)	0.43 (0.21-0.88)	0.32 (0.16-0.66)
WC			
Healthy	1.0	1.0	1.0
Below normal	1.40 (0.44-4.43)	1.31 (0.40-4.33)	2.22 (0.62-7.94)
Above normal	0.84 (0.55-1.29)	0.59 (0.37-0.93)	0.44 (0.27-0.72)
Body fat percentage			
Normal	1.0	1.0	1.0
Moderately excessive	0.81 (0.54-1.23)	1.57 (1.02-2.42)	0.89 (0.56-1.41)
Excessive	0.45 (0.26-0.78)	1.09 (0.60-1.98)	0.78 (0.42-1.43)

BMI = body mass index; WC = waist circumference.

association with body fat percentage was not confirmed by the regression model chosen.

Therefore, the physical fitness levels investigated were significantly influenced by age (all of them), sex (abdominal strength/resistance), obesity (all), body adiposity (flexibility, abdominal strength/resistance) and abdominal adiposity (abdominal strength/resistance and aerobic resistance).

Girls were more prone to be unfit in terms of abdominal strength/resistance and obesity and excessive abdominal adiposity predisposed schoolchildren of both sexes to exhibit poor abdominal strength/resistance and aerobic resistance fitness levels. Excessive body adiposity increased the likelihood of poor trunk flexibility.

Discussion

In the literature, studies describing the health-related physical fitness of Brazilian children are rare. Particularly so with relation to the Southeast of the country. Evaluating the trends in physical fitness component levels among children and adolescents should provide useful information on which to base public policies to promote better quality of life and general health status within this population, both today and in the future.

The objective of this study was to investigate the health-related physical fitness of schoolchildren from three schools that are distinct from one another in terms of their funding, administration, school meals provision and supervised physical activity and to test its association with demographic and anthropometric indicators.

Of the physical fitness components tested here, flexibility was the most homogeneous in terms of classification. More children were unfit in terms of abdominal strength/resistance and aerobic resistance, which may be related to a low level of physical activity, since regular, systematic, physical activity can contribute to improving many different components of health-related physical fitness.[7,18]

Although the girls were more flexible than the boys – corroborating the findings of other studies of children and adolescents–,[4,7] in this sample, sex did not influence flexibility. This result contrasts with what was observed among children at elementary schools in the town of Rio Grande, RS, Brazil, where sex was the variable most strongly associated with flexibility.[4] This difference in results may reflect the distinct characteristics of the two samples.

In contrast with flexibility, abdominal strength/resistance and aerobic resistance were better among the boys. This is similar to observations of schoolchildren from Rio Grande, RS, and from Jequié, BA (both in Brazil) where these two components exhibited interactions with sex, in agreement with what was observed among elementary school children.[4,6]

Additionally, this study found that girls were more likely to have poor fitness in terms of abdominal strength/resistance. Since low physical activity levels can be prejudicial for fitness,[7,18] and since inactivity is more associated with girls,[19] this may explain our results. However, physical activity levels were not assessed for this study, which makes it impossible to confirm this hypothesis.

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With regard to associations between physical fitness and anthropometric indicators, interactions were observed between flexibility and BMI and body fat percentage corporal and between abdominal strength/resistance and aerobic resistance with all indicators analyzed (BMI, WC and body fat percentage).

Studies indicate significant negative correlations between BMI and WC and the components abdominal strength/resistance and aerobic resistance.[4,9,10] These results are consistent with our study, since schoolchildren who were obese and those with excessive abdominal adiposity proved more susceptible to poor fitness in both, while schoolchildren with overweight exhibited a tendency to poor results for aerobic resistance.

Although in isolation BMI has low sensitivity for the diagnosis of excess body fat in children and adolescents,[13] and although it is this same fat that may worsen performance in fitness tests, the indicator proved sensitive for detecting it and was also endorsed by the results for WC, both for abdominal strength/resistance and for aerobic resistance.

Cardiorespiratory fitness has exhibited a strong association with total adiposity, more so than other components of fitness.[11,12,20,21] However, in this study it was schoolchildren with a moderately excessive body fat percentage who proved most likely to have good abdominal strength/resistance, thereby contradicting the results for BMI and WC.

It is suggested that this contradiction is the result of the indirect method used to evaluate body fat in this study, rather than a gold standard technique like dual energy X-ray absorptiometry (DEXA), which is a limitation.

Other limitations that merit consideration are the sample of convenience, since the assessments were conducted in just three of the city's schools, which is not representative of the city as a whole. As a consequence, the results cannot be extrapolated to all schoolchildren in elementary education in Botucatu and even less so to schoolchildren from other areas. Additionally, since parents and children over 11 had to sign consent forms to take part, it is possible that those who refused were less fit than those who consented.

In conclusion physical unfitness was related to female sex, to obesity and to excessive abdominal adiposity. These results indicate a need for intervention with health promotion programs designed to effect lifestyle changes, emphasizing working on, improving and developing the components of physical fitness and including dietary reeducation designed to prevent the emergence and progression of hypokinetic dysfunctions.

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