Comparison Analysis of Blood Pressure, Obesity, and Cardio-respiratory Fitness in Schoolchildren

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Abstract

Background: During childhood and adolescence, physical inactivity, excess weight, and poor nutrition are risk factors for chronic diseases, especially obesity, hypertension, and diabetes mellitus. Early intervention can prevent the development of these complications.

Objective: To determine the presence of cardiovascular risk (obesity and hypertension) in schoolchildren and its potential interactions with cardio-respiratory fitness.

Methods: This was a cross-sectional study conducted in a stratified cluster sample of 1,666 schoolchildren, aged between 7 and 17 years, 873 (52.4%) of them male and 793 (47.6%) of them female. The following variables were evaluated: systolic blood pressure (SBP), diastolic blood pressure (DBP), body mass index (BMI), body fat percentage (BF %), and cardio-respiratory fitness. SBP and DBP were correlated with waist circumference (WC), waist-hip ratio (WHR), sum of skin folds (∑SF), and cardio-respiratory fitness.

Results: A BMI assessment of the students showed that 26.7% of them were overweight or obese, and 35.9% had body fat percentage over moderately high. As to blood pressure, we found that 13.9% and 12.1% of the students were borderline or hypertensive, for SBP and DBP, respectively. There was an association among hypertension, obesity, and cardio-respiratory fitness. There was a significant correlation of SBP and DBP with all variables, and also a weak to moderate correlation with age, weight, height, BMI, and waist circumference.

Conclusion: The presence of hypertension associated with obesity and its effects on cardio-respiratory fitness stress the importance of recommending, since childhood, a more active and healthy lifestyle. (Arq Bras Cardiol 2010;94(6) : 739-744)

Key words: Hypertension; obesity; total lung capacity; risk factors; child; adolescents.

Introduction

The clinical complications of coronary artery disease begin to occur mainly at middle age. However, atherosclerosis is a process that starts in childhood[1] and progresses with age[2]. Multiple risk factors are associated with atherosclerosis, such as obesity; high blood pressure; dyslipidemia; insulin resistance; and diabetes mellitus, as well as smoking habit and a sedentary lifestyle[2,3].

An increased prevalence of severe obesity among children and adolescents has been observed in recent decades. Its relationship with other morbidities also indicates that there should be greater control of these young people, because this is a major public health concern worldwide[4]. In Brazil, the prevalence of overweight and obesity among children aged 6 to 17 years during the years of 1974 and 1997 tripled from 4.1% to 13.9%[5]. American data show an increase of up to 300% since 1960[6].

Obesity is characterized by an excessive accumulation of body fat, caused largely by a chronic imbalance represented by a caloric intake greater than the metabolic demand. Its diagnosis is made by quantifying the proportion of fat stored in the body in relation to other tissues[7]. Factors such as lifestyle, eating habits that favor hypercaloric and hyperlipidemic diets, and sedentary lifestyle, are among some of the explanations for this phenomenon[8].

Hypertension is a chronic disease; its prevalence is increasing among children, and may be secondary to other conditions related to kidney, heart, and endocrine diseases, or may have a primary or essential, idiopathic origin[9]. Hypertension is associated with obesity, a fact described by several authors[10-14].

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Due to the important influence of hypertension and obesity on the health status of schoolchildren, which may affect their adult health status, the goal of this study was to analyze the profile of these two cardiovascular risk factors in schoolchildren, in order to verify a possible interaction between these factors and their relationship with cardio-respiratory fitness.

Method

This was a cross-sectional study comprising 1,666 schoolchildren, 873 (52.4%) of them male and 793 (47.6%) of them female, aged between 7 and 17 years, randomly selected from a stratified cluster sample (center and north, south, east and west, in the periphery of the urban area; and north, south, east and west, in the rural area), from 18 schools (14 in the urban area, and 4 in the rural area), in the municipality of Santa Cruz do Sul, in the State of Rio Grande do Sul.

The project was submitted and approved by the Ethics in Research Committee of the University of Santa Cruz do Sul (CEP-Unisc) under Protocol 4913-2007, Letter No. 261/07, in accordance with the Declaration of Helsinki. Parents or guardians signed the informed consent at study entry, allowing the participation of their children in assessments and tests.

The body mass index (BMI) was calculated as weight (kg)/height^2 (m) and subsequently classified according to the Conde and Monteiro[15], Gaya and Silva[16] protocol. For the evaluation of the sum of skin folds ($\sum$SF) and body fat percentage (BF%), the triceps skinfold thickness and the subscapular skinfold thickness were measured with a Lange caliper. To calculate the BF%, we used the Slaughter et al[17] equation, and the result was then classified according to Heyward e Stolarczyv[17] data.

The waist circumference was measured with the subject standing, with arms hanging freely. We used a tape to measure the waist circumference in centimeters, considering the narrowest part of the trunk between the ribs and the iliac crest and the hip at the level of the greater trochanter as references. The waist-hip ratio was obtained by dividing the waist circumference (cm) by the hip circumference (cm)[17].

Blood pressure was measured with the subject sitting at rest. We used a sphygmomanometer and a stethoscope in the right arm and a cuff appropriate for the arm circumference of each subject. Blood pressure was classified by the 90th and the 95th percentile for borderline and hypertensive ranges, respectively, according to the parameters of the Brazilian Society of Hypertension[18].

To evaluate the cardio-respiratory fitness we used the general endurance test, with a 9-minute run/walk test to assess the distance traveled. The test was classified according to the tables of the Projeto Esporte Brasil (PROESP-BR)[16].

For statistical treatment of data, we used the SPSS 16.0 software for Windows, employing descriptive statistics. A Poisson regression was performed with robust adjustment for variance to estimate gross and adjusted prevalence ratios[19]. We used the X^2 test for variable categories, and Pearson's correlation, with significant differences at $p < 0.05$, and a confidence interval of 95%.

Results

According to Table 1, we observed that 71.3% of the students were within the normal BMI range, with a percentage of 72.0% and 70.4% for boys and girls, respectively. The BMI assessment showed that 27.1% of the boys and 26.4% of the girls were overweight or obese. A high proportion of students with increased body fat percentage (moderately high, high, and very high) was also observed, reaching up to 33.8% among boys and 38.5% among girls. Also in table 1, we observed that most of the students had normal range SBP and DBP levels. The percentage of students in SBP borderline and SBP hypertensive ranges were 5.2% and 8.7%, respectively, and for DBP, they were 7.0% and 5.1%, respectively. As to gender, girls and boys had similar results, but boys showed slightly higher results.

Table 2 compares the systolic and diastolic pressures with cardio-respiratory fitness, and shows that students with better cardio-respiratory fitness (good, very good, and excellent) had better results. A gradual increase in the number of normal blood pressure subjects was observed, as the classification of cardio-respiratory fitness increased; and an increase in borderline and hypertensive students was observed as this classification decreased. It was assumed that the students with better classification of cardio-respiratory fitness were the most physically active ones. Students in the overweight and obese groups also had a worse performance in the cardio-respiratory test. The fitness classification "poor" included the following categories: very weak and weak. The fitness classification "good" included the following categories: good, very good, and excellent.

Table 3 shows that the results of the cardio-respiratory test were 50% lower for the overweight group when compared to the normal group. The obese group had 120% lower results when compared to the normal group.

Table 4 evaluates possible relationships between the dependent variables (systolic and diastolic) and the independent variables (gender; age; weight; height; body mass index; waist circumference; waist-hip ratio; sum of skin folds; body fat percentage; and cardio-respiratory fitness), observing a significant correlation ($p < 0.05$) in all of them. As for SBP, there was a moderate correlation with weight and height, and a weak correlation with age, body mass index, waist circumference, and sum of skin folds. As for DBP, we found only a moderate correlation with weight, and a weak correlation with age, height, body mass index, and waist circumference.

Discussion

In reference to BMI and body fat percentage, most students were in the normal range (71.3% and 51.4%, respectively). However, the percentage of students in the classes that indicated obesity was high for both BMI and body fat percentage. As to gender, boys and girls showed similar results for these classes: 27.1 and 26.4%, respectively.

The prevalence of overweight and obesity among adolescents was lower in Fortaleza (19.5%). Males showed a slightly higher percentage (20.0%) compared to females (19.0%)[20]. But in Spain, the percentage of overweight and obese children aged

Table 1 – BMI, BF%, SBP and DBP, according to gender

BMI, BF%, SBP and DBP	Male	Female	Total
	n (%)	n (%)	n (%)
BMI classification			
Underweight	8 (0.9)	25 (3.2)	33 (2.0)
Normal	629 (72.0)	559 (70.4)	1.188 (71.3)
Overweight	183 (21.0)	134 (16.9)	317 (19.0)
Obese	53 (6.1)	75 (9.5)	128 (7.7)
BF% classification			
Very low	1 (0.1)	5 (0.6)	6 (0.4)
Low	127 (14.5)	77 (9.7)	204 (12.2)
Normal	450 (51.5)	406 (51.2)	856 (51.4)
Moderately high	127 (14.5)	165 (20.8)	292 (17.5)
High	95 (10.9)	99 (12.5)	194 (11.6)
Very high	73 (8.4)	41 (5.2)	114 (6.8)
SBP			
Normal	745 (85.3)	690 (87.0)	1.435 (86.1)
Borderline	37 (4.3)	49 (6.2)	86 (5.2)
Hypertensive	91 (10.4)	54 (6.8)	145 (8.7)
DBP			
Normal	766 (87.7)	699 (88.1)	1.465 (87.9)
Borderline	62 (7.1)	54 (6.8)	116 (7.0)
Hypertensive	45 (5.2)	40 (5.1)	85 (5.1)
Total	873 (100.0)	793 (100.0)	1.666 (100.0)

BMI - body mass index; BF% - body fat percentage; SBP - systolic blood pressure; DBP - diastolic blood pressure.

7 to 12 years reached higher values (38.0%), with a higher prevalence among girls (41.0%) than among boys (35.0 %)[21]. In Los Angeles, students aged between 11 and 13 years had higher values than those found in this study, and 51.4% of them were at risk of overweight and obesity[22].

As to body fat percentage, the students showed even more unsatisfactory results, reaching up to 35.9% for the classes that indicated obesity (moderately high, high, and very high). As to gender, girls showed better results (38.5%) than boys (33.8%), which was an expected finding because of the female growth pattern and pubertal development. Similar results were found in children in Londrina, where the body fat percentage, although lower than in the present study, proved to be of equal concern. However, unlike this study, boys had higher values than girls. The study conducted in the State of Parana also suggests that the body fat percentage is a better indicator of obesity than BMI, as it is a more sensitive technique which detects only body fat, unlike BMI[23]. However, the World Health Organization (WHO) considers the measurement of skin folds as a complement to weight and height measurements in the estimation of body fat, because of methodological difficulties in obtaining reliable values.

In this study, despite a high prevalence of normal SBP and DBP levels, borderline and hypertensive students, both for SBP and DBP, deserve attention, because they are children and adolescents with greater risk of developing cardiovascular problems later in life. Combining borderline and hypertensive groups, boys had slightly higher values (14.7% and 13.0%) than girls (12.2% and 11.9%) for SBP and DBP, respectively. A statistically significant difference in SBP was observed, in favor of females. In Niterói, studies conducted in adolescents showed similar results, but with lower values, in relation to hypertension, with 3.1% and 2.2% for SBP and DBP, respectively[14]. Higher values were found in American schools: 32.1% (boys) and 22.3% (girls) with pre-hypertension and hypertension[24].

Also in relation to SBP and DBP, in this study, a low to moderate correlation was observed with the following variables: age, weight, height, BMI, and waist circumference. In a study conducted in school in Argentina, a moderate correlation between SBP/DBP and waist circumference was also identified.[11] Corroborating this study, we also found associations between blood pressure, both systolic and diastolic, and age, weight, height, and waist circumference, in children and adolescents in Fortaleza[25].

As the magnitude of the long-distance running test (9 minutes) was evaluated, we found that the results may be influenced by the individual's ability to produce energy

Table 2 - Cardio-respiratory fitness according to gender, blood pressure, and BMI

Variables	Cardio-respiratory fitness		
	Poor	Good	p
Gender			
Male	440 (50.4%)	433 (49.6%)	0.032
Female	358 (45.1%)	435 (54.9%)	0.032
Age (y)			
7 to 9	161 (38.4%)	258 (61.6%)	<0.001
10 to 12	244 (49.9%)	245 (50.1%)	<0.001
13 to 17	393 (51.8%)	365 (48.2%)	<0.001
SBP			
Normal	672 (46.8%)	763 (53.2%)	0.079
Borderline	49 (57%)	37 (43%)	0.079
Hypertensive	77 (53.1%)	68 (46.9%)	0.079
DBP			
Normal	685 (46.8%)	780 (53.2%)	0.037
Borderline	67 (57.8%)	49 (42.2%)	0.037
Hypertensive	46 (54.1%)	39 (45.9%)	0.037
BMI			
Underweight	21 (63.6%)	12 (36.4%)	<0.001
Normal	477 (40.2%)	711 (59.8%)	<0.001
Overweight	195 (61.5%)	122 (38.5%)	<0.001
Obese	105 (82%)	23 (18%)	<0.001

Figures presented in absolute and relative frequencies. Pearson X^2 Test.

aerobically. Some authors have published studies to determine the correction coefficient between the duration and the distance of the test and the maximum oxygen consumption. However, to date, the values of these correction coefficients are varied. Therefore, the results of the cardio-respiratory fitness test were maintained in categories[26,27].

Regarding cardio-respiratory fitness, as the students' classification decreased there was an increase in the number of borderline and hypertensive subjects. It was assumed that these children and adolescents engaged in less physical activity than the students who had obtained satisfactory results. A study conducted among European children and adolescents demonstrated that cardio-respiratory fitness had a significant relationship with systolic and diastolic pressures[28].

Table 3 - Regression in relation to cardiopulmonary exercise testing

Variables	Gross PR (95% CI)	Adjusted PR (95% CI)
Age (y)		
7 to 9	1	1
10 to 12	1.3 (1.1; 1.5)	1.3 (1.1; 1.5)
13 to 17	1.3 (1.2; 1.6)	1.4 (1.3; 1.7)
SBP		
Normal	1	1
Borderline	1.2 (1; 1.5)	1 (1; 1.2)
Hypertensive	1.1 (1; 1.3)	0.9 (0.8; 1)
DBP		
Normal	1	1
Borderline	1.2 (1; 1.5)	1.1 (1; 1.3)
Hypertensive	1.2 (1; 1.4)	1 (0.8; 1.5)
BMI		
Normal	1	1
Overweight	1.5 (1.3; 1.7)	1.5(1.4; 1.7)
Obese	2. (1.8; 2.2)	2.2 (2; 2.5)

Gross and adjusted prevalence ratios (PR) for variables.

In accordance with some previous studies, we found that the amount of fat on the body weight may also be characterized as another influential factor in the relationship among long distance running test scores. According to Cureton et al[29] results of running tests are adversely affected by the amount of body fat.

As to BMI we observed that as its classification increased, there was an increase in the number of borderline and hypertensive subjects. Thus, when combined, overweight and obesity classes account for 19.1% (borderline) and 40.7% (hypertension) for SBP, and 15.2% (borderline) and 26.4% (hypertension) for DBP. The same was true regarding body fat percentage. When combining moderately high, high, and very high classes, the figures were even more inadequate, reaching 22.6% (borderline) and 50.8% (hypertension) for SBP, and 28.7% (borderline) and 30.4% (hypertensive) for DBP. In a study conducted among obese children and adolescents in Delaware, U.S.A., 34.7% had high blood pressure. Of these, 27.9% had prehypertension, and 6.8%, hypertension[30].

Table 4 - Correlation between SBP and DBP with independent variables

		Gender	Age	Weight	Height	BMI	WC	WHR	∑ SF	BF%	General endurance
SBP	C	-0.090	0.474*	0.597**	0.522**	0.476*	0.498**	-0.120	0.300*	0.292	0.125
	p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DBP	C	-0.050	0.416*	0.507**	0.443*	0.413*	0.405*	-0.146	0.269	0.266	0.099
	p	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

** Weak correlation (r = 0.30 to r = 0.49), ** moderate correlation (r = 0.50 to r = 0.69); C - Pearson correlation coefficient, p - significance level (p <0.05), SBP - systolic blood pressure, DBP - diastolic blood pressure, BMI - body mass index, BF% - body fat percentage, WC - waist circumference, WHR - waist-hip ratio; Σ SF - sum of skin folds.*

Another American study with children and adolescents has also demonstrated an association between BMI and blood pressure: as the BMI class increased, SBP and DBP also increased[31], corroborating the results of this study, thus showing that there are associations between these variables.

It is important to highlight some possible methodological limitations of this study. First, it is a cross-sectional study, with no monitoring over time in the study subjects, despite the number of participants. Another limiting factor may be related to the large number of evaluators in the study - although they had all been trained, there may be bias in their evaluation.

From this study we concluded that special attention should be given to the general health status of children and adolescents, as the results demonstrated the existence of disquieting cases of obesity and hypertension among these youngsters, and a relationship with some risk factors for cardiovascular disease.

It is worth noting that the more sedentary and obese subjects showed a high percentage of hypertension and therefore a higher risk of developing diseases in adulthood. Thus, greater control over eating habits and physical activity of school-aged children is essential in order to prevent these early risk factors and prevent the occurrence of premature cardiovascular disease.

Therefore, measures should be taken to promote health through the engagement of parents, teachers, health professionals, and government agencies in establishing policies regarding the promotion of a healthier lifestyle.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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