Original Article

High Blood Pressure in Children and its Correlation with Three Definitions of Obesity in Childhood

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Abstract

Background: Several authors have correlated the increase of cardiovascular risk with the nutritional status, however there are different criteria for the classification of overweight and obesity in children.

Objectives: To evaluate the performance of three nutritional classification criteria in children, as definers of the presence of obesity and predictors of high blood pressure in schoolchildren.

Methods: Eight hundred and seventeen children ranging 6 to 13 years old, enrolled in public schools in the municipality of Vila Velha (ES) were submitted to anthropometric evaluation and blood pressure measurement. The classification of the nutritional status was established by two international criteria (CDC/NCHS 2000 and IOTF 2000) and one Brazilian criterion (Conde e Monteiro 2006).

Results: The prevalence of overweight was higher when the criterion of Conde e Monteiro (27%) was used, and inferior by the IOTF (15%) criteria. High blood pressure was observed in 7.3% of children. It was identified a strong association between the presence of overweight and the occurrence of high blood pressure, regardless of the test used ($p < 0.001$). The test showing the highest sensitivity in predicting elevated BP was the Conde e Monteiro (44%), while the highest specificity (94%) and greater overall accuracy (63%), was the CDC criterion.

Conclusions: The prevalence of overweight in Brazilian children is higher when using the classification criterion of Conde e Monteiro, and lower when the criterion used is IOTF. The Brazilian classification criterion proved to be the most sensitive predictor of high BP risk in this sample. (Arq Bras Cardiol. 2014; 102(2):175-180)

Keywords: Hypertension; Child; Obesity; Body mass index.

Introduction

Diseases of modern life have been worryingly affecting children. Obesity is now seen as a global epidemic, which is accompanied by increase of cardiovascular risk factors such as Systemic Hypertension (SH)[1,2]. High blood pressure levels in children predict SH of the adult and contribute to the occurrence of cardiovascular events[1,2]. Therefore, early identification and treatment of high blood pressure in childhood have the potential to cause a great impact on future adverse outcomes.

Currently, it is considered mandatory the measurement of Blood Pressure (BP) since the age of three, annually or sooner, if there is any risk factors[3-5]. However, the complex methodology required for the verification of BP in children causes many professionals to exclude it from their routine or interpret the values measured incorrectly, which can result in underdiagnosis and incorrigible consequences for these individual[6,7].

Excess weight, commonly assessed by Body Mass Index (BMI) is an important predictor of high BP in children. The risk of high BP can increase more than twice at every unit increased in BMI z-score[8-12]. Therefore, the proper classification of nutritional status in children is a warning instrument for the risk of hypertension.

This classification can be established using different criteria. In 2000, the Centers for Disease Control (CDC) defined the 85th and 95th percentiles of distribution in the U.S. population as cut-off points for overweight and obesity, respectively[13]. In the same year, Cole et al[14,15], through the International Obesity Task Force (IOTF), involving six countries, established BMI cut-offs for age and sex corresponding to values of 25 kg/m^2 for overweight, and 30 kg/m^2 for obesity at age 18. In 2006, Conde and Monteiro used similar methodology to propose to the IOTF cut-off points based on the Brazilian population[16].

The purpose of this present study is to evaluate the performance of those criteria as predictors of high blood pressure levels in schoolchildren in the municipality of Vila Velha (ES).

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Methods

The study involved students enrolled in School District elementary public school in the city of Vila Velha (ES). It only included children whose parents or legal guardians agreed in the participation through an informed consent form, as approved by the Ethics Committee of the institution (procedure no. 34/2011).

The sample size calculation was performed using *Epi Info*, version 6.04, available for free on the internet. For calculation purposes, we considered the number of students enrolled in UMEF in the year of the study, the average prevalence of hypertension in children of 4%, the absolute error of 2%, confidence interval of 95%, 80% statistical power and effect of design of 2, reaching an amount of 730 children, whose objectified number was rounded to 800, predicting eventual losses.

Sampling was the complex type, in two stages. The first stage consisted of random selection by draw from a school of each of the five political-geographical regions of the municipality. In the second stage, we conducted an unsystematic selection of students from each school, according to the adhesion of such and the informed consent form in writing of their guardians or parents.

Children under the age of six years or with age superior to 13 years, which accounted for less than 2% of the sample, were excluded in order to ensure homogeneity.

The students were assessed with respect to height, weight and blood pressure. Measurements of height were performed by using a wall fixed stadiometer, graduated 20-200 cm, with scale accuracy of 0.1 cm, and represented by the average of three consecutive measurements. The child was placed in the standing position, without shoes, with hips and shoulders perpendicular to the central axis of the body, heels firmly planted on the ground, knees close and extended, relaxed arms and head in the Frankfurt plane. Body weight was determined by a digital anthropometric scale graduated from 0 to 150 kg, with a resolution of 0.05 kg, previously calibrated. The Body Mass Index (BMI) was calculated by the quotient of body weight in kilograms by height in m^2 and converted into Z-scores adjusted by age and sex.

The classification of children according to nutritional status (underweight, healthy weight, overweight or obese) was established through the three criteria mentioned above: CDC / NCHS 2000 IOTF (Cole et al[14]) and Conde and Monteiro[16].

The measurement methodology and classification of blood pressure followed the recommendations of the last international consensus on the subject, established in 4th National Task Force on Hypertension of the National Heart, Lung and Blood Institute[4]. Blood pressure levels were assessed by auscultation using a periodically calibrated aneroid sphygmomanometer and a stethoscope placed over the brachial artery pulse 2 cm above the cubital fossa/elbow pits. The cuff was selected according to arm circumference, measured at the midpoint between the acromion and the elbow, with the arm flexed at 90 degrees with the forear, according to the recommendations of the guidelines above[4]. The measurements were performed with the child in a sitting position, with their right arm flexed at 90 degrees at the heart level and supported on a fixed surface, in a calm environment. During preparation, the child remained at rest for at least 5 minutes, the child was instructed not to talk during the measurement. The average of three measurements taken within an interval of 3 minutes was used for classification as blood pressure levels and to calculate the Z-score for blood pressure, adjusted by age, sex, and height percentile. Children with average Systolic Blood Pressure (SBP) and/or Diastolic Blood Pressure (DBP) equal to or greater than the 95th percentile for sex, age and height percentile were classified as having high BP, whereas children with average SBP and/or DBP between the 90th and 95th percentiles were classified as pre-hypertensive.

For statistical analyzes, the outcomes of interest (nutritional status and blood pressure) were analyzed both as categorical variables as continuous variables in the form. For continuous analysis, the absolute values of weight, height and BMI were converted into Z-scores by age and sex, using the software *Growth Analyser® version 3.5*[13]. The values of mean blood pressure, systolic and diastolic blood pressure were adjusted by sex, age and height percentile, according to the recommendations of the 4th National Task Force on Hypertension of the National Heart, Lung and Blood Institute[4].

Association analyzes were performed by means of group comparisons, correlations and regressions. Comparisons between groups with respect to quantitative variables were made by Student *t* test or Mann-Whitney test, as appropriate. Qualitative variables were analyzed using the chi-square test.

Using the presence of excess weight as a predictor of high blood pressure, the profiles of sensitivity, specificity, and overall accuracy (area under the ROC curve) were calculated of each nutritional classification criteria regarding detection capability of high BP in these children.

All statistical analyzes were performed using the *SigmaStat* for Windows (version 3.5, SPSS, Inc., San Rafael, CA). It was considered statistically significant at $p < 0.05$.

Results

Regarding the general characteristics of the sample studied, it was obtained homogeneity in relation to sex, being represented by 51% (n = 417) of boys and 49% girls (n = 400). The mean age was 8.8 ± 1.6 years. Depending on the criteria used to evaluate nutritional status, the percentage of eutrophic children ranged between 67% and 73%, and the percentage of children presenting excess weight (overweight or obese), between 21% and 27% (Figure 1).

The highest prevalence of overweight, including both overweight and obesity, was observed by the criterion of Conde and Monteiro (27%), although the CDC criterion has shown the highest percentage of obesity (11%). Using the IOTF criterion, we observed the lowest percentage of children classified as having excess weight (21%) and the highest percentage of underweight (12%).

It was observed that 3.4% of the children had average levels of BP, adjusted by age, sex and height percentile, consistent with the diagnosis of pre-hypertension, and 3.9% diagnosed with hypertension. There was no significant association between the presence of high blood pressure

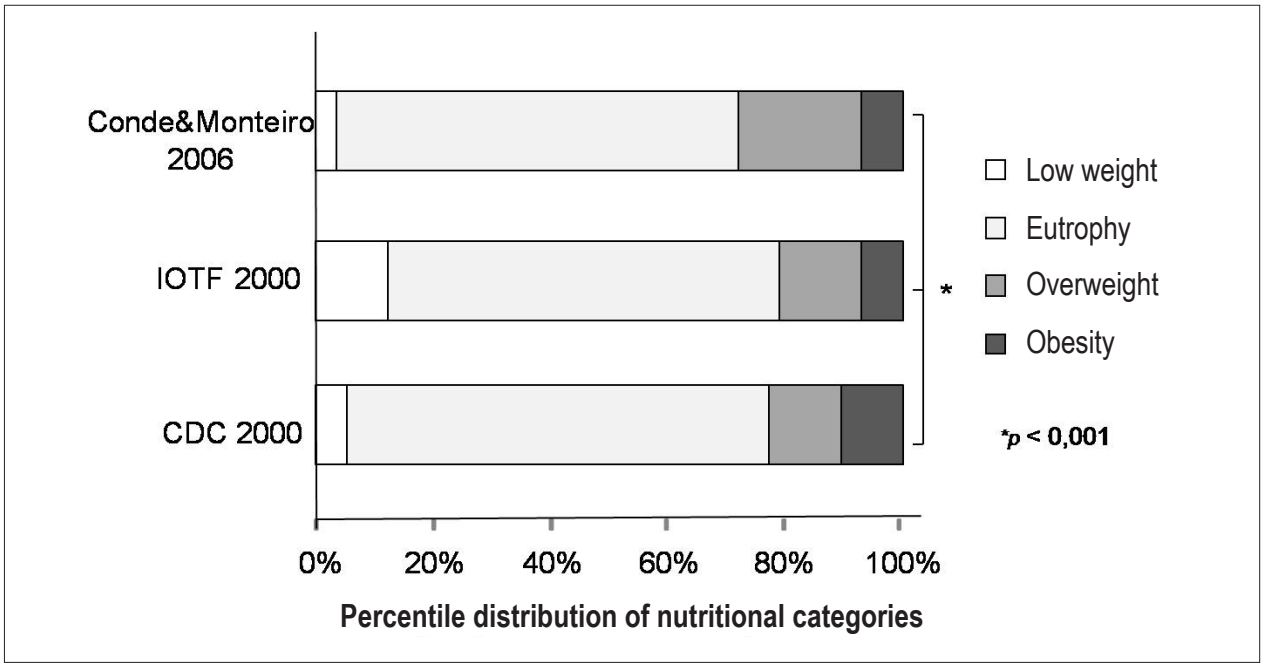

Figure 1 - *Proportions of children with nutritional status classified as underweight, normal weight, overweight or obese according to criteria established by: CDC 2000, IOTF 2000 and Conde and Monteiro 2006. (* p < 0,001; chi-square test).*

and age. The only correlation identified as to sex was the presence of higher levels of diastolic blood pressure in males (p = 0.02)

There was a strong correlation between the presence of overweight and the occurrence of high blood pressure, as shown by highly significant direct linear regression (p < 0.001) between BMI Z and blood pressure Z, both systolic and diastolic blood pressure (Figure 2). Furthermore, categorical analyzes demonstrated that, regardless of the nutritional classification criterion used, levels of BP Z increase as one progresses of nutrition class, from low weight to obesity (Figure 3).

When using the presence of excess weight as a predictor of high blood pressure, the criterion demonstrating the highest sensitivity (44%) was the Conde and Monteiro, while the highest specificity was the CDC criterion (94%). The latter also proved to have the highest overall accuracy (AUC = 63%) (Table 1).

Linear regressions, using the Z scores of blood pressure as the outcome of interest, did not demonstrate superiority of any one of the criteria with respect to the ability to predict absolute levels of BP Z score high. This predictive ability remained around 5% for Z of diastolic BP and 6% for Z of systolic BP, with slight differences in the criteria used.

Discussion

Overweight and obesity in childhood are known to be global and epidemic disorders associated with cardiovascular and metabolic risk. Therefore, the nutritional classification in children is an important characteristic of the screening, both in clinical practice and in epidemiological studies in order to identify individuals at risk for a number of comorbidities, such as hypertension[17,18].

Currently, the definition of overweight and obesity in children, as well as the comparison of studies in the area, is made difficult by the absence of a consensus on classification criteria to be used. There are several methods available, and although there is a standing of class societies in favor of either one or another criterion[18], many discussions about the advantages and disadvantages of each method when applied to a given population[19-25].

In this sample of schoolchildren from Vila Velha, it was observed that the distribution according to the cut-off points proposed by the IOTF had the highest percentage of low birth weight. Possibly, as mentioned by Barbosa et al[21], the prevalence of underweight was higher for this criterion due to the cut-off used (18.5 kg/m^2) that represents the z-score -1, while in the CDC criterion the low weight is represented by the 5th percentile (score z -1.6). Similarly, the significant prevalence of overweight by the Conde and Monteiro criterion was also observed in other studies[21,22].

The percentage of obesity obtained by the CDC criteria surprises due to the fact that it demonstrates that over 10% of our children have BMI levels adjusted by sex and age greater than the 95th percentile of BMI for the American population. Similar observations were described by studies conducted in the Brazilian population[26], reaching prevalence rates as high as 29.7% of obesity among boys private school in the city of Santos (SP)[27].

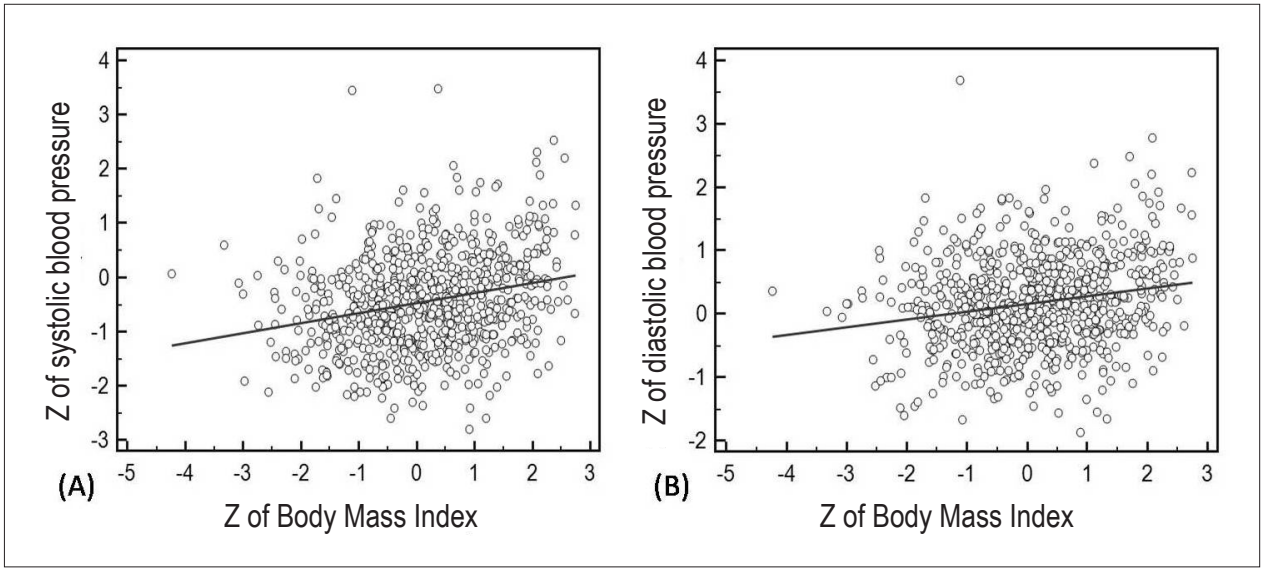

Figure 2 - *Linear regression between Z of Body Mass Index (calculated by reference of CDC 2000) and Z of Systolic BP (A) and diastolic BP (B) (calculated according to the recommendations of the 4th National Task Force on Hypertension of the National Heart, Lung and Blood Institute 2004).*

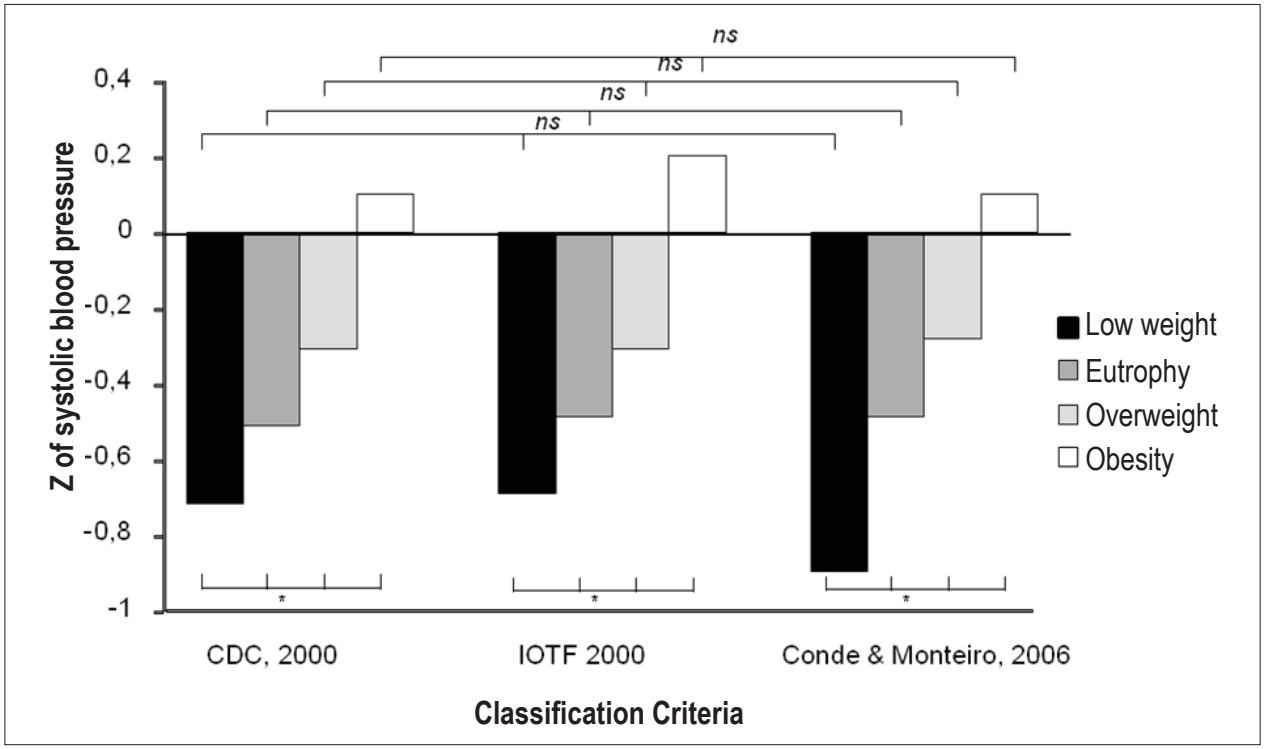

Figure 3 - *Average of Z of Systolic BP (A) in accordance to the nutritional classification established by three criteria: CDC 2000, IOTF 2000 and Conde and Monteiro 2006. (* p < 0,001; ns: statistically not significant).*

One of the possible limitations of the present study was not evaluating the benchmark established by the World Health Organization (WHO) in 2006, also frequently used in Brazil. This is due to the unavailability of a database on the statistical program used to calculate the Z scores of BMI. However, the differences between the referential of CDC and WHO stand out particularly in children under five, so that little affect the results of the present study. Furthermore, the absence of this criterion does not invalidate the results demonstrated with respect to selected criteria.

Table 1 - Sensitivity and specificity of each nutritional classification method when using excess weight as a marker of risk of high blood pressure in children

	Sensitivity		Specificity		Accuracy (ASC)*
	%	(CI 95%)	%	(CI 95%)	% (CI 95%)
CDC 2000	31	19 – 44	94	92 – 96	63 (59 - 66)
IOTF 2000	42	30 – 57	80	77 – 83	62 (58 – 65)
Conde 2006	44	32 – 58	74	71 – 77	60 (56 - 63)

Area under the curve - Curve ROC; CI: confidence interval.

Although no differences have been observed with respect to the ability of each criterion to predict, continuously, blood pressure levels, the criterion of Conde and Monteiro was demonstrated to have the highest sensitivity in predicting risk categories of high BP. In our opinion, this fact should be highlighted in the practical implications that it presents in terms of screening, research and clinical follow-up of these children.

Finally, we highlight the importance of school-age children having their blood pressure verified regularly, since hypertension is not a rare condition in childhood, and early detection can prevent the occurrence of future irreversible damage to these individuals. Overweight or obese by any of the available criteria deserve careful attention as to blood pressure levels, since excess weight is indisputable a risk marker for early manifestation of the disease.

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Author contributions

Conception and design of the research, Analysis and interpretation of the data and Statistical analysis: de Moraes LI, Nicola TC, Fuly JTB, Costalonga EF; Acquisition of data: de Moraes LI, Nicola TC, de Jesus JSA, Alves ERB, Giovaninni NPB, Marcato DG, Sampaio JD, Fuly JTB, Costalonga EF; Writing of the manuscript: de Moraes LI, Nicola TC, Costalonga EF; Critical revision of the manuscript for intellectual content: Fuly JTB, Costalonga EF.

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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