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Blood pressure and obesity of children and adolescents - association with body mass index and waist circumference

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Summary

The objective of this work was to evaluate the association between the average levels of blood pressure of 706 children in Porto Alegre with their nutritional state - body mass index (BMI), body fat percentage, waist circumference - and with their social-economic state. A prevalence of 12.3% (n=87) of high blood pressure was found. According to the BMI, 11% of the sample was obese. 47.7% belonged to the social class with an income less than two monthly minimum salaries. All of the correlations of the SBP (systolic blood pressure) and DBP (diastolic blood pressure) with variables in the nutritional state showed to be significant (p<0.001). What ended up having a stronger association was the BMI and waist circumference with SBP (R=0.27). This study made it possible to notice that the anthropometric indicator that best is related to the existence of high BP is the BMI along with the waist circumference. This seems to be an easy method that is noninvasive and of low cost to detect the risk of high BP in children and adolescents.

Key words: Blood pressure, obesity, body mass index.

Resumo

O objetivo deste trabalho foi avaliar a associação entre os valores médios de pressão arterial de 706 crianças de Porto Alegre com seu estado nutricional - índice de massa corporal (IMC), percentual de gordura corporal e circunferência da cintura -, com o estado sócio-econômico. Foi encontrada uma prevalência de 12.3% (n=87) de pressão arterial alta. De acordo com o IMC, 11% das crianças da amostra eram obesas e 47,7% pertenciam à classe social com renda menor que dois salários mínimos mensais. Todas as correlações da PAS (pressão arterial sistólica) e PAD (pressão arterial diastólica) com variáveis do estado nutricional mostraram-se significativas (p<0,001). A que se manteve como uma associação mais forte foi o IMC e circunferência da cintura com PAS (R= 0,27). Este estudo possibilitou verificar que o indicador antropométrico que melhor relaciona-se com a existência de PA alta, é o IMC juntamente com a circunferência da cintura. Mostrando-se um método fácil, não invasivo e de baixo custo para detecção do risco de PA alta em crianças e adolescentes.

Palavras chave: Pressão arterial, obesidade, índice de massa corporal.

Pressão arterial e obesidade em crianças e adolescentes – associação com índice de massa corporal e circunferência da cintura

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Introduction

Systemic Arterial Hypertension (SAH), a multifactorial clinical entity, is characterized by the presence of high blood pressure levels associated to metabolic and hormonal changes and to trophic phenomena (cardiac and vascular hypertrophy). The prevalence of arterial hypertension is high. The estimate is that 15% to 25% of Brazil's adult population has this pathology (1).

Rio Grande do Sul, the same as all Brazil, has built over its history a regional scenario characterized by diversity and by economic and social disequilibrium. This scenario occurred due to the specific social formation that arose in each region resulting from its agri-livestock and industrialization process. These factors are directly or indirectly the determinants of the urban network and demographic movement frameworks of this State. This had an impact on the association of social classes and on the incorrect eating habits, which in turn result in the development of changes in blood pressure (2).

Hypertension holds second place in the United States for reasons to make a doctor's appointment, losing only to respiratory diseases (3). Data from the Municipal Health Department of Porto Alegre (RS) from 2003 showed that diseases related to the circulatory system still are the greatest causes of death by non-transmissible diseases in our city (31.3%) (4).

The early diagnosis and the treatment of SAH reduces the risk of acute myocardium infarction, chronic coronary disease, and congestive cardiac insufficiency, and lowers disease and death from cardiovascular causes (5).

In a study with adults in the city of Porto Alegre, the prevalence of hypertension varied between 12% and 19% when individuals with a normal BP that use anti-hypertensive medication were included (6). In a recent study with a representative sample of children and adolescents in the city of Canoas (metropolitan region of Porto Alegre), the prevalence of high systolic and diastolic blood pressure (BP) was found in 12% of the total sample (7).

Various factors are associated with high blood pressure among children and adolescents. A direct relation with weight has already been documented among children with less than 5 years of age. In the association between obesity and hypertension, a significant association was also found with other cardiovascular risk factors such as elevated cholesterol (8).

At an international level, we have identified six studies that have to do with the association between obesity and arterial hypertension in children and adolescents (9-14). All of them showed significant correlations between these two variables, showing the association of indexes such as the BMI with the percentage of body fat, and hypertension with waist and hip circumferences.

In another study with 672 children between the ages of 2 and 12 in the city of Belo Horizonte, some risk factors associated with an increase in the SBP and DBP were evaluated. It demonstrated that only in pre-school children was there a significant association between overweightness and obesity (15).

The diagnostic of obesity, in infancy and in adolescence, is defined based on the weight, the height, and the body composition. There are many cutoff points for body mass index (BMI), percentages of comparing the weight to height, and of body fat percentage, which define the excess of adiposity.

Skinfolds are also used as ways to measure adiposity. With children and adolescents, the ones most used for this purpose are the tricipital and the subscapular (8,16). With the values of these two measurements, it is possible to calculate the percentage of body fat using the Slaughter formula (17) as done in this present study.

Materials and Methods

Identification and selection of subjects

Using a process of proportional random sampling by multiple stages and by conglomerates, households in the urban region of Porto Alegre were selected and all the residents were included between the age of 6 and before turning 18. The sampling method of a recent study (6) carried out was used where the IBGE data related to 1991 census was applied. This sample was reached by first of all using a Lotus program of 27 numbers (from 1 to 1,263,403, which corresponds to the number of inhabitants detected in that census), each one of them representing a neighborhood (first stage). From this a consensus sector of the IBGE (Brazilian Institute of Geography and Statistics) was drawn using a table of random numbers (second stage). After the collective, commercial, and uninhabited households were excluded, the first one was drawn randomly and the following in a systematic way by direct observation, maintaining an interval of five houses, which were selected in a clockwise fashion. These houses (conglomerates) made up a list of addresses that followed the order of the drawing. The children and adolescents evaluated between 2000-2001 were studied.

The gathering of data was done by a group made up of one supervising nutritionist and scholarship students studying Medicine (interviewers) under the coordination of the researcher responsible for the study and consulting of the associated researchers. The students were previously trained by the coordinator, being tested again during the study. The data was gathered during a visit to the homes. This study was funded by FIPE (Research Fund of HCPA).

Measuring the blood pressure

The systolic and diastolic blood pressure is measured in the unit of millimeters of mercury (mmHg). For this analysis, two measurements were taken with at least 1 minute between each one and the average between them was considered. The average blood pressure complies with the technical determinations of the American Heart Association and of the Task Force (8): (a) the individual must be in a sitting position, at rest, with the right arm at the level of the heart, (b) two measurements must be taken with at least 1 minute interval between both and taken at least 30 minutes after exercise or a meal, (c) the readings were rounded to the 2 closest mmHg, (d) palpating of the radial pulse, followed by the quick inflation of the cuff up to 30 mm Hg above the last beat and at this point begin deflation at a speed of 2 to 3 mm Hg/second, (e) record of the beginning of the 1st phase of the Korotkoff sounds as the SBP marker for all age brackets; record of the beginning of the 5th phase as marker of the DBP.

The blood pressure manometers used were of the brand WANROSS and a cloth cuff with an inflatable rubber chamber. The chamber was wrapped around 80 to 100% of the right arm's circumference measured at the average point between the acromion and the olecranon, leaving the elbow bend and the axillary region free. Its height corresponded to 40% of this circumference (8,18). The widest chamber possible was used to increase the validity of the measurement (15,19). The stethoscopes used were all of the same brand.

The children were then classified according to the tables that have the cutoff points for each age and sex and height percentiles.

The height percentile is classified first and then the blood pressure is checked together with this indicator of height classification. The classification is done according to the levels of blood pressure that refers to the 90 and 95 percentiles of blood pressure in children and young people according to the percentiles of stature.

The limits of blood pressure according to sex, age and height percentile are the following, as recommended by the Task Force on Blood Pressure Control in Children (8,18): normal pressure - systolic and/or diastolic blood pressure below the 90 percentile, normal-high or borderline blood pressure - systolic and/or diastolic blood pressure between the 90 and 95 percentile, and arterial hypertension - systolic and/or diastolic blood pressure above the 95 percentile, measured on 3 different occasions.

The updating, in 1996, of the 1987 Report of the Task Force adopted the work concepts of Rosner et al (20), with specific limits for each range of height percentile and separated by age and sex.

Anthropometric assessment

The body composition was evaluated by weight, height, thickness of skinfolds (subscapular and tricipital) and by the measurement of waist circumference. The cutoff points used, both for BMI as well as for the body fat percentage and waist circumference, are the international reference (WHO, 1995).

In order to determine body weight, the child would have light clothes on and no shoes and be positioned in the center of the scales where he/she stayed until the reading of the weight was done in kg (21). The body weight was measured with a scale of the brand Bender, with increments of 100 grams and a capacity of 150 kg.

The height was measured by anthropometer with the participant standing up against a wall without a baseboard, barefoot, the heels close together forming an angle of 60 degrees, the body weight distributed evenly on both, arms hanging along the body trunk and the palms of the hand opened toward the thighs, the scapular waist and buttocks remained in contact with the wall at the same vertical plane with the occipital. None of the rooms used were carpeted; the participant was asked to take a deep breath and to maintain a completely erect position; one of the observers would then slide the anthropometer on top of the highest point of the skull with sufficient pressure to compress the hair, while a second observer measured the height from the floor to the sliding part of the apparatus, and a third observer would write down the measurement (18).

The cutoff points used with the BMI are those recommended by WHO (1995) (19): P<5 = underweight; P5-85 = eutrophy; P85-95 = overweight; P=95 = obesity.

The thickness of skinfolds are used as ways to measure adiposity. With children and adolescents, the ones most used for this purpose are the tricipital and the subscapular (22,8,16). The skinfolds were measured with approximation of 0.2mm on the right arm in three different readings and their average was used later on in the analyses. An adipometer of Cerscorf brand (Porto Alegre) was used to do the measuring. With these levels, the percentage of body fat was calculated for children older than 8 years of age using the Slaughter formula (17).

The classification of the levels related to the body fat percentage, using this method, is as follows: <17% = below normal; 17-19% = normal; 19-24% = overweight; >25% = obesity (23).

For the children younger than 8 we used the sum of the tricipital and subscapular skinfolds, which later were classified according to the following percentiles: underweight (<P10%), eutrophy (P10-85), and obesity (>P85) (24).

The measurement of the waist circumference allows an estimate of mass of intra-abdominal fat and total body fat. The children were measured while standing up, with outstretched arms, relaxed abdomen, and feet separated at a distance of 25-30cm. The evaluator would stand in front of the person, hold the zero point of the metric tape with the right hand and with the left hand would pass the tape around the waist at the smallest curvature located between the ribs and the hip bone. The child was asked to take a breath and then to exhale deeply. The reading was then done before the child would breathe again. The following percentage cutoff points were used: eutrophic (<P90), obese (>P90) (25).

Study profile

This is a transversal study.

Statistical analysis

For calculating the size of the sample needed, we used the formula from Epi-Info, tested for each independent variable. The sample size (n) estimated was 513 households (n=700) for $p < 0.05$ and statistical power of 80%.

The data was analyzed using SPSS version 10 software.

In order to describe the population we used the Student-t test. To evaluate the correlation between the SBP and DBP averages we used Pearson’s Correlation.The effect of studied variables on SBP and DBP was evaluated by means of ANOVA-one way and relationships by using multiple linear regression (MLR).

Results

Table 1 describes the sample studied. The average age of the sample was 11.6 years and 51.0% belonged to the masculine sex. In relation to the social economic state, 47.7% of the sample represented children with a family monthly salary below 2 minimum salaries, while 27.6% said their income was between 2 and 4 minimum salaries, and only 24.6% had an income higher that 4 monthly minimum salaries.

Classification of the blood pressure

The prevalence of high BP was 12.3% in the total Group (Table 2). However, when we included children with normal-high BP – 8.1% of the total – the prevalence of normal/high BP rises to 20.4%, which, if confirmed by posterior measurements, is an elevated level for this age bracket.

Nutritional state

Table 3 shows the distribution of the nutritional state of the sample according to the different indicators used. The different levels obtained showed how heterogeneous they were.

TABLE 1
Description of the sample according to the measurements of age, sex, systolic blood pressure (SBP), diastolic blood pressure (DBP), Body Mass Index (BMI), and the social-economic state (N=706)

Variable	Levels
Age (years)	11.6 ± 3.3
Masculine sex - n (%)	360 (51.0)
SBP (mmHg)	107.99 ± 12.4
DBP (mmHg)	64.01 ± 9.8
BMI (Kg/m²)	19.51 ± 3.9
WC (cm)	67.37 ± 10.1
Family income in minimum salaries	n (%)
< 2 minimum salaries	337 (47.7)
2-4 minimum salaries	195 (27.6)
> 4 minimum salaries	174 (24.6)

Levels expressed as average ± standard deviation (SD) or absolute frequency and relative frequency (%)
WC = Waist Circumference.

TABLE 2
Distribution of the sample studied according to the percentiles of distribution of systolic blood pressure (SBP) and diastolic blood pressure (DBP)

Classification of the blood pressure	n	%
Normal (< P90)	562	79.6
Normal-high (P90-95)	57	8.1
High (≥ P95)	87	12.3

TABLE 3
Distribution of the sample studied according to the different nutritional state indicators – absolute values (n) and relative values (%) of each sub-sample

Indicators	n	%
BMI	706	100
Underweight (<P5)	33	4.7
Eutrophy (P5-P85)	482	68.3
Overweight (P85-P95)	113	16.0
Obesity (>P95)	78	11.0
Sum of the tricipital and subscapular folds (mm) ?	**97**	**14**
Underweight (<P10)	9	9.3
Eutrophy (P10-85)	73	75.3
Obesity (>P85)	15	15.5
Percentage of fat ??	**605**	**86**
Below normal (< 17%)	204	33.7
Normal (17-19%)	59	9.8
Overweight (19-24%)	124	20.5
Obesity (>25%)	218	36.0
Waist Circumference	**706**	**100**
Eutrophic (<P90)	454	64.3
Obese (>P90)	252	35.7

* Classification in percentiles in the sample of children younger than the age of 8
** Classification in percentiles in the sample of children older than the age of 8. (Four children were lost in this sub-sample).

The prevalence of overweight was greater than that of obesity, according to the BMI indicator. When adding the overweight and obesity levels, we found that these conditions are well represented in our sample (27.0%).

The levels of the various indicators determine different classifications of the nutritional state. When we use the percentage of body weight, we find obesity prevalence of 36% and 15.5% in children older than 8 and in those younger than 8, respectively. When the sample was classified according to the waist circumference, we find an obesity prevalence of 35.7%. This classification includes, in the same group, obese and overweight children.

Association between the SBP and DBP averages with sex, age, social-economic state and nutritional state indicators.

Table 4 show the results referring to the SBP and DBP levels, the variables of sex and social class, and their correlations with age, BMI, and waist circumference. The difference found between the SBP and DBP averages between the sexes was not statistically significant. The same occurred in relation to the SBP and social class. DBP presented a significant association, being greater among children belonging to the subgroup with a family income lower than 2 monthly minimum salaries.

TABLE 4
Association of the SBP and DBP averages with the variables of interest

	Total sample (n=706) SBP	DBP
Sex		
Masculine	109.6±12.8	64.2±10.2
Feminine	106.2±10.2	63.7±9.29
p?	0.226	0.183
Social Class		
< 2 SM	108.0±11.7	65.0±9.4
2-4SM	107.6±13.4	62.5±9.9
>4SM	108.2±12.3	63.6±10.0
p??	0.898	0.016
Age		
R	0.31	0.06
p*	0.001	0.010
BMI		
R	0.45	0.13
p*	0.001	0.001
WC		
R	0.41	0.12
p*	0.001	0.001

? Student-t Test
??ANOVA (Analysis of Variance)

There was a correlation of SBP and DBP with age, stronger for SBP (regular). BP was correlated with all of the nutritional state indicators. BMI and waist circumference presented a regular correlation with SBP and weak with DBP.

The levels related to the percentage of body fat of children older than the age of 8 showed a weak correlation with SBP (r=0.19) and DBP (r=0.12).

Multiple Linear Regression applied to the nutritional state indicators with SBP and DBP.

The results of the multiple linear regression showed a higher variation percentage of SBP (27.9%) when there is an interaction with the waist circumference indicators and BMI (r=0.27) (Table 5). The other indicators of the nutritional state presented a less explicatory variation when associated with SBP. The indicator that demonstrated less variation percentage was the body fat percentage (r=0.18). The values of the DBP association with the nutritional state indicators were not significantly explicatory for the DBP variation.

TABLE 5
Results of the multiple linear regression of SBP and DBP in relation to the variables of interest

	SBP			
	n	r^2??	F	p
BMI	706	0.27	53.506	<0,001
BMI ? ? ?	609	0.26	43.411	<0,001
WC	705	0.26	50.716	<0,001
WC ?? ?	608	0.25	40.738	<0,001
BFP	604	0.18	27.137	<0,001
BMI, WC and BFP	706	0.27	53.506	<0,001

	DBP			
	n	r^2??	F	p
BMI	706	0.03	5.066	<0.001
BMI ? ? ?	609	0.02	3.567	<0.003
WC	705	0.03	4.833	<0.001
WC ?? ?	608	0.02	3.272	<0.006
BFP	604	0.03	3.748	<0.002
BMI, WC and BFP	705	0.03	4.277	<0.001

? all of the variables were controlled by sex, age, and social class
?? Coefficient of determination of the multiple linear regression
?? ? Children under the age of 8
BFP = Body Fat Percentage

Discussion

Arterial hypertension, because of it being a disease with a high mortality rate that can have its beginning during childhood, has been widely studied by doctors and nutritionists involved with pediatric populations. Research in this context is of great value in order to serve as a guide for public health policies, bringing information about the determining factors involved in the rise of pressure levels. Nutritional factors – obesity, sensitivity to sodium – are continually more described in association with high levels of blood pressure. For these reasons, according to orientation from the World Health Organization (WHO), nutritional evaluation is an important tool in the prevention of cardiovascular diseases.

The cutoff points used both for BMI as well as for the percentage of body fat and waist circumference have international standards (WHO, 1995). In this study, by classifying the nutritional state according to the different indicators used, we demonstrated that according to the BMI percentiles, 113 children (16% of the sample) were overweight and 78 (11% of the sample) were obese, which shows an elevated prevalence of children above the normal weight range. This data, in relation to overweight, is similar to Garcia's (15) study done in Belo Horizonte where he found a prevalence of 14%. However, in this same study, the prevalence of obesity was 3.7%, which shows a difference between the samples studied. In relation to the nutritional state of the population studied by Moura (26) in Maceió, a transversal study evaluating children and adolescents from 7 to 17, the levels were lower than those found in our study (Porto Alegre). In this one (Maceió), 9.2% of the children were overweight and 4.5% were obese when using BMI as the indicator.

Upon making the analysis of the BMI association with SBP, a regular correlation was detected (r=0.45). When we compared the BMI averages with DBP, the relation found was weak (r=0.13). An important characteristic of our strategic analysis was the use of Pearson's Correlation for evaluating the strength of the association between the averages of BMI with the average BP levels.

Al-Sendi et al (10), in a randomized transversal study with a sample of 504 students between the ages of 12 to 17, gathered the data from schools selected according to pre-determined areas in the city (which is divided into four different regions). This study found results similar to ours. Upon analyzing weight, height, waist circumference and thickness of the subscapular and tricipital skinfolds, a regular association of these indicators with high SBP and DBP levels were found. This study, as was the case in ours as well, suggests that children with larger bodies, mainly those related to central obesity, have greater chances to present higher SBP and DBP levels. This study also found a similar result to ours with respect to the association of BMI with SBP (r=0.4).

A weak association was seen between percentage of fat in children older than 8 with SBP and DBP. Possibly due to this stratification, the sample analyzed did not present the power necessary to evidence a stronger correlation. However, the methodology applied was the most correct since the percentage levels of body fat cannot be used in the same way for all children. Some studies (10,14), when they analyze this nutritional indicator in children, use the Slaughter formula for all the ages, which makes the association found incorrect.

The multiple linear regression of our indicators on SBP and DBP confirmed the results similar to those of the correlation when evaluating the body fat percentage calculation, which confirms the weak association of body fat with SBP and DBP. Leccia et al. (11), upon associating body fat percentage with SBP in a sample of 1,090 children, found a weak correlation, but only significant in the association with SBP. In this transversal study, the correlations were done based on the sample stratified by sex. Even evaluating this difference at the moment of the correlations, we find similarities with our study with respect to the strength of the correlations.

Al-Sendi et al. (10), upon associating body fat percentage with SBP, showed a regular correlation between these variables, while in our study we found a weak correlation. In relation to the association of body fat percentage with DBP, the levels of the associations of this study were less than ours (r=0.07). The difference found in the strength of the associations between this study and ours could be due to the smaller sample size and the different age bracket evaluated (12 to 17 years).

The application of the waist circumference percentiles is a differential of our study in relation to the other works published in literature. The reference levels for waist circumference were obtained from a transversal study carried out with English children (25). This last study, done with a sample of 8,355 children and adolescents, generated a reference table with average sizes of waist circumference, in centimeters, stratified by sex and age and subdivided into percentiles. The study was chosen as a reference due to its perfect profile as well as because of the size of the sample evaluated, which is representative of the population of its country of origin. The second and main reason for choosing it was its similarity in the prevalence of the nutritional state—overweight and obesity—of the English population with the Brazilian one: 11% and 18.5% respectively (25).

When we analyze the waist circumference averages from our sample, we find correlations with SBP and DBP that are very close to the levels found when we correlate BMI with SBP and DBP. Our study, as well as the one carried out by Al Sendi et al.[10], demonstrated stronger correlations in the association with SBP than with DBP. We point out once again how this finding reinforces the primary objective of our study: evaluate which indicators would be better correlated with the increase of SBP and DBP. The multiple linear regression demonstrated that, when associated, BMI and waist circumference better explain the variation of the SBP than its isolated use.

Most epidemiologic studies found an association of some indicators of cardiovascular mortality with hypertrophy of the left ventricle only in children with a high SBP, but not with those with high DBP. The Bogalusa Hearth Study (27) evaluated the relation between the thickness of the left ventricular wall with the size of the chamber, significantly correlating with the SBP, but not with DBP. Maybe this is the reason for the weak association of the nutritional state indicators with DBP, due to the different dimensions in ventricular wall thickness. As for the relation with the effect of body fat on the SBP and DBP levels, it seems that the distribution of body fat has a greater influence on the SBP than on the DBP, as shown in the studies cited.

Overweight and obesity, evaluated in our study, are recognizably associated to elevated levels of blood pressure, especially SBP. Longitudinal studies in adult populations have demonstrated that the excessive levels of BMI are strongly associated with risk of cardiovascular diseases (28,29). Al-Sendi (10), by associating BMI with SBP and DBP, found levels similar to ours for SBP. The correlation levels of DBP were also similar to ours, which indicated a weak correlation between DBP and BMI.

Brandon,1993 (13) analyzed 675 school and pre-school age children found the level related to prevalence of high SBP and DBP (>p95) was 12.3%. Other studies show different levels, which vary from 8 to 15% (10,12-14).

In our study, the prevalence of high blood pressure (12.3%) is very high. If we consider the borderline levels for high blood pressure as related to children, which are those children in the normal-high range (P90-95), the prevalence of high blood pressure levels reached a total of 20.4% in this sample.

The recommendation of the Task Force is that every child above the age of three have their blood pressure checked during medical care and that these measurements be routine when providing medical services. This is the only way to diagnose cardiovascular or renovascular diseases early on (8).

Another factor that can become a risk for bringing about arterial hypertension is the consumption of sodium (30). Children, especially in the age bracket involved in this study, tend to have consumption levels that are considered higher than normal.Today, the diet of children and adolescents include various sources of sodium-based preserved foods and are rich in this micronutrient. However, the high intake of sodium, in and of itself, cannot be a determining factor for the development of hypertension because not all people with high ingestion of sodium in their diets develop the disease.

One of the objectives of this study was to analyze which anthropometric parameter was most associated with the risk of high BP levels. We wanted to identify which one could be used in a clinical practice with the best reliability. Our findings suggest that the BMI and the waist circumference, associated, have the best predictive value for the levels of high BP. The use of these indicators is easy, non-invasive, and their association has a better correlation to suggest risk of high blood pressure than the use of BMI alone.

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