RBCDH Brazilian Journal of KINANTHROPOMETRY and Human Performance

DOI: http://dx.doi.org/10.5007/1980-0037.2012v14n6p636

original article

Anthropometric profile and abdominal adiposity of school children aged between 6 and 10 years in southern Brazil

Perfil antropométrico e adiposidade abdominal de escolares entre 6 a 10 anos de idade do Sul do Brasil

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Abstract – The aims of the present study were to assess the association of anthropometric measures with body mass index (BMI) and to verify the presence of abdominal adiposity in school children. This is a cross-sectional study conducted with 4,964 school children between 6 and 10 years of age registered in 345 schools from eight municipalities of the state of Santa Catarina (Brazil). The independent variables used were the following: subscapular (SSF) and triceps skinfold (TSF) thickness, arm circumference (AC), waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR). BMI was used as the dependent variable. Unadjusted and adjusted associations were estimated using linear regression and expressed as a regression coefficient (β). All anthropometric measurements were controlled during adjusted analysis to remain within the $p < 0.20$ model. Abdominal adiposity was defined as WHtR ≥ 0.5. The mean BMI was 17.4 kg/m^2 (SD = 2.8) in males and 17.2 kg/m^2 (SD = 2.8) in females. The mean anthropometric measurements for males and females respectively were as follows: SSF = 7.2 and 8.3mm; TSF = 10.8 and 12.6mm; AC = 20.0 and 20.2cm; WC = 60.1 and 58.5cm; HC = 71.3 and 71.9cm; WHR = 0.84 and 0.81; WHtR = 0.45 and 0.44. All anthropometric measurements were positively associated with BMI in the unadjusted analysis of both sexes. In the adjusted analysis, associations among males were as follows: SSF (β = 0.05), AC (β = 0.17), WC (β = 0.19), and WHtR (β = 30.5). Associations among females were as follows: SSF (β = 0.19), AC (β = 0.17), WC (β = 0.13), WHR (β = -6.2), and WHtR (β = 32.1). The prevalence of abdominal adiposity was 11.9%. It was concluded that the anthropometric indicators SSF, AC, WC, and WHtR had a satisfactory relationship with BMI in school children of both sexes. These measurements could be used, in addition to BMI, to determine total and central adiposity.

Key words: Adiposity; Anthropometry; Body composition; Body mass index; School children.

Resumo – *O estudo teve como objetivo avaliar a associação de medidas antropométricas com o Índice de Massa Corporal (IMC) e verificar a presença de adiposidade abdominal em escolares. Estudo transversal realizado entre 2007-2008, com 4.964 escolares de 6 a 10 anos de idade, matriculados em 345 escolas de oito municípios do Estado de Santa Catarina. As variáveis independentes utilizadas foram: dobras cutâneas subescapular (DCS) e tricipital (DCT), circunferências do braço (CBr), cintura (CC) e quadril (CQ) e relações cintura/quadril (RCQ) e cintura/estatura (RCEst). O IMC foi utilizado como variável dependente. Associações brutas e ajustadas foram estimadas mediante regressão linear e expressados como coeficiente de regressão (β). Para análise ajustada, todas as medidas antropométricas foram controladas entre si, mantendo-se no modelo aquelas com p<0,20. Classificou-se a adiposidade abdominal com a RCEst ≥ 0.5. Os resultados mostram que o IMC médio dos meninos foi 17,4kg/m^2 (DP=2,8) e das meninas 17,2kg/m^2 (DP=2,8). As médias das medidas antropométricas para os sexos masculino e feminino foram, respectivamente: DCS=7,2 e 8,3mm; DCT=10,8 e 12,6mm; CBr=20,0 e 20,2cm; CC=60,1 e 58,5cm; CQ=71,3 e 71,9cm; RCQ=0,84 e 0,81; RCEst=0,45 e 0,44. Todas as medidas antropométricas se associaram positivamente com o IMC na análise bruta, para ambos os sexos. Na análise ajustada, nos meninos, mantiveram-se associadas: DCS (β=0,05), CBr (β=0,17), CC (β=0,19) e RCEst (β=30,5). Nas meninas, continuaram associadas a DCS (β=0,19), CBr (β=0,17), CC (β=0,13), RCQ (β=-6,2) e RCEst (β=32,1). Apresentaram adiposidade abdominal 11,9% (n=589) dos escolares, de acordo com a RCEst. Pode-se concluir que os indicadores DCS, CBr, CC e RCEst apresentaram boa relação com o IMC em escolares de ambos os sexos. Estas medidas poderiam ser utilizadas como complemento ao IMC para determinação da adiposidade corporal total e central.*

Palavras-chave: *Adiposidade; Antropometria; Composição corporal; Escolares; Índice de massa corporal.*

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Received: 15 January 2012
Accepted: 23 May 2012

INTRODUCTION

Children's growth and body dimensions at all ages can reflect the health status of individuals and populations. Thus, anthropometry assesses size, proportions and composition of the human body, being one of the tools used to analyze nutritional status[1].

There is a variety of methods available to estimate body fat patterns[1], such as hydrodensitometry, 40K spectrometry, hydrometry, infrared method, electrical bioimpedance, nuclear magnetic resonance, and dual-emission X-ray absorptiometry. However, they are not very appropriate for population studies, usually consisting of costly methods that are limited to specialized research centers. The most used methods in epidemiological evaluations are based on anthropometric measurements, such as skinfold thickness, circumference measurements, and indices like waist-to-hip ratio (WHR) and body mass index (BMI), due to easy execution and low cost[1].

BMI has been used for the diagnosis of overweight and obesity in adults and children, reflecting the total body fat excess[2]. Nevertheless, there has been an increasing concern with regard to fat pattern, since the type of fat distribution deposit is related with the prognosis of health risk[3].

The distribution of body fat concerns the deposits of adipose tissue in different regions of the body and can be described by a variety of anthropometric measurements[3], such as arm circumference (AC), waist circumference (WC), WHR, and waist-to-height ratio (WHtR). WC and WHtR have been proposed to assess central adiposity, because they might be associated with cardiovascular risk factors, regardless of body weight condition[4].

Another way of verifying the amount of fat located in certain regions of the body is the analysis of skinfold thicknesses, considering that a great amount of total body fat is in the subcutaneous tissue. While the sum of skinfolds can estimate total fat, the specific skinfold can map the distribution of subcutaneous fat[5].

In the last decades, there has been an increase in the prevalence of overweight and obesity among school-aged children[6], and anthropometric measurements are very used for the diagnosis of these events on the community level. Thus, observing how these measurements relate among each other can improve studies on this subject, providing relevant results for the public health field. Hence, the aims of the present study were to assess the association of different anthropometric measurements with BMI and to verify the presence of abdominal adiposity in school children between 6 and 10 years of age registered in public and private schools from the State of Santa Catarina, Brazil.

METHODOLOGY

The data analyzed in this study come from a research project entitled "Monitoring implementation of the School Cafeteria Regulation Law on food habits and nutritional status of school children of Santa Catarina"

("Acompanhamento da implementação da Lei de Regulamentação das Cantinas Escolares sobre os hábitos alimentares e o estado nutricional de escolares de Santa Catarina"). The state of Santa Catarina is located in the Center South Brazil.

Data were collected between June 2007 and May 2008, with school children registered in public and private schools located in eight cities of the state of Santa Catarina.

The sampling plan included two focus units of interest: the school and students. To build the universe of elementary schools in Santa Catarina, schools were divided into three regions: West (West and Mid West), Center (North, Mountain and Valley Areas) and Coast (Great Florianópolis, North and South Coast).

In the three geographical regions, schools were located in eight reference municipalities, classified as those with the higher number of school children registered in the initial grades of elementary school: Chapecó and Joaçaba in the West; Blumenau, Jaraguá do Sul and Lages in the Center; Criciúma, Florianópolis and Joinville in the Coast.

According to the Educational Census conducted by the Ministry of Education in 2006 there were 4,007 elementary schools in the state of Santa Catarina – one federal, 3,661 public (municipal and state) and 345 private[7]. To calculate the sample, the federal school and the schools that declared not having school children in the initial grades of elementary school were excluded. For the final definition of schools to be investigated, other criteria were introduced based on financial-operational aspects, such as whether schools were public or private and the number of school children registered.

In this manner, the study universe comprised 140,878 school children registered at 569 public and private schools of the eight municipalities previously selected, separated into six extracts that included a combination of the three regions and both public and private schools.

The number of schools to be studied was calculated so as to guarantee a sample error of a maximum of plus or minus 6 percentage points, for each of the six extracts. Thus, the final sample comprised 347 schools, 266 public and 81 private, with the inclusion of schools located in urban and rural areas.

The sample of school children was random with a split proportional to grade, and depended on the number of school children registered in the grade drawn in each school. All participants had a Consent Form signed by their parents or guardians, totaling 5,686 school children authorized to take part in the survey.

The team responsible for collecting data comprised dietitians and students of the Nutrition Undergraduate and Graduate courses of Universidade Federal de Santa Catarina (UFSC). The team was trained based on a protocol to standardize data collection procedures, previously established in order to minimize possible intra and inter observation errors. The technical measurement error among members of the collecting team was not determined, but 10% of the sample of school children was measured in duplicate to control the quality of anthropometric measurements.

Data that refer to school children's age and sex were obtained at the office of the schools and copied to students' identification records. Anthropometric weight, height, circumference and skinfold data were collected according to the procedures described in the *Anthropometric Standardization Reference Manual*, of Lohman et al.[8]. Weight was measured once on a digital, PP 180 Marte branded scale with capacity for 180kg and 100g accuracy. In order to attain height, a stadiometer manufactured by Alturaexata, with 1mm accuracy, was used in a single measurement. Weight and height were used to calculate BMI.

Circumference and skinfold measurements were collected three times each, not consecutively, utilizing the mean of values for analysis. Arm, waist and hip circumferences were verified using a non-elastic measuring tape with 0.1mm accuracy. The waist circumference measurement was read horizontally, at the narrowest width of the trunk, at the level of the natural waist. The quotient between waist circumference and hip allowed building the waist-to-hip ratio and the quotient between waist circumference and height allowed building the waist-to-height ratio. In order to get triceps and subscapular skinfold measurements, a scientific Lange branded 0.1mm accuracy adipometer was used.

BMI was considered the dependent variable. Subscapular skinfold thickness (SSF), triceps skinfold thickness (TSF), arm circumference (AC), waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) were used as independent variables. Means and standard deviations of anthropometric measurements were calculated in total and stratified by sex. Unadjusted and adjusted associations were estimated with linear regression and expressed as a regression coefficient (β), overall and by sex. All anthropometric measurements were controlled during adjusted analysis to remain within the p<0.20 model.

Abdominal adiposity was defined as a value equal or greater than 0.50 for WHtR[9]. Finally, school children were considered overweight or obese according to the BMI cutoff points proposed by Cole et al.[4]. Stata software, version 10 (Stata statistical software release 10, CollegeStation, TX Stata Corporation), was used for data analysis.

The research project was approved by the Research Ethics Committee of the Universidade Federal de Santa Catarina (judgment n.031/06 of 24/04/06) and followed the rules of Resolutions 196/96 and 251/97 of the National Health Council.

RESULTS

The present study had the participation of 345 schools, 269 public and 76 private, and 4,964 school children between 6 and 10 years of age registered in the initial grades of elementary school (1st to 4th grade). We excluded from the final sample 275 school children absent on the collection of anthropometric data, as well as 358 above 10 years of age, and 89 due to inconsistent data. Among the school children, 47.8% were boys.

Table 1 shows mean and standard deviation for skinfolds, circumferences, WHR, WHtR, and BMI in total and stratified by school children's sex. The mean BMI was 17.4kg/m^2 (SD=2.8) for males and 17.2kg/m^2 (SD=2.8) for females. Similar values for these measurements were observed among school children.

Table 1. Number of subjects evaluated, mean and standard deviation (SD) of the anthropometric variables studied for both sexes and stratified by sex among school children from eight cities of Santa Catarina, Brazil, 2008.

Anthropometric measure	N	Mean	SD
Both sexes			
Subscapular skinfold thickness (mm)	4,952	7.77	4.96
Triceps skinfold thickness (mm)	4,951	11.73	5.75
Arm circumference (cm)	4,865	20.10	2.96
Waist circumference (cm)	4,909	59.22	6.79
Hip circumference (cm)	4,910	71.62	7.82
Waist-to-hip ratio	4,880	0.83	0.05
Waist-to-height ratio	4,909	0.45	0.04
Body mass index	4,960	17.30	2.80
Males			
Subscapular skinfold thickness (mm)	2,368	7.17	4.79
Triceps skinfold thickness (mm)	2,369	10.80	5.72
Arm circumference (cm)	2,325	20.00	2.99
Waist circumference (cm)	2,343	60.06	6.85
Hip circumference (cm)	2,349	71.33	7.84
Waist-to-hip ratio	2,329	0.84	0.04
Waist-to-height ratio	2,343	0.45	0.04
Body mass index	2,373	17.39	2.81
Females			
Subscapular skinfold thickness (mm)	2,584	8.33	5.06
Triceps skinfold thickness (mm)	2,582	12.58	5.64
Arm circumference (cm)	2,540	20.19	2.93
Waist circumference (cm)	2,566	58.45	6.64
Hip circumference (cm)	2,561	71.89	7.79
Waist-to-hip ratio	2,551	0.81	0.05
Waist-to-height ratio	2,566	0.44	0.04
Body mass index	2,587	17.22	2.76

In Table 2, a statistically significant association was observed between BMI and all anthropometric variables in the bivariate analysis, for both sexes and divided by male and female sex. In the multivariate analysis, considering both sexes and each sex separately, a statistically significant association was verified between BMI and SSF, AC, WC, and WHtR. The anthropometric variables that did not remain associated with BMI for both sexes were TSF, HC, and WHR. These findings demonstrate the relationship between BMI and SSF, AC, WC and WHtR in this population.

According to the WHtR, 11.9% (n=589) of school children showed abdominal adiposity, 13.9% (n=330) of the boys and 10.0% (n=259) of the girls. The prevalence of overweight was 15.4% (n=766) and of obesity 6.0% (n=300), totaling 21.4% (n=1066) of overweight school children. Considering male and female sexes, prevalences of overweight were respectively 14.9% (n=354) and 15.9% (n=412), and of obesity 6.7% (n=158) and 5.5% (n=142).

Table 2. Results from linear regression between body mass index (BMI) and anthropometric variables in school children from eight cities of Santa Catarina, Brazil, 2008.

	Both sexes				Males				Females			
Anthropometric measure	Bivariate Analysis		Multivariate Analysis		Bivariate Analysis		Multivariate Analysis		Bivariate Analysis		Multivariate Analysis	
	β*	p**	β	p	β	p	B	p	β	p	β	p
Subscapular skinfold thickness (mm)	0.44	<0.001	0.03	<0.001	0.47	<0.001	0.05	<0.001	0.43	<0.001	0.19	0.001
Triceps skinfold thickness (mm)	0.37	<0.001	0.01	0.169	0.39	<0.001	0.01	0.114	0.37	<0.001	0.01	0.066
Arm circumference (cm)	0.82	<0.001	0.17	<0.001	0.82	<0.001	0.17	<0.001	0.82	<0.001	0.17	<0.001
Waist circumference (cm)	0.31	<0.001	0.18	<0.001	0.31	<0.001	0.19	<0.001	0.31	<0.001	0.13	<0.001
Hip circumference (cm)	0.37	<0.001	-0.44	0.112	0.37	<0.001	-0.08	0.094	0.38	<0.001	0.02	0.635
Waist-to-hip ratio	6.39	<0.001	-1.44	0.473	5.42	<0.001	-0.06	0.986	7.28	<0.001	-6.16	0.014
Waist-to-height ratio	52.46	<0.001	31.31	<0.001	53.94	<0.001	30.54	<0.001	52.23	<0.001	32.14	<0.001

*β: regression coefficient, ***p*: significance level

DISCUSSION

Among the limitations of the present study, we should mention that the final sample of school children depended on the number of children registered in the group selected at the school and on the return of the Consent Form. The technical measurement error of the data collecting team was not determined, and although the team was experienced, the variations in the execution of the technique are unknown. However, 10% of the school children sample were measured twice in order to control the quality of anthropometric measures, a fact that minimized this limitation. It should be highlighted that this study was conducted in eight cities of the state of Santa Catarina and its data can be used to obtain an overview of school children's anthropometric measurements, in the universe of children registered in public and private schools of this state.

In 2008, weight excess (overweight and obesity) affected 33.5% of Brazilian children aged between 5 and 9 years, and 16.6% of the overall number of boys were obese; among girls, obesity was found in 11.8%. Overweight was higher in the urban area than in the rural area: 37.5% and 23.9% for boys and 33.9% and 24.6% for girls respectively[6]. In childhood and adolescence, obesity has been identified as an important predictive factor of obesity in adulthood, causing an increase in health risks and in morbidity and mortality rates[10].

Several methods have been used to assess overweight and obesity in children. Among them, BMI is the most used anthropometric method because it is a simple and low-cost measurement that has shown agreement with adiposity indicators[11]. The performance of studies aimed at understanding the associations of different measurements and anthropometric indices with BMI is mainly centered in the fact that high levels of body fat are associated with the early development of non-communicable chronic diseases, such as cardiovascular diseases, hypertension, obesity, and diabetes[12,13]. Thus, it becomes essential to quantify body fat with as few errors as possible[14], particularly at school age, with the purpose of developing health promotion programs to prevent these children from becoming overweight adults.

The assessment of anthropometric indices can also be used for early detection and prevention of metabolic syndrome among children and adolescents[15,16]. A study conducted in Turkey with 1,194 9-year-old school children associated anthropometric indices and the presence of metabolic changes. This study pointed out that 20% of the school children had hypertriglyceridemia and/or low HDL cholesterol, 30% had high blood pressure, e 21% were overweight or obese. Among TSF, BMI, WC, WHR and WHtR variables, BMI was the only variable that was positively associated with a higher likelihood of school children having two or more risk factors for metabolic syndrome (OR=3.5; confidence interval [CI]=1.69-7.41 for boys and OR=4.7; CI=1.61-13.55 for girls)[15].

In the present study, five out of six anthropometric measurements/indices investigated remained positively associated with BMI in girls, while in boys four out of six measurements/indices remained associated (WHR showed association only in females). Although BMI allows a very practical and quick assessment of overweight and obesity, this index has some limitations. It expresses global changes that may occur in the set of body components, but does not identify which organic components are the most affected[17] and does not verify the body fat distribution pattern[3].

There has been concern regarding fat pattern, since the type of fat distribution deposit relates with the prognosis of health risk[3]. Body fat distribution can be described by a variety of anthropometric measurements[18]. Special attention should be paid to the fat located in the abdominal region, which characterizes central obesity.

Regional obesity measures, such as WC and WHR, can provide estimates of centralized fat, which in turn is related to the amount of visceral adipose tissue[19]. We highlight that these measurements have been very used in population-based studies as abdominal fat indicators, whether because of its association with the occurrence of cardiovascular diseases or because of its high correlation with laboratory methods of body composition assessment[20].

In the present study, WHR remained associated with BMI only in females, in the adjusted analysis. WHR is used as indicator of the amount of adipose tissue deposited in the waist region in relation to hip structure.

An increased WHR can result from a high waist circumference and/or a reduced hip circumference. These two components of WHR can be affected by different factors and at different periods of growth[21].

A study conducted in Zaragoza, Spain, with children aged between 6 and 14 years, pointed out a significantly higher WHR in obese compared that of non-obese, indicating that the increase in adiposity was accompanied by an increase in WHR[22]. However, in a survey conducted by Soar et al.[23], a weak positive correlation was observed between WHR and BMI in children aged between 7 and 10 years from a public school of Florianópolis, state of Santa Catarina, Brazil.

Some authors suggest that children with high cardiovascular risk can be identified according to WC[18,24]. In Santa Catarina, WC and WHtR measurements remained associated with BMI in both sexes in the adjusted analysis. Surveys conducted in other locations corroborate the results of the present study.

Soar et al.[23] verified a positive correlation between BMI and WC in children aged between 7 and 10 years from a public school of Florianópolis, Brazil. In Recife, state of Pernambuco, Brazil, a cross-sectional study was conducted with 1,405 school children aged 10-14 years, in which the authors observed that BMI, WC and WHtR showed a strong positive correlation ($p<0.001$)[4]. Sung et al.[24] observed that WC correlated more with BMI than with WHtR in Chinese children and adolescents ($r = 0.93$; 0.91; $r = 0.65$; 0.50 for boys and girls respectively).

The data from the present study in Santa Catarina indicated that, among the two skinfolds investigated, the subscapular skinfold was the only one that remained positively associated with IMC in the adjusted analysis, both in boys and in girls. Although TSF has shown association in the unadjusted analysis, it did not keep the same pattern in the adjusted analysis.

Some studies have examined the relationship between skinfolds and BMI[11,25,26]. Zambon et al.[25] studied the correlation between BMI and TSF among 4,236 children in four surveys conducted in Paulínia, state of São Paulo, Brazil, and verified that the correlation between BMI and TSF were higher in the group of children with obesity risk.

A study conducted in Brasília, Distrito Federal, Brazil, with 528 school children in the age group from 6 to 10 years, pointed out significant correlations between BMI and body fat (estimated by the sum of triceps and subscapular, triceps and medial calf skinfold measurements)[11].

Januário et al.[26] compared the agreement between two obesity indicators and showed that BMI, when compared with percent body fat calculated with skinfolds, showed moderate agreement to classify children of both sexes regarding obesity, above and within the criterion for health. Thus, we can observe that there is a variety of anthropometric measurements that indicate body fat distribution, showing different relationships between these indicators.

Observing overweight and obesity prevalences in school children from Santa Catarina, one can find close values to those of studies conducted in

France[27](14.3 and 3.8%) and Germany[28] (15.5 and 4.3%). A survey previously conducted in the state capital, Florianópolis, indicated 15.5% of overweight and 5.5% of obesity in public and private schools[29]. These data confirm that overweight and obesity have become one of the major public health challenges.

Although BMI allows a very practical and quick assessment of overweight and obesity, this index has some limitations, since it expresses global changes that may occur in the set of body components[17] but does not verify the body fat distribution pattern[3].

With specific regard to abdominal adiposity, it can be assessed with the WHtR parameter. Surveys conducted in the United States[30] and England[9] with children and adolescents suggest that WHtR would be a better predictor of cardiovascular risk compared with the use of the BMI in isolation. In the present study, the prevalence of abdominal adiposity was 11.9% (n=589). A survey conducted in Recife, Brazil, with school children aged 10-14 years, identified a prevalence of abdominal obesity of 12.6% (95%CI: 10.9-14.4) using WHtR, and of overweight of 20.4% (95%CI: 18.3-22.6)[4] with BMI. Although the studies were conducted in different locations in Brazil, the prevalences were similar. Thus, it is interesting to use different anthropometric indices to assess the nutritional status of school children.

CONCLUSIONS

The results of the present study demonstrated a statistically significant association between the anthropometric measurements SSF, AC, WC, WHtR and BMI, meaning that these measures could be used in addition to BMI to determine total and central body adiposity. However, it is important to highlight the need of population-based studies in Brazil that determine cutoff points for the use of these measurements.

The prevalence of abdominal adiposity classified by WHtR was higher compared with that of obesity, using the BMI. Therefore, using more than one anthropometric indicator to assess nutritional status can help in providing a more accurate population diagnosis, aiming at future and appropriate interventions.

These results points out to the need of improving research to understand the associations of different anthropometric measurements and indices with BMI, since high levels of body fat are associated with the early development of non-communicable chronic diseases.

Acknowledgments

This research was funded by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Process no. 402334/2005-1, and by the Fundo Nacional de Desenvolvimento da Educação (FNDE), from the partnership established with the Centro Colaborador em Alimentação e Nutrição do Escolar Sul (CECANE Sul) and with the Centro Colaborador em Alimentação e Nutrição do Escolar do Estado de Santa Catarina (CECANE SC).

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