Does the Body Mass Index Reflect Cardiovascular Risk Factors in Brazilian Children?

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Summary

This cross-sectional study aimed to: (i) investigate whether obesity and overweight defined according to body mass index (BMI) are good predictors of body fat excess, abdominal adiposity and hypertension in 769 Brazilian children aged 6–11 years, (ii) assess the relationship between overweight/obesity and cardiovascular risk factors. Overweight and obesity were estimated using cut-off points corresponding to World Health Organization 1and 2 SD (standard deviation) scores. Based on the results of a multiple logistic regression analysis, overweight and obesity were significantly associated with body fat excess, abdominal adiposity and hypertension. The prevalence of obesity (10.7%), overweight (18.7%), abdominal adiposity (17.6%) and systolic (10.1%) and diastolic hypertension (9.3%) was high in this population of Brazilian children. The cardiovascular risk factors increased significantly according to the BMI SD scores, indicating that in epidemiologic studies, BMI may be a good indicator of risk for cardiovascular diseases.

Key words: children, body mass index, hypertension, body fat excess, nutritional epidemiology.

Introduction

The increasing incidence of childhood obesity stresses the importance of nutritional evaluation to investigate physical growth conditions and help in the prevention and treatment of obesity. The relationship between body fat (BF), fat distribution and blood pressure, which are related to increased prevalence of childhood obesity, is crucial from a public and clinic health viewpoint [1].

Anthropometric and clinical measurements should be the preferential method for assessment of body composition in epidemiological studies, as they are indirect, simple and non-invasive with low costs in comparison with more sophisticated alternatives.

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Their correct use, however, demands adequate training of the investigators, as they may become inaccurate and introduce errors in the results. Laboratory methods, such as dual-energy X-ray absorptiometry, magnetic resonance and computed tomography, are more accurate for the evaluation of body composition, but they are mainly available in specialized centers and are not adequate for population studies, owing to their high costs and complexity [2].

The increased prevalence of pediatric obesity, as well as its associated morbidities, demonstrates the need for a simple anthropometric tool, which can be used to assess and identify children who are at risk of becoming obese and subsequently require appropriate intervention. Estimates of the prevalence of overweight and obesity in population groups are typically based on body mass index (BMI), and curves have been developed for use in the pediatric population for clinical and possibly epidemiological purposes [3].

Although the BMI is generally used for assessment of overweight and obesity in children and adolescents, its use as an indicator of BF should be carefully considered [4]. Wells [5] observed that the use of BMI for routine assessment of BF does not allow the identification of BF excess and risk factors associated with it in the pediatric population.
The prevalence of overweight and obesity based on BMI has tripled in Brazilian children and adolescents during the past 2 decades [6]. However, BMI in children had not been regarded an important predictor of adiposity and blood pressure, like in adults. To these ends, this study aimed to investigate whether obesity and overweight defined according to BMI [7] are good predictors of BF excess, abdominal adiposity and hypertension in Brazilian children, and assess the relationship between overweight/obesity and cardiovascular risk factors.

**Materials and Methods**

**Population and design**

The present study was conducted in the city of Viçosa located in the province of Minas Gerais, in the southeast of Brazil. Viçosa has a population of around 64,800 inhabitants of which 59,792 (92.2%) live in the urban area [8]. A cross-sectional study was conducted with 769 school children aged 6–11 years, chosen by simple random selection stratified by proportion of students according to age and gender in classes at public and private schools. The sample size was calculated using the following premises: obesity prevalence (8%) [9], the desired level of precision of 2%, 95% of power, 5% of significant level and estimated loss of 10%.

**Anthropometric and clinical measurements**

Parents and children were invited for nutritional consultation at the Laboratory of Nutritional Evaluation of the Nutrition and Health Department of Federal University of Viçosa.

Anthropometric measurements of weight and height were performed according to Jelliffe [10]. Weight was assessed with a portable digital electronic scale (Filizola PL 200®, Filizola, Brazil), with 150 kg capacity and 50 g sensitivity. Height was assessed with a 2 m long portable stadiometer (Seca®, Marsden, UK), divided into centimeters and subdivided into millimeters. The BMI was calculated from the weight and height measures (kg/m²), and the nutritional status was classified according to the World Health Organization [7]. Overweight and obesity were estimated using cut-off points corresponding to 1 and 2 SD (standard deviation) scores, respectively [7].

The triceps and sub-scapular skinfold were measured to the nearest millimeter with a skinfold caliper (Lange®, Diversey Inc., UK). Triceps skinfold was measured at the mid-point between the acromion and olecranon process. Sub-scapular skinfold was measured about 20 mm below the tip of the scapula, at a 45° angle to the lateral side of the body. Each measurement was repeated three times, non-consecutively, and the result represented the average of the two most similar results. BF percentage was estimated according to the Slaughter equations, based on the results for tricipital and sub-scapular skin fold thickness [11]. BF excess was estimated using cut-off points corresponding to the 95th percentiles of the McCarthy, *et al.* [12].

Waist and hip circumferences were measured with a non-elastic flexible tape with the subject in a standing position at the end of expiration. Waist circumference (WC) was measured at a level midway between the lower rib margin and iliac crest, and hip circumference was measured as the maximal circumference over the buttocks [13]. Waist–hip relationship was calculated as the waist divided by the hip circumference. The abdominal adiposity was estimated using cut-off points corresponding to the 95th percentiles of the WC British reference [14].

Sitting blood pressure was measured using an automatic unit with the right arm at the same level of the heart using an appropriate cuff size. This equipment (Omron® HEM 907) was validated against mercury sphygmomanometers according to the international validation protocol [15]. The blood pressure was measured three times at 5 min intervals and was considered the average of second and third measurements. The classification individually took into account gender, age and height based on parameters of the Brazilian Hypertension Society [16]. The cuff size was appropriated to arm circumference of children [16]. Hypertension was defined as average blood pressure above the 95th percentile [16].

The nutritional status of the mothers was evaluated. Weight was assessed with a portable digital electronic scale (Filizola PL 200®), with 150 kg capacity and 50 g sensitivity, and height was determined with a 2 m long stadiometer (Seca®), divided into centimeters and subdivided into millimeters. These measurements were made according to Jelliffe [10]. The nutritional status was classified by BMI according World Health Organization [17].

Information concerning physical activity was obtained by face-to-face interviews. Children who watched television, played games and/or sat in front of the computer for >2 h a day were considered sedentary [18].

All anthropometric evaluations, blood pressure measurements and interviews were conducted by the same researcher to avoid possible biases in the measurements.

The socioeconomic status was assessed by type of school attended by children, with a predominance of families with low and high socioeconomic status in public and private schools, respectively [8].

**Statistical analysis**

The variables are presented as medians because almost all were not normally distributed (Kolmogorov–Smirnov test). Parametric and non-parametric tests were performed according to the distribution of parameters.
variables, as well as tests of association. The Pearson χ² test was used to compare proportions.

A one-way analysis of variance was used to verify differences in anthropometric and clinical characteristics between groups of nutritional status. When a statistical difference was detected, Tukey’s test was then performed to assess specific differences between the groups.

Multiple logistic regression analysis was used to examine the relationship of obesity and overweight with abdominal adiposity, BF excess and hypertension. The potential confounders were divided in two groups: children (age, gender, practice of physical activity and socioeconomic status) and mother (nutritional status and education level). Statistical analyses were carried out in SPSS version 15.0. Values of p < 0.05 were considered to be statistically significant.

This study was approved by the Research and Ethics Committee of the Federal University of Minas Gerais (protocol number 0392/05), and conforms to provisions of the Declaration of Helsinki in 1995 (as revised in Tokyo in 2004). Participation in the study was entirely voluntary: child consent and signed informed consent of the parents or legal guardians were obtained.

Results

The prevalence of obesity (10.7%), overweight (18.7%), abdominal adiposity (17.6%) and systolic (10.1%) and diastolic hypertension (9.3%) was high in this population of Brazilian children.

All anthropometric variables, body composition and blood pressure had larger means in obesity and overweight groups than eutrophic (p < 0.001). Compared with eutrophic, obese and overweight children were taller and had mothers with higher BMI values (p < 0.001) (Table 1).

Table 2 shows the prevalence of variables with values above the recommendation. Obese children had higher prevalence of excess of BF, abdominal adiposity and hypertension than in the eutrophic group (p < 0.001).

Table 3 shows positive correlations of BMI with height, waist and hip circumference, BF, systolic and diastolic blood pressure and mothers’ BMI (p < 0.05). WC presents positive correlations with height, hip circumference, waist–hip relationship, BF, systolic and diastolic blood pressure and mothers’ BMI (p < 0.001).

Table 4 shows the multiple logistic regression analysis for obesity and overweight. The risk of obesity was greater in children presenting with abdominal adiposity, excess of BF and hypertension, and whose mothers were obese and with low level of education. The risk of overweight was greater in children presenting with abdominal adiposity and hypertension and whose mothers were obese.

Almost half of the children (41.5%) presented one or more cardiovascular risk factors. The number of risk factors increased significantly with the nutritional status (Pearson ρ² < 0.001, Fig. 1).

Discussion

This study in Viçosa presented higher prevalence of Cardiovascular diseases (CVD) risk factors than other schoolchildren living in the southeast and northeast of Brazil [9, 19].

Some limitations of the present study have to be considered. The cut-off points corresponding to BMI, WC and BF were determined by international references whose specific information on ethnicity was not available. Children from different populations vary in their rate of growth and in fat patterning because of socioeconomic status, dietary and physical activity patterns and ethnic characteristics [20]. It is known that body and visceral fats are highly variable in children and are related to ethnicity. Because of a high degree of miscegenation in the Brazilian population, it might be advisable to develop standards in the national context, with representative samples of children from all ethnic backgrounds. In the absence of Brazilian BF and WC reference data to age of this study, we used the cut-off point based on British reference data, to compare frequencies of BF excess and abdominal adiposity.

Some strengths of our study should also be considered. First, the control of potential confounding variables constituted an important characteristic of this study. Second, all interviews and anthropometric and clinical evaluations were collected by the same researcher, which contributes for reduction of biases in the evaluations. Third, it is important to notice that the BMI cut-off point for classification of obesity is highly specific, with a smaller probability of false-positive results. This was a methodological concern of the present study, so that any relationship observed between obesity and hypertension and total and central BF could be investigated with reliability.

Even after adjusting potential confounders by multiple logistic regression analysis, this study confirms that the BMI cut-off points [7] for obesity and overweight were capable of identifying BF excess, abdominal adiposity and hypertension in Brazilian children. Similar results were described by Giugliano and Melo [21], who reported that BMI/age presented concordance with excessive body adiposity and visceral and central fat. In a study of individuals from 6 months to 21 years of age, Frontini, et al. [22] observed that the BMI is useful in the evaluation of associated obesity and cardiovascular risk in children >4 years of age, independent of age, race and gender. In Texas, the prevalence of hypertension in children increased progressively as the BMI percentile increased from <5th percentile (2%) to >95th percentile (11%). After
**TABLE 1**

*Anthropometric, socioeconomic and clinical characteristics according to nutritional status of the children*

| Variable                              | Eutrophic | Overweight | Obesity | p-value |
|---------------------------------------|-----------|------------|---------|---------|
|                                       | X ± SD    | X ± SD     | X ± SD  |         |
| Age (years)                           | 9.1 ± 1.3
d | 9.2 ± 1.3
db | 9.5 ± 1.4
db | <0.001* |
| Height (cm)                           | 133.4 ± 9.3
d | 137.4 ± 8.5
d | 141.7 ± 9.6
d  | <0.001* |
| WC (cm)                               | 56.0 ± 3.7
d | 63.6 ± 4.3
d | 73.4 ± 4.7
d  | <0.001* |
| Hip circumference (cm)                | 67.8 ± 5.6
d | 77.1 ± 5.9
d | 67.8 ± 5.4
d  | <0.001* |
| Waist–hip relationship                | 0.83 ± 0.04
d | 0.83 ± 0.04
d  | 0.85 ± 0.03
d | 0.001* |
| BF %                                  | 10.3 ± 3.2
d | 17.5 ± 4.4
d  | 24.0 ± 5.1
d  | <0.001* |
| SBP (mm Hg)                           | 110.0 ± 9.2
d | 119.1 ± 9.6
d  | 128.5 ± 10.3
d | <0.001* |
| DBP (mm Hg)                           | 67.2 ± 6.8
d | 72.8 ± 6.9
d  | 80.5 ± 9.7
d  | <0.001* |
| Education level of mothers (years)    | 10.2 ± 4.8
d, b | 11.3 ± 4.6
d  | 9.1 ± 4.4
d  | 0.004* |
| Mothers’ BMI (kg/m²)                  | 24.2 ± 4.1
d | 25.9 ± 4.6
d  | 29.2 ± 6.0
d  | <0.001* |

Means followed of a same letter in lines did not differ significantly.

*ANOVA: p < 0.05 (statistically significant).

**X ± SD, mean ± SD; SBP, systolic blood pressure; DBP, diastolic blood pressure.**

**TABLE 2**

*Prevalence of inadequate of BF and blood pressure according to nutritional status of the children*

| Variable                              | Eutrophic | Overweight | Obesity | p-value |
|---------------------------------------|-----------|------------|---------|---------|
|                                       | n (%)     | n (%)      | n (%)   |         |
| BF % (>p95th)                         | –         | 1 (0.7)    | 13 (15.9)| <0.001a* 0.216b |
| WC (>p95th)                           | 4 (0.8)   | 56 (39.2)  | 74 (91.4)| <0.001a* <0.001b* |
| SBP (>p95th)                          | 194 (37.0)| 105 (72.4) | 76 (92.7)| <0.001a* <0.001b* |
| DBP (>p95th)                          | 68 (13.0) | 48 (33.1)  | 47 (57.3)| <0.001a* <0.001b* |

*Obesity vs. eutrophic.

*Overweight vs. eutrophic.

*Statistically significant (p < 0.05). Pearson χ² test. p95th, 95th percentile.

**TABLE 3**

*Linear correlation coefficient of anthropometric, socioeconomic and clinical characteristics with BMI and WC of children*

| Variable                              | BMI       | WC        |
|---------------------------------------|-----------|-----------|
|                                       | r         | p-value   | r         | p-value |
| Heighta                               | 0.43      | <0.001*   | 0.57      | <0.001* |
| WC                                    | 0.86      | <0.001*   |           |         |
| Hip circumference                     | 0.84      | <0.001*   | 0.86      | <0.001* |
| Waist–hip relationship                | -0.06     | 0.12      | 0.11      | 0.002*  |
| BF %                                  | 0.78      | <0.001*   | 0.71      | <0.001* |
| SBP                                   | 0.59      | <0.001*   | 0.58      | <0.001* |
| DBP                                   | 0.48      | <0.001*   | 0.42      | <0.001* |
| Education level of mothers (years)    | -0.05     | 0.146     | 0.02      | 0.515   |
| Mothers’ BMI (kg/m²)                  | 0.38      | <0.001*   | 0.32      | <0.001* |

*Pearson and Spearman correlations.

*Statistically significant (p < 0.05).
Table 4

Multiple logistic regression models considering overweight and obesity as dependent variables and BF, WC and blood pressure as independent variables

| Variables                                          | Adjusted OR (95% CI) | p-value |
|----------------------------------------------------|----------------------|---------|
| **Obesity**                                        |                      |         |
| WC (>p95th)                                        | 74.5 (30.5–181.5)    | <0.001* |
| BF % (>p95th)                                      | 9.7 (1.1–84.8)       | 0.04*   |
| SBP (>p95th)                                       | 5.8 (2.1–15.9)       | 0.001*  |
| Mothers’ obesity (BMI >30 kg/m²)                   | 3.9 (1.7–9.0)        | 0.001*  |
| Mothers’ education level (not-concluded undergraduate) | 3.6 (1.5–8.8)         | 0.005*  |
| **Overweight**                                     |                      |         |
| WC (>p95th)                                        | 72.1 (26.9–192.7)    | <0.001* |
| SBP (>p95th)                                       | 3.6 (2.1–5.9)        | <0.001* |
| DBP (>p95th)                                       | 2.2 (1.3–3.7)        | 0.005*  |
| Mothers’ obesity (BMI > 30 kg/m²)                  | 2.0 (1.1–3.9)        | 0.03*   |

*Adjusted for children (age, gender, lifestyle, socioeconomic status, blood pressure, WC and BF) and mothers (obesity and education level) characteristics.

*Statistically significant (p < 0.05).

OR, odds ratio; CI, confidence interval.

cardiovascular diseases (25.9%) of adults aged ≥60 years, and the larger proportional mortality ratio by diseases of the circulatory system (27.0%) of adults aged 60–69 years in Viçosa [27].

This study is one for the few that evaluated the BMI as predictor of cardiovascular risk factors in children of developing countries. We conclude that obesity and overweight defined according BMI [7] was a sensitive indicator of cardiovascular risk factors in Brazilian children. Because of a high degree of miscegenation in the Brazilian population, it might be advisable to develop standards in the national context, with representative samples of children from all ethnic and socioeconomic status backgrounds.

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