



## Relationship between anthropometric and hemodynamic indexes in school children

Ana Paula de Oliveira Azambuja<sup>1\*</sup>, Edna Regina Netto-Oliveira<sup>2</sup>, Amauri Aparecido Bássoli de Oliveira<sup>1</sup>, Maximiliano dos Anjos Azambuja<sup>3</sup> and Wilson Rinaldi<sup>1</sup>

<sup>1</sup>Programa de Pós-graduação em Educação Física, Universidade Estadual de Maringá, Av. Colombo, 5790, 87020-900, Maringá, Paraná, Brazil.

<sup>2</sup>Departamento de Farmácia, Universidade Estadual de Maringá, Maringá, Paraná, Brazil. <sup>3</sup>Departamento de Engenharia Civil, Universidade Estadual Paulista, Bauru, São Paulo, Brazil. \*Author for correspondence. E-mail: [ana\\_paula\\_3005@yahoo.com.br](mailto:ana_paula_3005@yahoo.com.br)

**ABSTRACT.** Cardiovascular diseases are the main cause of death in world population. Current analysis with 1074 schoolchildren in municipal schools of Cruzeiro do Oeste, Paraná State, Brazil, evaluated anthropometric indexes and blood pressure levels of schoolchildren and verified the relationship between Body Mass Index (BMI) and Waist Circumference (WC) with blood pressure (BP). Evaluations comprised weight and height for the calculation of BMI, waist circumference and arterial pressure. Chi-square test and Cramer's coefficient verified whether the variables were associated. High percentage of weight excess was reported, or rather, 16.6% of children were overweight; 9.8% were obese; 30.6% had high WC and 38.3% had high blood pressure. BMI and WC were associated with high BP. Overweight schoolchildren with central adiposity had a great trend of having high blood pressure.

**Keywords:** body mass index, waist circumference, blood pressure.

## Relação entre os indicadores antropométricos e hemodinâmicos em escolares

**RESUMO.** As doenças cardiovasculares são a principal causa de morte na população. O estudo objetivou avaliar os indicadores antropométricos e os níveis pressóricos de escolares e verificar a relação entre esses indicadores: Índice de Massa Corporal (IMC) e Circunferência de Cintura (CC) com Pressão Arterial (PA). O estudo foi realizado com 1.074 escolares, em escolas municipais do município de Cruzeiro do Oeste, Estado do Paraná. As avaliações consistiram em medida de peso e estatura para o cálculo do Índice de Massa Corporal, da Circunferência da Cintura e da Pressão Arterial. Associações entre as variáveis foram verificadas utilizando do teste de qui-quadrado e pelo coeficiente de Cramer. Observou-se elevado percentual de excesso de peso, sendo sobrepeso de 16,6% e obeso 9,8%, 30,6% de CC alterada e 38,3% de escolares com medidas pressóricas elevadas. Tanto IMC como CC demonstraram associação com PA elevada. Os escolares com excesso de peso e adiposidade central apresentam maiores chances de elevar suas medidas pressóricas.

**Palavras-chave:** índice de massa corporal, circunferência da cintura, pressão arterial.

### Introduction

Arterial hypertension is a chronic disease characterized by persistent pressure levels above normal rates. Since it is a risk factor, it is the commonest of cardiovascular diseases (CVDs) and a serious concern for public health in all social and economical conditions. Moreover, its onset may occur from factors in childhood (MONEJO; JARDIM, 2006).

There is evidence that high blood pressure in adulthood may have started during childhood and adolescence. For many years, the association between alterations in anthropometric indexes and high blood pressure in childhood has been highlighted. In fact, it is one of the most important concerns in child health

(MONEJO; JARDIM, 2006; MOZER et al., 2011; RINALDI et al., 2012).

In their study on the positive relationship between hypertension and BMI, Rinaldi et al. (2012) stated that increasing prevalence of weight excess in children and adolescents had contributed towards an increase in cases of arterial hypertension. Other factors affected the risks in the development of cardiovascular diseases regardless of whether the subject was obese or not. One of these factors, measured by waist circumference (WC), has been recently identified as a cardiovascular disease risk not only in adulthood but also in childhood (SARNI et al., 2006). Weight control is an important measure to reduce the arterial hypertension index and, consequently, health promotion and prevention of other cardiovascular diseases (AMER et al., 2011).

Obesity may be identified by two practical and viable methods, namely, WC and BMI. Although abdominal obesity in adults is more often associated with cardiovascular risks than general obesity, the same association in pediatric conditions has been only scantily analyzed. A previous study on the association between fat distribution and cardiovascular risks in children indicated that both types of obesity were linked to high blood pressure in childhood (CHRISTOFARO et al., 2009).

WC represents the accumulation of abdominal or visceral fat that, in its turn, is one of the most relevant risk factors in cardiovascular diseases (CVD), diabetes, atherosclerosis and arterial hypertension (CHRISTOFARO et al., 2009; SARNI et al., 2006). WC is a very simple measuring method, easy to perform and repeat, for the end mentioned above (BERGMANN et al., 2011).

No agreement exists with regard to measured points in BMI with regard to the nutritional evaluation of children to identify overweight and obesity. According to the World Health Organization, difficulties exist with regard to any agreement on belly measurements. Although the method is highly efficient, measurements in childhood are in constant flux (OMS, 2004).

Since excess weight is related to high blood pressure levels in childhood and the same indexes may also forecast increased blood pressure rates in adulthood, current study may be justified by the social and scientific relevance of the early identification of the disease, and may thus contribute to Brazilian data so that its prevalence in childhood may be estimated. Consequently, educational activities may be undertaken to combat the epidemic as early as possible.

Current study evaluated the anthropometric and blood pressure levels of schoolchildren and the relation between the indicators body mass index (BMI) and waist circumference (WC) and blood pressure (BP).

## Material and methods

Current descriptive analysis was carried out with male and female schoolchildren, aged between 6.0 and 10.9 years, enrolled in the municipal schools of Cruzeiro do Sul, Paraná State, Brazil, in the northwestern region of the state of Paraná, Brazil. The economically agricultural town has 22,000 inhabitants and, according to the Human Development Atlas of Brazil, its Human Development Index (HDI) ranks 0.751 (PNUD, 2011).

Weight (W) was measured by a digital balance Tanita 2202, with a capacity of 136 kg and resolution of 100 g. Height (H) was measured by a stadiometer

SECA (Bodimeter 206). BMI was calculated to define the nutritional status of the children, according to Cole et al. (2007). WC was measured by a non-stretching metric tape (Sanny), and points were measured according to Fernández et al. (2004); Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) was performed by digital sphygmomanometer Omron (HEM-741CINT) with an inflatable cuff proper for the diameter of children's arm. AP was measured once by calculating the mean of three measurements and classified according to the V Brazilian Guidelines of Arterial Hypertension (MION JUNIOR et al., 2006). Altered pressure levels were defined by the Brazilian Hypertension Guidelines, such as pressure equal to or higher than 95% of arterial pressure distribution, and taking into consideration the child's age, sex and height (MION JUNIOR et al., 2006). All measurements were collected by a single researcher at school, during lesson hours. The researcher was duly trained in the GREPO (Study and Research Group in Obesity and Physical Exercise) laboratory.

All schoolchildren (n = 1,224) enrolled in the public schools (n = 6) of the municipality during 2010 were invited to participate in the research. Exclusion criterion was the lack of signature of the parents' or tutor's Free Consent Term. Consequently, 87.7% (n = 1,074) of enrolled schoolchildren took part in the experiment.

Data were organized with Window's Excel Program and statistical treatment was carried out with Statistical Package for Social Science - SPSS 13.0 for Windows. Data were organized by descriptive statistics (frequency, percentage, median). Data normality distribution was verified by Kolmogorov-Smirnov test. Tests were performed for non-parametric statistics and the differences between median rates were verified by Mann Whitney test and associations verified by chi-square test and by Cramer's coefficient, with odds ratio (OR). Significance level 95% ( $p < 0.05$ ) was used for all procedures.

The study was conducted according to the ethical principles for research involving humans and was approved by the Permanent Committee for Ethics in Research with Human Beings of the State University of Maringá (Doc. 556/2009).

## Results

The 1074 schoolchildren comprised 531 males (49.4%) and 543 (50.6%) females.

Table 1 provides results on anthropometric variables, age and blood pressure variables for all children evaluated, according to sex.

**Table 1.** Anthropometric, age and arterial pressure variables by sex for 6.0 – 10.9-year-old children enrolled in public schools of Cruzeiro do Oeste, Paraná State, Brazil.

| Variables                  | Total          | Male             | Female         |
|----------------------------|----------------|------------------|----------------|
|                            | Med (min~max)  | Med (min~max)    | Med (min~max)  |
| Age (years)*               | 9 (6~10)       | 9 (6~10)         | 8 (6~10)       |
| Weight (kg)*               | 29 (14.4~103)  | 28.8 (15.1~103)  | 29 (14.4~81.7) |
| Height (m)*                | 1.3 (1.0~1.7)  | 1.3 (1.0~1.7)    | 1.3 (1.0~1.7)  |
| BMI (kg m <sup>-2</sup> )* | 16.7 (12~35.3) | 16.7 (12.8~35.3) | 16.7 (12~33)   |
| WC (cm)*                   | 60 (38~123)    | 60 (38~123)      | 60 (47~107)    |
| SBP (mmHg)*                | 108.3 (68~153) | 109.8 (69~153)   | 108.3 (68~147) |
| DBP (mmHg)*                | 63.5 (38~88.5) | 63.5 (58~88.5)   | 63.6 (38~81)   |

Mann Whitney test ( $p < 0.05$ ); \*Med-median; min-minimum; max-maximum; BMI – Body Mass Index; WC- Waist Circumference; SBP – Systolic Blood Pressure; DBP – Diastolic Blood Pressure.

Table 2 gives absolute and relative frequency of the variables BMI, WC and AP according to sex.

**Table 2.** Absolute and relative frequency of anthropometric and hemodynamic variables according to sex for 6.0 – 10.9-year-old children enrolled in public schools of Cruzeiro do Oeste, Paraná State, Brazil.

| Variables  | Total |      | Male |      | Female |      |
|------------|-------|------|------|------|--------|------|
|            | N     | %    | N    | %    | N      | %    |
| <b>BMI</b> |       |      |      |      |        |      |
| Adequate   | 791   | 73.6 | 410  | 77.2 | 381    | 70.2 |
| Overweight | 178   | 16.6 | 76   | 14.3 | 102    | 18.8 |
| Obese      | 105   | 9.8  | 45   | 8.5  | 60     | 11   |
| <b>WC</b>  |       |      |      |      |        |      |
| Desirable  | 745   | 69.4 | 383  | 72.1 | 362    | 66.7 |
| Changed    | 329   | 30.6 | 148  | 27.9 | 181    | 33.3 |
| <b>BP</b>  |       |      |      |      |        |      |
| Normal     | 663   | 61.7 | 332  | 62.5 | 331    | 61   |
| High       | 411   | 38.3 | 199  | 37.5 | 212    | 39   |
| Total      | 1074  | 100  | 531  | 49.4 | 543    | 50.6 |

Chi-square test  $p < 0.05$ ; BMI – Body Mass Index; WC- Waist Circumference; BP – Blood Pressure.

Table 2 shows that 26.4% of schoolchildren had excess of weight, or rather, 16.6% were overweight and 9.8 were obese. Altered WC and AP were measured respectively for 30.6% and 38.3% of the children (Table 2).

When variable on Tables 1 and 2 were compared, no significant statistical differences and possible associations between males and females were found. Consequently, all analyses were carried out jointly.

Table 3 shows the distribution of anthropometric indexes (BMI and WC) according to the absence and presence of high blood pressure measurements

Table 3 shows that all variables were associated with high blood pressure measurements. Further, 69.4% of schoolchildren with desirable WC had normal blood pressure and 30.6% had high blood pressure; among schoolchildren with altered WC, 44.4% had normal blood pressure and 55.6% had high blood pressure ( $p = 0.000$ ).

When chances were evaluated that a child would have high blood pressure (relative risk), it was verified that overweight schoolchildren had 2.19 times more chance of having high blood pressure when compared to schoolchildren with adequate

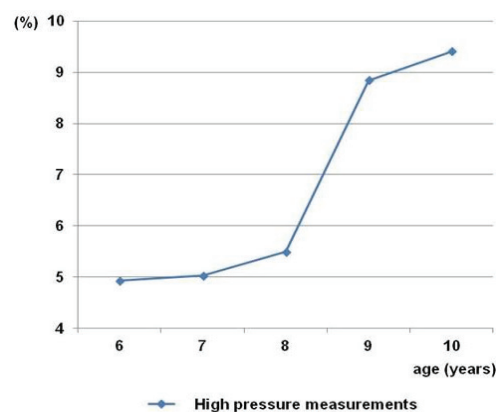
BMI; schoolchildren with altered WC had 2.02 times more chances of having high blood pressure when compared to schoolchildren with desirable WC (Table 3).

**Table 3.** Association of anthropometric indexes according to normal or altered blood pressure levels.

|               | Normal blood pressure levels |      | Altered blood pressure levels |      | P     | OR   |
|---------------|------------------------------|------|-------------------------------|------|-------|------|
|               | N                            | %    | N                             | %    |       |      |
| BMI           |                              |      |                               |      |       |      |
| Adequate      | 543                          | 68.6 | 248                           | 31.4 | 0.000 | 1    |
| Weight excess | 120                          | 42.4 | 163                           | 57.6 | 0.000 | 2.19 |
| WC            |                              |      |                               |      |       |      |
| Desirable     | 517                          | 69.4 | 228                           | 30.6 | 0.000 | 1    |
| Altered       | 146                          | 44.4 | 183                           | 55.6 | 0.000 | 2.02 |

Chi-square test  $p < 0.05$ ; OR – Odds Ratio (IC 95%); BMI- Body Mass Index; WC – Waist Circumference.

Figure 1 demonstrates a significant association ( $p = 0.000$ ) between high blood pressure levels and children's age. Schoolchildren's percentage with high blood pressure increased according to age. Percentage at 6 years old was 4.9%, whereas at 10 years old it increased to 9.4%. At 8 years old, schoolchildren's percentage with high blood pressure reached 5.5%, with a sharp increase at 9 years old when percentage reached 8.8%. Value of the association was tested ( $v = 0.589$ ) and high blood pressure levels might be explained by age increase, or rather, an association between age and high blood pressure levels.

**Figure 1.** Percentage of high blood pressure in 6 - 10-year-old schoolchildren. Chi-square and Cramer's V tests.

## Discussion

Cardiovascular diseases (CVD), the main causes of death in developed and in developing countries (CERILLO et al., 2012), develop slowly and gradually throughout the person's life, with childhood as the onset mark (BERGMANN, 2011; MONEJO; JARDIM, 2006).

Increase in the prevalence of overweight and obesity among children and adolescents has been

registered by Monejo and Jardim (2006) in several researches in different regions of Brazil. They are actually a warning sign to health authorities since above normal BMI is associated to the development of several pathologies early in life, which include inadequate levels of blood pressure. In fact, BMI is an important index in the development of these pathologies in adulthood (CHRISTOFARO et al., 2009). Current study showed that schoolchildren with over average BMI were 26.4%, similar to studies by Gordia et al. (2011) who reported 24.5% of overweight children and adolescents in the metropolitan region of Curitiba, Paraná State, Brazil.

Similar to Brazil, other countries too have an increase in overweight and obese prevalence, as studies by Pereira et al. (2011) with 6 – 10-year-old schoolchildren in Portugal showed. High prevalence in overweight and obesity in children of the Azores Islands reached 22%, similar to that found in Spain with regard to 8 – 9-year-old children, as reported by Cerillo et al. (2012) for Seville.

Percentage increase in schoolchildren with high blood pressure occurs every year and is a great concern for child health (ARAUJO et al., 2008). Current study showed higher rates (25.3%) when compared to those by Passos-Santos et al. (2013) who reported altered arterial blood pressure in approximately 15.0% among 2598 children between eight and ten years old in Paranaíba PR Brazil. Different results were reported by Christofaro et al. (2009) for Londrina, Paraná State, Brazil, with a prevalence of BP alteration in 11.8% of 1,021 adolescents between 10 and 17 years old. These rates were higher than those of the previous study, albeit lower than those of current one. Great variations existed between the frequency of high blood pressure alterations in the different studies investigated, which may be due to different methodologies with regard to sampling methods, to the size and characteristics of the sample, to the quality of measuring tools and employed technique, and to the number of verifications and WC points for the classification of arterial pressure. Mozer et al. (2011) have already found and commented on the above.

Genetic heredity as the cause of high blood pressure was also reported by researchers who underpinned the fact that members of the same family, besides sharing the same genes, also participated in the same social environment (ARAUJO et al., 2008). The latter was not analyzed in current study.

Several investigations analyzed the influence of BMI and WC in the variation of risk factor results for CVD in children and adolescents (PARADIS et al., 2004; JANSSEN et al., 2002; WILLIAMS et al., 2002). The three studies showed a direct

association between BMI and WC with AP. Araújo et al. (2008) also confirmed the above results.

Results by Amer et al. (2011) corroborated those obtained in current study with regard to the increase of arterial hypertension and weight gain according to age. In a study with adults in Belém, Pará state, Brazil, undertaken by a telephone questionnaire, the association between age and weight excess with arterial hypertension in both sexes was registered. Arterial hypertension risk was 1.80 in males and 2.49 in females in the pre-obesity phase and 6.33 and 3.33 respectively for obese males and females (BORGES et al., 2008).

In fact, child BMI is a relevant forecasting factor of cardiovascular diseases in adulthood since it is positively related to increased rates in insulin during fasting, triglycerides and systolic blood pressure, coupled to low scores of high-density lipoproteins in adults (CHRISTOFARO et al., 2009).

Therefore, BMI and WC control are highly important for the decrease in arterial hypertension indexes and thus for the promotion of health and for the prevention of other cardiovascular diseases. In fact, Ferreira and Aydos (2009) reported that arterial hypertension in schoolchildren with the 7 - 14 year bracket was highly significant among overweight children and that educational attitudes were required to promote changes in this situation.

Santos and Rabinovich (2011) highlighted that obesity is a complex and chronic disease that involved environmental and genetic aspects. Environmental factors, however, are the main cause for obesity in childhood worldwide. It should be emphasized that child obesity is increasing in number and size. Obese children have higher risks than non-obese ones to become obese adults. The increase in body fat is a real risk factor in raising the levels of arterial pressure and, consequently, of high pressure rates earlier in life (RINALDI et al., 2012). General and central fat deposition seems to behave as a real risk factor since it is associated with high blood pressure levels (MOZER et al., 2011). Such an association is also found in the investigation by Pereira et al. (2011) with Portuguese children in whom high overweight and obesity prevalence was associated with AP levels.

Brazilian society has recently experienced great cultural changes that modified behaviors and habits, with great repercussions on children. Contrastingly to their parents and grandparents, contemporary children do not have the same playing space in which they cycled, played football and exercised themselves by running, jumping and skipping. Today's habits and behaviors are different and

children live isolated in their homes, playing electronic games or in front of computers and TV, for many hours.

The school has an important role towards the formation of good habits and behaviors with regard to the life style of schoolchildren. These include basic concepts in healthy food and the practice of physical exercises and lessons in physical education, recovering forgotten games.

In the wake of the enormous complexities of the bad consequences caused by obesity and altered blood pressure during childhood, scientific evidences abound in showing that CVDs are pathological processes that frequently originate in childhood and adolescence with a persistence during adulthood. Current analysis contributes within the scientific milieu through the forwarding of data on the theme with regard to children that live off the main research centers. Although current investigation has its limitations, mainly because children's AP was evaluated only once and the heredity variable was left out, a greater support in the diagnosis of the illness within the school environment is provided.

## Conclusion

Current research investigated the relationship between anthropometric indexes and blood pressure levels in schoolchildren, which are actually risk factors for cardiovascular diseases in adulthood.

Results showed that 26.4% of schoolchildren were overweight, 30.6% were obese, 38.3% had high blood pressure and 31.4% of schoolchildren with adequate nutritional conditions presented high blood pressure levels. Schoolchildren featuring overweight and central adiposity had higher chances for increasing their blood pressure rates.

Results also demonstrated that attacking fat increase during childhood should be a public health issue since it is associated with the emergence of important diseases in childhood, such as arterial hypertension that may become chronic and more serious in adulthood. In fact, other pathologies, such as cardiovascular diseases, may originate from it.

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