Original Article

Elevated Blood Pressure and Obesity in Childhood: A Cross-Sectional Evaluation of 4,609 Schoolchildren

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Abstract

Background: The incidence of obesity in children is increasing worldwide, primarily in urbanized, high-income countries, and hypertension development is a detrimental effect of this phenomenon.

Objective: In this cross-sectional study, we evaluated the prevalence of excess weight and its association with high blood pressure (BP) in schoolchildren.

Methods: Here 4,609 male and female children, aged 6 to 11 years, from 24 public and private schools in Maringa, Brazil, were evaluated. Nutritional status was assessed by body mass index (BMI) according to cutoff points adjusted for sex and age. Blood pressure (BP) levels above 90th percentile for gender, age and height percentile were considered elevated.

Results: The prevalence of excess weight among the schoolchildren was 24.5%; 16.9% were overweight, and 7.6% were obese. Sex and socioeconomic characteristics were not associated with elevated BP. In all age groups, systolic and diastolic BP correlated with BMI and waist and hip measurements, but not with waist-hip ratio. The prevalence of elevated BP was 11.2% in eutrophic children, 20.6% in overweight children [odds ratio (OR), 1.99; 95% confidence interval (CI), 1.61–2.45], and 39.7% in obese children (OR, 5.4; 95% CI, 4.23–6.89).

Conclusion: Obese and overweight children had a higher prevalence of elevated BP than normal-weight children. Our data confirm that the growing worldwide epidemic of excess weight and elevated BP in schoolchildren may also be ongoing in Brazil. (Arq Bras Cardiol. 2014; 103(3):238-244)

Keywords: Hypertension; Pediatric Obesity; Child; Prevalence; Epidemiology.

Introduction

The incidence of obesity and high blood pressure (BP) has increased considerably in children and adolescents and is strongly associated with the development of further disease in adulthood[1-7] Moreover, because the incidence of obesity is rising in early phases of life, certain diseases, such as hypertension and diabetes, are becoming a public health issue.

In the 1990s, the prevalence of hypertension among children and adolescents was approximately 2 to 3%[8]. Currently, the prevalence varies from 1 to 13% depending on the methodology used[9]. Because obesity has become epidemic in developing countries, the incidence of hypertension also may be increasing. Recognition and awareness of this problem are needed to encourage development of future preventive strategies against excess weight and its complications.

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Brazil has intrinsic discrepancies and socioeconomic inequalities in common with other developing nations. In Brazil, there have been few studies showing a correlation between BP and obesity in children. Thus, the purpose of the present cross-sectional study was to evaluate the prevalence of excess weight and its association with high BP in schoolchildren.

Methods

This study was designed using the national register of children enrolled in schools in the metropolitan area of Maringa, a city in southern Brazil with a high Human Development Index (0.841) and a high Gini Index (0.56). Maringa has an economy primarily based on agriculture, commerce, and services. At the time this study was planned, Maringa had a population of approximately 356,000 people and 24,723 students between the ages of 6 and 11 years.

In 2006, there were 202 schools in the city of Maringa (public and private schools in the urban area) with an enrollment of 22,302 children aged 6.0 to 11 years. For sample size calculation, considering that the expected prevalence of excess weight was unknown because of the lack of previous studies in the area, the prevalence was set to 50% as this value would produce the largest sample size (confidence limits 2% and confidence level 95%). A clustering sampling was performed considering each school as a sampling unit. Accordingly, the city was divided into 4 different geographical quadrants by taking the municipal cathedral located in the middle of the city as the intersection point of the north–south/east–west dividing line. Fifteen percent of the schools in the city were randomly selected and were selected according to the proportion of schools in each quadrant; the proportion between private and public schools was also considered. In anticipation of possible losses, 30% more children than the calculated sample size were invited to participate in the study (a total of 5,345 children from 24 schools). Data collection occurred between March and December 2006.

This cross-sectional study was approved by the Ethics Committee of the Universidade Estadual de Maringa (n. 016/2006) according to the norms of Resolution 196/96 of the National Health Council regarding research involving human beings.

The students enrolled in the selected schools and grades were notified of the study and instructed to take a term of consent document and questionnaire to their parent or guardian to obtain permission to participate in the study. One week later, the children were asked to hand in the signed authorization and evaluated at the school.

Children younger than 6 or older than 11 years were evaluated to avoid peer resentment, but their data were not entered in the sample. Children who either refused, did not receive authorization from their parent or guardian, whose forms were not filled out completely, or were absent from class on the day scheduled for data collection were excluded from the study.

Data collection

Data collection was performed in the school environment (in private classrooms) at prescheduled hours during a school day by a team of previously trained professionals[10]; these professionals were members of the Studies in Obesity and Exercise Research Group of the Universidade Estadual de Maringa (GREPO/UEM).

BP was measured and classified as proposed by the 4th Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents[11] and was measured after the child had been lying down for at least 5 min, with the 2 measurements made 10 min apart. Values for sex, height, and age below the 90^{th} percentile were considered normotensive, those between the 90^{th} and 95^{th} percentile were considered borderline, and those at the 95^{th} percentile and above were considered to be elevated. The outcome measured in this study was elevated BP, which was determined for the elevated and borderline groups.

Weight and height measurements were performed in triplicate, and the mean value was used. The procedures used for weight and height evaluation followed those proposed by the World Health Organization[12]. The equipment used included a Tanita digital scale (Model 2202), with a capacity of 136 kg and ability to measure to the nearest 100 g, and a SECA stadiometer (Bodymeter 206). The nutritional profile was classified by body mass index (BMI) according to cutoff points adjusted for sex and age, as proposed by Cole[13,14].

Waist and hip circumferences were obtained by using a metallic measuring tape with an accuracy of 0.1 mm, following the norms described previously[15]. These waist and hip parameters allowed construction of the waist-to-hip ratio (WHR), which was the quotient obtained by dividing the waist circumference by the hip circumference.

Socioeconomic level was determined according to the Brazilian Association of Research Firms (ABEP) criteria[16], which considered the presence of consumer goods and educational level of the head of the household. As proposed in the ABEP criteria, educational level was classified as illiterate, primary education, middle education, high school, or superior (university). For our analysis, we divided the children into 2 groups according to heads of households with lower (illiterate, primary, and middle) and higher (high school and university) degree of education. In addition, for analysis purposes, the socioeconomic level was regrouped as follows: level A (classes A1 and A2), level B (classes B1 and B2), level C (C1 and C2), and level D, with A being the highest level and D being the lowest. Inconsistent data in the socioeconomic level of the household head were excluded only for these items.

Statistical analysis

Descriptive statistical values were described as means ± standard deviations (SDs) (quantitative variables) or frequencies and percentages (qualitative variables). Pearson's correlation coefficients were estimated to evaluate the association between systolic and diastolic BP and anthropometric measures. For quantitative variables, one-way ANOVA was used to compare groups defined by BMI (underweight, eutrophic, overweight, and obese). Student's t test was used to compare groups defined by BP levels. The chi-square test was used for comparing qualitative variables among groups. The logistic regression model was adjusted to assess factors associated with normal or borderline/elevated BP. All assumptions of logistic regression were checked and met. Variables with statistical significance in the univariate analysis were included in the multivariable model, and the results are shown as ORs [95% confidence interval (CI)]. Statistical significance was set at $p < 0.05$. SPSS v.14.0 software was used for data analysis.

Results

The characteristics of the 4,609 schoolchildren between 6 and 11 years of age enrolled in the study were analyzed with regard to their nutritional status (Table 1). In this study, 99.8% of the children declared their race to be white. Population age, type of school health behaviors, and socioeconomic status of the family were recorded.

Fifty-three percent of the children were female, and 78% were studying in public schools. Excess of weight was found in 24.5% of the sample; 16.9% of the children were overweight and 7.6% were obese. Being overweight was more prevalent in males than in females ($p = 0.008$). The prevalence of being overweight was higher in private than in public schools (22.2% and 15.4%, respectively, $p < 0.001$), and the distribution of weight varied significantly according to socioeconomic status stratum ($p < 0.001$).

Table 1 – Distribution of the BMI of studied schoolchildren classified by sex, age, type of school, educational level, and socioeconomic status of the head of household

Variable	All (n = 4609)	Underweight n = 353 (7.7%)	Eutrophic n = 3128 (67.9%)	Overweight n = 778 (16.9%)	Obese n = 350(7.6%)	p-value*
Gender						0.008
Female	2455 (53.3%)	203 (8,2%)	1695 (69%)	393 (16%)	164 (6,6%)	
Male	2154 (46.7%)	150 (6,0%)	1433 (66,5%)	385 (17,8%)	186 (8,6%)	
Age (years)	8.63 ± 1.27	8.75 ± 1.23	8.63 ± 1.28	8.78 ± 1.26	8.54 ± 1.28	0.003
Type of school						< 0.001
Private	976 (21.2%)	44(4,5%)	639(65,4%)	217(22,2%)	76(7,5%)	
Public	3633 (78.8%)	309(8,5%)	2489(68,5%)	561(15,4%)	274(7%)	
Educational level						0.353
Lower	1939 (42.1%)	158 (8,1%)	1328 (68,4%)	308 (15,8%)	145 (7,4%)	
Higher	2670 (57.9%)	195 (7,3%)	1800 (67,4%)	470 (17,6%)	205 (7,6%)	
Socioeconomic status						< 0.001
A/B	2481 (54.0%)	162 (6,5%)	1635 (65,9%)	480 (19,3%)	204 (8,2%)	
C/D	2112 (46.0%)	188 (8,9%)	1482 (70,1%)	296 (14%)	146 (6,9%)	

*Results are expressed as means ± standard deviations or frequency (%). *One-way ANOVA or chi-square test, p < 0.05. Socioeconomic status: 16 missing values.*

Table 2 shows BP by age group and its correlation coefficients according to BMI, waist circumference, hip circumference, and WHR ratio. In all age groups, systolic and diastolic BP were both positively and significantly correlated with BMI, waist circumference, and hip circumference but not with WHR (with a significant but low correlation for the 8-year-old children's group). The correlation was stronger for the older age groups than for the younger age groups both for systolic and diastolic BP.

The associations between normal and borderline/high BP with sex and socioeconomic characteristics are shown in Table 3. Elevated BP (borderline levels and high BP combined) was found in 14.4% of the total population and was not associated with sex or level of educational or socioeconomic status (p = 0.884, p = 0.683, and p = 0.785). However, while the prevalence of elevated BP was 11.2% in eutrophic children, in those with overweight the prevalence was 20.6% and in the obese children was 39.7%.

Figure 1 shows the association of elevated BP with age, BMI, and type of school. The chance of having elevated BP increased 19% with every year of increase in age (OR, 1.19; 95% CI, 1.11–1.27). The eutrophic category was used as a reference, and the OR (95% CI) of having elevated BP was 5.40 (4.23–6.89)-fold higher among obese than among eutrophic children. Compared with children in public schools, children in private schools had a marginally significant chance [OR, 1.23; 95% CI, 1.01–1.50] of showing elevated BP.

Discussion

In this study, we showed that excessive weight was highly prevalent in our population of schoolchildren. We also showed that 25% of the evaluated children were overweight or obese. Moreover, we found a significant association between being overweight or obese and elevated BP in this population.

Even though the prevalence determined in this study is concerning, it is still lower than those found in other national studies. Previous reports of studies conducted in Brazil found that the excess weight prevalence among boys in 1974–1975 was 10.9%, increased to 15.0% in 1989, and was 34.8% in 2008–2009. A similar pattern was observed among girls who showed prevalences for the same periods of 8.6%, 11.9%, and 32.0%, respectively. Our findings are in the range of those reported from international population studies. Gupta et al[17] reported the prevalences in some other developing countries: 41.8% in Mexico 22.0% in India, and 19.3% in Argentina for populations of similar ages as those in the present study.

In 2002, there were more than 155 million schoolchildren with excess weight worldwide. The prevalence of being overweight is estimated to be increasing 1% every year in developed countries, which affects 15 million children and adolescents[18]. Although underweight status due to malnutrition can occur in early years of life, excessive weight is prevalent among all other ages. Changes in nutritional habits and lack of physical activity in the Brazilian population may explain these findings[19]. In fact, there is a complex relationship between rapid weight changes in childhood and adolescence and various factors, including genetics, social environment, parental life style, and dietetic behavior[20-23]. Therefore, several studies have attempted to identify determinants of childhood obesity and associated diseases[24-26].

Our results showed that obese children had a 5.4% chance of having elevated levels of BP relative to eutrophic children[19]. High or borderline BP was almost twice as prevalent in overweight children than in eutrophic children, a finding that is consistent with the increasing excess weight and high BP epidemics in schoolchildren seen worldwide. Moreover,

Table 2 – Correlation coefficient between BP (systolic and diastolic) and anthropometric measures (waist, hips, and waist-hip ratio)

Age (years)	BP (mmHg)	Mean ± SD	BMI (kg/m²)	Waist (cm)	Hips (cm)	Waist-hip ratio
6	Mean ± SD		16.6 ± 2.6	55.1 ± 6.1	64.5 ± 6.53	0.9 ± 0.04
(n = 515)	Systolic	95.4 ± 10.7	0.40*	0.41*	0.40*	0.08
	Diastolic	59.3 ± 9.7	0.30*	0.30*	0.30*	0.05
7	Mean ± SD		16.8 ± 2.6	56.3 ± 6.2	66.5 ± 6.74	0.8 ± 0.04
(n = 1037)	Systolic	96.6 ± 10.9	0.38*	0.38*	0.40*	0.03
	Diastolic	59.5 ± 9.4	0.29*	0.28*	0.28*	0.03
8	Mean ± SD		17.5 ± 3	58.9 ± 7.1	70.3 ± 7.52	0.8 ± 0.04
(n = 1108)	Systolic	98.9 ± 11	0.44*	0.45*	0.45*	0.11*
	Diastolic	60.5 ± 9.6	0.34*	0.33*	0.31*	0.11*
9	Mean ± SD		17.9 ± 3.3	60.8 ± 8	73.1 ± 8.06	0.8 ± 0.05
(n = 1045)	Systolic	100.5 ± 10.8	0.45*	0.44*	0.47*	0.07
	Diastolic	60.9 ± 8.9	0.35*	0.34*	0.37*	0.06
10	Mean ± SD		18.5 ± 3.4	63 ± 8.3	76.7 ± 8.49	0.8 ± 0.05
(n = 904)	Systolic	103.5 ± 11.1	0.42*	0.42*	0.47*	0.05
	Diastolic	62.6 ± 9.1	0.34*	0.32*	0.37*	0.02
All	Mean ± SD		17.5 ± 3.1	59.1 ± 7.8	70.7 ± 8.61	0.8 ± 0.05
(n = 4609)	Systolic	99.3 ± 11.2	0.45*	0.46*	0.49*	0.01
	Diastolic	60.7 ± 9.4	0.34*	0.33*	0.34*	0.03

*SD: standard deviation. *Denotes p < 0.05; BP: blood pressure; BMI: body mass index.*

Table 3 – Evaluation of elevated blood pressure (BP) (borderline and high BP) according to sex and socioeconomic characteristics

Variable	N	Normal BP n = 3943 (85.6%)	Borderline/High BP n = 666 (14.4%)	p-value* (univariate)
Sex				
Female	2455	2102 (85.6)	353 (14.4)	
Male	2154	1841 (85.5)	313 (14.5)	0.884
Educational level				
Lower	1939	1654 (85.3)	285 (14.7)	
Higher	2670	2289 (85.7)	381 (14.3)	0.683
Socioeconomic status				
A/B	2481	2118 (85.4)	363 (14.6)	
C/D	2112	1809 (85.7)	303 (14.3)	0.785

*Results expressed as means ± standard deviations or frequency (%). *Student's t test or Fisher's exact test, p < 0.05. †Logistic regression model and Wald test, p < 0.05.*

we demonstrated that there were positive and moderate correlations between BMI, hip and waist measurements, and BP, mainly systolic, but at present, it is not clear why these correlations with diastolic BP were weaker and why there was no correlation with WHR. Further study is needed in these areas.

The association between elevated BP and obesity shown here is more concerning than that reported in previous studies in Brazil[27]. In the city of Belo Horizonte[28], overweight and obese children had a 3.6-fold greater risk of having high systolic BP and a 2.7-fold greater risk of elevated diastolic BP than normal-weight students. In another Brazilian study[29], overweight and obese students had a 3.3-fold greater risk of having systolic BP and a 1.9-fold greater risk of having elevated diastolic BP than other students.

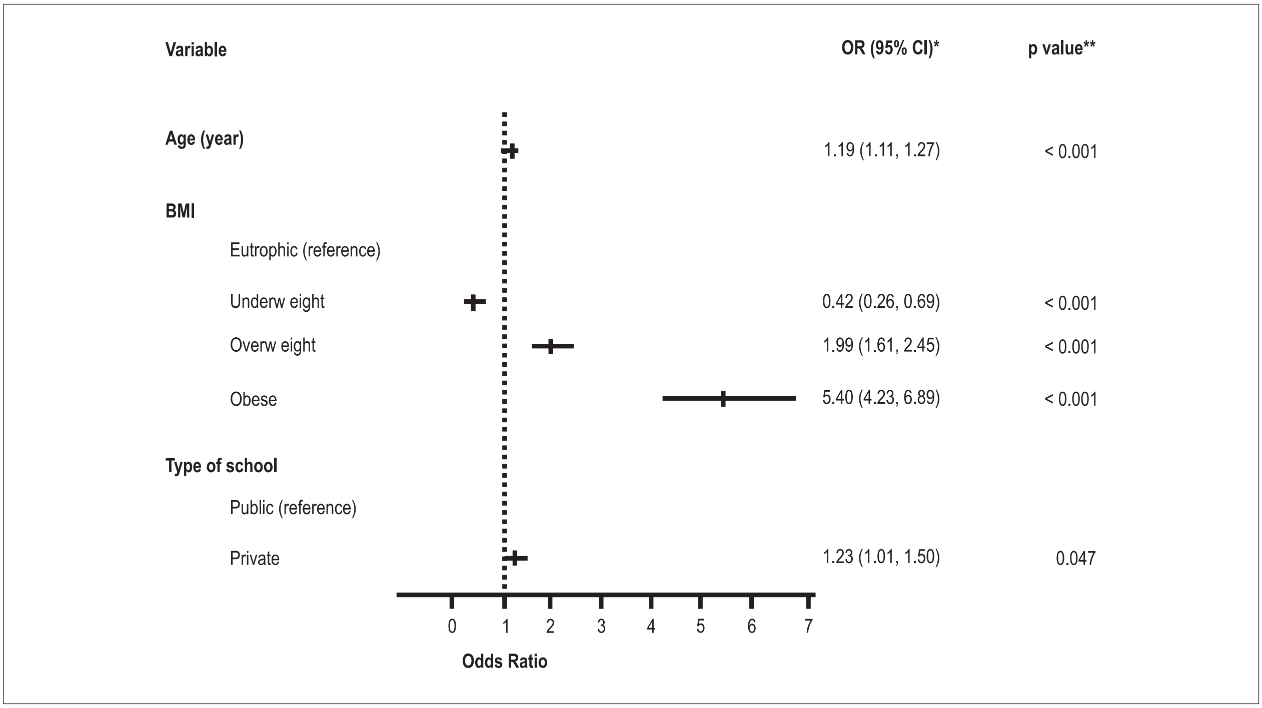

Figure 1 – *Association of elevated blood pressure with age, BMI, and type of school. OR: Odds Ratio. * Logistic regression model. † p value for Wald test; BMI: body mass index.*

To date, most studies in Brazil that evaluated hypertension and its association with obesity before adulthood limited their research to adolescents or included smaller samples of children in the age range assessed in the present research[30,31]. Our study should help address the previous lack of population-based studies in Brazil and may provide useful information on nutritional profiles and associated childhood risk factors. Hence our findings may have important implications because high BP in childhood is a predictor of hypertension in adults[32].

Schools provide environments that can promote healthy lifestyle choices, including those regarding nutrition and physical activity, which are decisive factors in disease causation. In our study, because a marginally but significantly higher chance of elevated BP was found for children in private schools, further investigations focusing on socioeconomic variables should be conducted to clarify this association.

In conclusion, excessive weight affected 25% of the schoolchildren in our sample. Although causality cannot be determined in a cross-sectional study, the strong association found between elevated BP and excessive weight, mainly obesity, indicates that future studies should investigate both obesity and BP in children, especially in those who are overweight. Our results indicate that preventive measures targeting young children must be undertaken by those responsible for defining and implementing public health policies in this population.

Author contributions

Conception and design of the research: Rosaneli CF, Oliveira- Netto ER, Oliveira AB, Faria-Neto JR; Acquisition of data: Rosaneli CF, Auler F, Nakashima ATA, Oliveira- Netto ER, Oliveira AB; Analysis and interpretation of the data: Rosaneli CF, Auler F, Nakashima ATA, Olandoski M, Oliveira- Netto ER, Oliveira AB, Baena CP, Guarita-Souza LC, Faria-Neto JR; Statistical analysis: Olandoski M, Baena CP, Faria-Neto JR; Obtaining financing: Oliveira- Netto ER, Oliveira AB; Writing of the manuscript: Rosaneli CF, Olandoski M, Faria-Neto JR; Critical revision of the manuscript for intellectual content: Rosaneli CF, Oliveira- Netto ER, Baena CP, Guarita-Souza LC, Faria-Neto JR.

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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