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RESEARCH ARTICLE

WAIST CIRCENFERENCE AS AN INDICATOR OF CLINICAL PARAMETERS IN BRAZILIAN CHILDREN

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ABSTRACT

Objective: The purpose of this study was to verify and set a standard for the Waist Circumference (WC) in children as a marker for abdominal obesity.
Methods: The study involved 8 state schools in the city of Lins, state of São Paulo, Brazil. The population of the study comprised 882 children of both sexes, with ages ranging from 6 to 10. The following anthropometric variables were evaluated: BMI/A (body mass index in relation to age); W/A (weight in relation to age); the TSF (Tricipital Skinfold), and the WC. The curves used to determine the parameters evaluated here are for children and adolescents aged 2 to 20.
Results: An analysis of the WC values in terms of pBMI/A, pTSF, and pW/A indicates that, in terms of the variables studied here, the WCs are the same for both sexes and it is reasonable to suggest that a correlation between the WC and the pBMI/A, pTSF and pW/A is a good parameter to diagnose the nutritional status of 6 to 10-year-old children, and that it can be used in clinical practice to aid the diagnosis of obesity and its correlation with the development of metabolic disorders.
Conclusions: The results show that the WC is a valid parameter to diagnose the nutritional status of children between 6 and 10 years of age.

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INTRODUCTION

Obesity is considered a public health problem that affects both young and adult populations. It is generally caused by an excessive consumption of fat and sugar-rich foods, associated with low consumption of energy. This pathology is difficult to control, with high percentages of therapeutic failure and recurrence, which may lead to serious psychosocial repercussions. This condition represents a multifactorial disease resulting from a complex interaction of behavioral, cultural, genetic, physiological and psychological factors. Thus, it can be determined by external agents relating to a hypercaloric diet, environmental and economic, genetic or endocrinal factors. It is believed that external factors are more relevant in the incidence of obesity than genetic factors (Lazorick *et al*., 2016; Rocca *et al*., 2016 and Pbert *et al*., 2016). Overweight and obesity affects groups with low or high socio-economic status, both adults and children. Over the last decades, obesity has become one of the greatest challenges of researchers and professionals in the field of health, since the excessive accumulation of body fat is associated with the development of innumerable metabolic dysfunctions such as cardiopathies, arterial hypertension, diabetes, hyper cholesterolemia and hyperlipidemia. Besides, it has reached epidemic proportions in industrialized countries, negatively affecting the health of children and adults, and leading to excessively high costs for society as a whole (Ma *et al*., 2016; Liu *et al*., 2016 and Norman *et al*., 2016). Obese children may have greater chances of becoming obese adults, and also be at higher risk of contracting these obesity-related diseases. In industrialized countries, childhood obesity has reached alarming proportions, exceeding the rates of malnutrition and infectious diseases. Brazil is no exception, and the high rates of childhood obesity have become a major public health concern, particularly due to the impact it causes in children's lives, with its physical, social, economic and psychological consequences (Fernández-Barrés *et al*., 2016; Lee *et al*., 2016; Buckley *et al*., 2016; Costa Junior *et al*., 2015). In line with the latest census performed in Brazil, there are 33.5% of overweight in children and adolescents are 14.3% are obese (Costa Junior *et al*., 2015;

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Sobol-Goldberg *et al*., 2013) (http:// www.ibge.gov.br/home/ presidencia/noticias/noticia_visualiza. php?id_noticia=1699). Therefore, the purpose of this work was to carry out a survey of the anthropomorphic profile and nutritional classification of children of both sexes, aged 6 to 10, and to ascertain if the waist circumference (WC) is a suitable parameter to indicate the child's nutritional status.

MATERIALS AND METHODS

The study was conducted at eight public state schools in the city of Lins, state of São Paulo, Brazil, authorized by the municipality's Supervisor of Education. This project was approved by the Research Ethics Committee of UNIMEP, and only children whose parents or caregivers had signed the consent form participated in the study (Resolution 196/10 of October 1996 – National Health Council – CNS). The population of this study encompassed 882 children of both sexes aged 6 to 10. The anthropomorphic measurements were taken and evaluated according to the World Health Organization (http://www.abeso.org.br/ artigos.htm).

The children's weight and height were measured at their school with an electronic balance (Filizola), with capacity for 180 kg, and a SANNY stadiometer with millimetric precision. The skinfolds were measured with the aid of a Lange compass with 0.5mm reading. The diagnosis of overweight and obesity was based on the criterion of the WHO (1995), which considers the 50 percentile (p50) to be normal, p≥85 indicating an overweight classification, and p≥95 a diagnosis of obesity (WHO, 1995). The anthropomorphic data of TSF (tricipital skinfold) were collected and analyzed according to (Harrison *et al*., 1998) and the WC following the proposal of (Lean *et al*., 1995). The curves used for the determination of the parameters evaluated here are for children and adolescents aged 2 to 20 (National Center for Health Statistics, 2000; Redfern *et al*., 2016). The data were analyzed by Descriptive Statistics and significance tests.

RESULTS

Table 1 presents the WC values in terms of the parameters of pBMI/A, pTSF, and pW/A for male children considered underweight, eutrophic, overweight and obese. This table indicates that a comparison of the WC against pBMI/A showed values of 50.28 to 55.95, while for pTSF the values were 49.69 to 58.71, and for pW/A they were 49.68 to 65.65 for underweight children. The WC for eutrophic children in relation to the pBMI/A was 56.87 to 57.90; for pTSF the values were 57.84 to 59.31, and for pW/A they were 61.52 to 63.44. The WC of overweight children in relation to the pBMI/A was 59.89 to 65.54 and for pTSF the values were 59.27 a 65.8. The WC could not be compared with the pW/A because, in this study, there was no record of any overweight male child in terms of pW/A. Analyzing the WC of obese children revealed pBMI/A values of 72.58 to 75.96.

Table 1. WC (in cm) in relation to the parameters of pBMI/A (body mass index in relation to age), pTSF (tricipital skinfold), and pW/A (weight in relation to age) for underweight, eutrophic, overweight and obese male children aged 6 to 10. (CI = confidence interval, LL = lower limit, and UL = upper limit)

CI	Underweight			Eutrophic			Overweight			Obese		
	pBMI	pTSF	pW/A	pBMI	pTSF	pW/A	pBMI	pTSF	pW/A	pBMI	pTSF	pW/A
	50.28	49.69	49.68	56.87	57.84	61.52	59.89	59.27		72.58	70.99	
LL												
UL	55.95	58.71	65.65	57.90	59.31	63.44	65.54	65.8		75.96	75.01	

CI = confidence interval of 95%

Table 2. WC (in cm) in relation to the parameters of pBMI/A (body mass index in relation to age), pTSF (tricipital skinfold), and pW/A (weight in relation to age) for underweight, eutrophic, overweight and obese female children aged 6 to 10. (CI = confidence interval, LL = lower limit, and UL = upper limit)

CI	Underweight			Eutrophic			Overweight			Obese		
	pBMI	pTSF	pW/A	pBMI	pTSF	pW/A	pBMI	pTSF	pW/A	pBMI	pTSF	pW/A
	48.37	50.02	44.45	56.71	58.27	61.10	63.57	63.83		70.74	70.74	
LL												
UL	54.56	54.58	57.22	57.78	59.62	62.68	66.38	69.24		73.46	74.47	

CI = confidence interval of 95%

Table 3. Comparison of WC values (in cm) in relation to pBMI/A, pTSF and pW/A for male and female children

	pBMI/A	pTSF	pW/A
Underweight	48 to 55.9	49 to 59	44 to 66
Eutrophic	56.7 to 57.9	57.8 to 59.6	61.1 to 63.4
Overweight	59.9 to 65.5	59.2 to 69.3	-
Obese	70.7 to 76	70.9 to 75.01	-

The analysis of the WC in relation to the pTSF showed values of 70.99 to 75.01. The WC could not be compared with pW/A due to the absence of any male child with obesity in relation to pW/A. Table 1 presents the WC values in terms of the parameters of pBMI/A, pTSF, and pW/A for female children considered underweight, eutrophic, overweight and obese. This table indicates that that a comparison of the WC against pBMI/A showed values of 48.37 to 54.56, while for pTSF the values were 50.02 to 54.58, and for pW/A they were 44.45 to 57.22 for underweight children. The WC for eutrophic children in relation to the pBMI/A was 56.71 to 57.78; for pTSF the values were 58.27 to 59.62, and for pW/A they were 61.10 to 62.68. The WC of overweight children in relation to the

pBMI/A was 63.57 to 66.38 and for pTSF the values were 63.83 to 69.24. The WC could not be compared with the pW/A because there was no record of any overweight female child in terms of pW/A in this study. Analyzing the WC of obese children revealed pBMI/A values of 70.74 to 73.46. The analysis of the WC in relation to the pTSF showed values of 70.74 to 74.47. The WC could not be compared with pW/A due to the absence of any female child with obesity in relation to pW/A. Table 3 summarizes the values of WC in terms of the parameters of pBMI/A, pTSF and pW/A presented in Tables 1 and 2 for children of both sexes according to the nutritional classification.

DISCUSSION

In the last few decades, obesity has been identified in the literature as an important risk factor for the development of cardiovascular diseases (CVD). However, it is well known that this risk is aided and abetted by other factors, regardless of whether or not the individual is obese. These factors include the WC, which has been exhaustively shown in adults to participate in metabolic syndrome and which has, more recently, been identified as a risk factor in children and adolescents. Visceral fat accumulated in the abdominal perimeter is considered one of the most relevant risk factors for CVD, diabetes, cancer and other metabolic problems. Among the various methods to evaluate visceral fat, the WC measurement is the, simplest, easiest and most reliable one (Costa Junior *et al*., 2015; Redfern *et al*., 2015; Fernández-Barrés *et al*., 2016; Lee *et al*., 2016; Hatipoğlu *et al*., 2015). There are many difficulties to find out cut-off points to evaluate the WC in children because in this life phase it is necessary to consider age, height, sexual maturity stage converging to a fast physical growth (Hur *et al*., 2015). In face of these difficulties, this work considered age, sex, height and weight of the studied children to have more credible data to find the cut-off points to waste WC in children of both sexes aged 6 to 10. Based on the results listed in Tables 1 to 3, it was found that the correlation of the WC (WC) with the pTSF and W/A were not good parameters to evaluate the nutritional status of the children of this study, since there are variations in the value ranges among the different nutritional classification parameters. However, using the BMI/A, one can establish a range for female and male children's WC (in centimeters) of 48 to 55 for underweight; 56 to 58 for eutrophic, 59 to 69 for overweight, and above 70 for obesity. The establishment of these values provides a reliable standard of nutritional classification based on a simple, fast and noninvasive measurement.

These data are useful for classifying children, since it is known that excessive body fat, especially in the abdominal perimeter, leads to the accumulation of lipids in tissues, particularly in the adipose tissue, muscles, liver and pancreatic β cells, which seem to induce the biochemical alterations that occur in metabolic syndrome (Hur *et al*., 2015; Mårild *et al*., 2015; Zardast *et al*., 2015; Hirschler *et al*., 2015). According to some authors, not only adults but also children can suffer effects resulting from the so-called metabolic syndrome when they present abdominal-type fat distribution. This finding indicates that the early diagnosis of alterations in the accumulation of abdominal fat underlines the importance of possessing an easy measuring method for children, since it is a rapid method that facilitates the work of the researcher in studies involving large numbers of individuals. Some studies show that the distribution of body fat can be checked by a variety of anthropometric procedures. The waist-hips ratio has been used for adults, but studies have shown that only the measurement of the WC can be a safer tool to determine central adiposity, including in children.

In central adiposity, the distribution of adipose tissue occurs preferentially at the level of the trunk, with increased deposition in the intra-abdominal region (Harrison *et al*., 1998; Fernández-Barrés *et al*., 2016; Lee *et al*., 2016; Hatipoğlu *et al*., 2015; Monzani *et al*., 2016; Bahk *et al*., 2016; Hur *et al*., 2015; Mårild *et al*., 2015; Zardast *et al*., 2015; Hirschler *et al*., 2015; Juan *et al*., 2015). An analysis of the results obtained with the children of the public schools in Lins showed a predominance of overweight and obesity for WC values in terms of the pBMI/A and pTSF, which is congruent with studies on obesity by (Duncan *et al.,* 2011) that found overweight and obesity in a large sample of children and adolescents living in São Paulo (Brazil). These authors encountered a prevalence of 19.4% of boys and 16.1% of girls with overweight classification and 8.9% and 4.3% were obese. Nihues *et al.,* (2014), performed a review in order to identify the prevalence of overweight and obesity in children and adolescents between 2 and 19 years old in different regions of Brazil and found a higher prevalence of overweight in the south (25.7%) and north (28.8%) of the country, and obesity in the southeast (15.4%) and south (10.4%). The cut-off points currently in use for classifying the WC were defined initially by Lean Han, Morrison, 1995. The cut-off points of the WC associated with 25 kg/m^2 and 30 kg/m^2 BMI were identified. To facilitate their use for clinical purposes and in public health programs, these cut-off points were described at two levels: level 1 (WC of $\geq$ 80 cm for women and $\geq$ 94 cm for men), where the individuals were classified according to their increased risk of obesity-related morbidities, and level 2 ($\geq$ 88 cm for women and $\geq$ 102 cm for men), where individuals were classified as at very high risk for CVD, morbid obesity and metabolic syndrome. In the case of children, this comparison can establish a cut-off parameter that would serve as a warning to seek the help of a health professional for the reduction of WC and hence of weight, in order to avoid future obesity-related morbidities and a more in-depth diagnosis of other risk factors, aiming to enhance the quality of life since childhood. The increase in levels of fat, as indicated by the WC values in relation to the pBMI/A, pTSF and pW/A, indicate that children may be accustomed to the consumption of food rich in fats and simple carbohydrates, associated with a sedentary lifestyle. This finding is corroborated by many studies, which shows that the comparison of anthropometric measurements and frequency of energy balance disorders confirms a predominance of nutritional disorders relating to excessive food consumption, as well as little physical activity (Jean *et al*., 2011; Pauline *et al*., 2015; Erik *et al*., 2011). In view of all the results presented here, it is reasonable to suggest that a correlation between the WC and the pBMI/A, pTSF and pW/A was a good parameter to diagnose the nutritional status of 6 to 10-year-old children in the studied population, and that it can be used in clinical practice to aid the diagnosis of obesity and its correlation with the development of metabolic disorders. However, it is important to stress the need for further studies to establish cut-off points for abdominal WC that indicate the

child's risk of developing disorders associated with the accumulation of abdominal adiposity in future life. Data such as those evaluated in this population demonstrate that increased adiposity indicates the need for early nutritional education programs, as well as changes toward a healthier lifestyle.

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Conflict of interests

Authors declare no conflict of interests related to this work.

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