Excess of body weight among children: comparison between international and national criteria for body mass index classification

Excesso de peso em crianças: comparação entre o critério internacional e nacional de classificação do índice de massa corpórea

Exceso de Peso en Niños: Comparación entre los Criterios Internacional y Nacional de Clasificación del Índice de Masa Corporal

Teresa Maria B. de Quadros[1], Rosane Carla R. da Silva[2], Alex Pinheiro Gordia[3], Cândido Simões P. Neto[4]

ABSTRACT

Objective: To evaluate the performance of the body mass index cut-off points recommended by Cole *et al* and Conde and Monteiro in order to identify the excess of body weight in children.

Methods: The sample was composed of 585 schoolchildren aged six to nine years, from Ponta Grossa, Paraná, Brazil. The anthropometric measurements were body mass, height and subscapular skinfold, which was considered the gold-standard test to characterize the excess adiposity, using as the cut-off the 85th percentile of the National Center for Health Statistics reference curve. Sensitivity, specificity, positive and negative predictive values of body mass index classification criteria, developed by Cole *et al* and Conde and Monteiro, were estimated.

Results: The overweight prevalence was 20.7 and 28.9%, respectively for Cole *et al* and Conde and Monteiro criteria. Regardless of age, the sensitivity of the national criterion was higher than the international one for males, with the extension of 53.3 to 100.0% *versus* 33.3 to 92.3%, and similar for females, ranging from 68.4 to 100.0% for both criteria. In contrast, Cole *et al* cut-off points had higher specificity than those of Conde and Monteiro in both genders, ranging from 87.3 to 98.4% *versus* 74.6 to 93.5%.

Conclusions: Both criteria properly diagnosed overweight in Brazilian children. However, Conde and Monteiro criterion was more sensitive, resulting in fewer false-negative cases.

Key-words: nutritional status; overweight; body mass index; sensitivity and specificity; adiposity; child health.

RESUMO

Objetivo: Avaliar o desempenho dos pontos de corte para o índice de massa corpórea recomendados por Cole *et al* e Conde e Monteiro para diagnosticar o excesso de peso em crianças.

Métodos: A amostra foi composta por 585 escolares com idades entre seis e nove anos, do município de Ponta Grossa, no estado do Paraná. Foram realizadas medidas de peso, estatura e da dobra cutânea subescapular, a qual foi considerada como padrão-ouro para a caracterização do excesso de adiposidade, utilizando como ponto de corte o percentil 85 da curva de referência do *National Center for Health Statistics*. Foram calculados a sensibilidade, a especificidade e os valores preditivos positivo e negativo dos critérios de classificação

Instituição: Universidade Federal de Santa Catarina (UFSC), Florianópolis, SC, Brasil

[1]Mestre em Educação Física pelo Programa de Pós-Graduação em Educação Física da UFSC; Professora-Assistente do Curso de Licenciatura em Educação Física do Centro de Formação de Professores da Universidade Federal do Recôncavo da Bahia (UFRB), Amargosa, BA, Brasil

[2]Doutora em Educação Física pela Michigan State University, EUA; Professora do Programa de Pós-Graduação em Educação Física da UFSC, Florianópolis, SC, Brasil

[3]Mestre em Educação Física pelo Programa de Pós-Graduação em Educação Física da Universidade Federal do Paraná (UFPR); Professor-Assistente do Curso de Licenciatura em Educação Física do Centro de Formação de Professores da UFRB, Amargosa, BA, Brasil

[4]Doutor em Educação Física e Saúde pela University of New Mexico, EUA; Professor da Unidade de Ensino Superior Vale do Iguaçu, União da Vitória, PR, Brasil

Endereço para correspondência:
Teresa Maria B. de Quadros
Avenida Nestor de Melo Pita, 535 – Centro
CEP 45300-000 – Amargosa/BA
E-mail: tetemb@gmail.com

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do índice de massa corpórea desenvolvidos por Cole *et al* e Conde e Monteiro.

Resultados: A prevalência do excesso de peso foi de 20,7 e 28,9%, de acordo com os critérios de Cole *et al* e de Conde e Monteiro, respectivamente. Independentemente da idade analisada, a sensibilidade do critério nacional foi superior ao internacional para o sexo masculino, com extensão de 53,3 a 100,0% *versus* 33,3 a 92,3%, e semelhante para o feminino, variando de 68,4 a 100,0% para ambos os critérios. Em contrapartida, os pontos de corte de Cole *et al* apresentaram especificidade superior aos de Conde e Monteiro em ambos os sexos, variando de 87,3 a 98,4% *versus* 74,6 a 93,5%.

Conclusões: Tanto o critério internacional quanto o nacional apresentaram resultados satisfatórios para o diagnóstico do excesso de peso em crianças brasileiras. Entretanto, o critério de Conde e Monteiro mostrou-se mais sensível, acarretando menor número de falsos-negativos.

Palavras-chave: estado nutricional; sobrepeso; índice de massa corporal; sensibilidade e especificidade; adiposidade; saúde da criança.

RESUMEN

Objetivo: Evaluar el desempeño de los puntos de corte para el Índice de Masa Corporal (IMC), recomendados por Cole *et al* y Conde y Monteiro para diagnosticar el exceso de peso en niños.

Métodos: La muestra fue compuesta por 585 escolares, con edades entre 6 a 9 años, del municipio de Ponta Grossa, Paraná (Brasil). Se realizaron medidas de peso, estatura y del pliegue cutáneo (PC) subscapular. Se consideró esta DC como criterio estándar oro para caracterizar el exceso de adiposidad, utilizando como punto de corte el percentil 85 de la curva de referencia del *National Center for Health Statistics*. Se calculó la sensibilidad, especificidad, valor predictivo positivo y negativo de los criterios de clasificación del IMC desarrollados por Cole et al y Conde y Monteiro.

Resultados: La prevalencia de exceso de peso fue de 20,7 y 28,9% conforme a los criterios de Cole et al y Conde y Monteiro, respectivamente. Independientemente de la edad analizada, la sensibilidad del criterio nacional fue superior a la del internacional para el sexo masculino, con extensión de 53,3% a 100% vs. 33,3 a 92,3%, y semejante para el sexo femenino, variando de 68,4 a 100% para ambos criterios. Por otra parte, los puntos de corte de Cole et al presentaron especificidad superior a los de Conde y Monteiro en ambos sexos, variando de 87,3 a 98,4% vs. 74,6 a 93,5%.

Conclusión: Tanto el criterio internacional como en nacional presentaron resultados satisfactorios para el diagnóstico de exceso de peso en niños brasileños. Sin embargo, el criterio de C&M se mostró más sensible, con un menor número de falsos negativos.

Palabras clave: estado nutricional; sobrepeso; índice de masa corporal; sensibilidad y especificidad; adiposidad; salud del niño.

Introduction

The increase in the prevalence of overweight and obesity in children in the last decades[1] has become a public health problem. Overweight children are more susceptible to cardiovascular risk factors, such as dyslipidemia[2], hypertension[3,4], hyperglycemia[3] and metabolic syndrome[5]. Moreover, obese children have greater chances of becoming obese adults[6], which accelerates the early outcomes of morbidity and mortality due to chronic noncommunicable diseases.

The body mass index (BMI) is frequently used in clinical practice and epidemiological studies to evaluate the nutritional status of populations. The World Health Organization (WHO)[7] recommends the use of the BMI in screening overweight and obesity in children and adolescents because measurements are easy to make, the cost of the equipment for assessments is low, and the index is strongly correlated with body fat.

Cole *et al*[8] developed an international criterion to define underweight, overweight and obesity based on BMI cut-off points in individuals 2 to 18 years of age using data reported by studies conducted in six countries. As there was no Brazilian criterion to classify BMI, Conde & Monteiro[9] established cut-off points for underweight, overweight and obesity for Brazilian children and adolescents based on the Health and Nutrition National Survey, conducted by the Brazilian Institute of Geography and Statistics in 1989[10]. The cut-off points for overweight and obesity were estimated based on the WHO[7] criteria for adults, and the method used to build the Brazilian curve was basically the same as the one used for the international criterion.

Several studies evaluated the performance of different BMI criteria to diagnose overweight and obesity in children and adolescents by calculating specificity and sensitivity[11-16]. However, few studies with Brazilian children have been conducted, particularly to compare the international and

the national criteria. Therefore, this study evaluated the performance of BMI cut-off points recommended by Cole *et al*[8] and Conde & Monteiro[9] to diagnose overweight and obesity in children using the subscapular skinfold (SSF) as the criterion standard.

Method

This study used the database of the study Prevalence of overweight and obesity in schoolchildren in the public and private healthcare system, conducted in Ponta Grossa, Brazil, after approval by the Ethics in Research Committee of Universidade Estadual de Ponta Grossa.

The study population comprised 23,931 first to fourth graders in the city of Ponta Grossa, Brazil, who studied in 22 private (3,249) and 77 public (20,682) schools. A representative sample of the population was calculated using the method described by Silva[17] for an estimated maximum obesity prevalence of 30%, considering the highest values found in the literature[18]; the confidence interval was set at 95%, and precision, at 4% around the prevalence adopted. After the addition of a 5% safety margin, the final sample size was 557 children, and 585 children were evaluated after they submitted an informed consent form signed by their parents or guardians.

Data were collected from 2004 to 2005 by a team of six researchers previously trained to ensure to precision of measurements and the reliability of the study. Anthropometric data were obtained for each patient on the same day: body mass (kg), height (cm) and SSF (mm). During data collection, each measurement was made by the same observer.

Body mass was measured using a Filizola scale and recorded to the nearest 100g. Height was measured at a precision of 0.1cm using a stadiometer. Both measurements were made according to standardized procedures and techniques[19].

BMI was calculated as a weight-to-height ratio (BMI=weight(kg)/height(m^2)); overweight and obesity according to BMI were defined based on the criteria developed by Cole *et al*[8], as an international reference, and Conde & Monteiro[9], as a Brazilian reference. In both criteria, overweight was defined based on cut-off points that were equivalent to a BMI of 15$kg.m^{-2}$ for adults. The cut-off points selected for overweight corresponded to the mean value of the child's age in years (for example, 6.5 years).

SSF was measured using a skinfold caliper (Cescorf, Porto Alegre, Brazil) at 1/10mm, and measurements were made according to standardized procedures and techniques[20]. Measurements were made on the right side of the child and repeated three successive times at each site. The mean value of the three measurements was recorded. Overweight and obesity were defined based on the SSF measurement, used as the criterion standard. This skinfold value is an important marker of cardiovascular risk factors in children and adolescents[4]. The cut-off point used to diagnose overweight by means of SSF measurement was the 85th percentile of the reference distribution for sex and age according to the reference curve of the National Center for Health Statistics (NCHS)[21]. The 85th percentile has been used to describe overweight in studies conducted with children[22].

The variables body mass, height and BMI were not normally distributed according to the Kolmogorov-Smirnov test and were, therefore, log-transformed. Two-way ANOVA was used to evaluate the interaction between sex and age for body mass, height and BMI. Specific differences were defined using confidence intervals (interaction) and the Tukey post hoc test, and the significance level was set at $p<0.05$. The SSF measurements of the sample under study and the NCHS references[21] were described as mean and standard deviations, and the values corresponding to the 85th percentile of the NCHS reference[21] were also presented.

Sensitivity (SEN), specificity (SPE), positive predictive value (PPV), negative predictive value (NPV) and their respective 95% confidence intervals (95%CI) were calculated for the Cole *et al*[8] and Conde & Monteiro[9] criteria based on the criterion standard. SEN was the percentage of schoolchildren diagnosed with overweight by the BMI classification criteria and the criterion standard. SPE was the percentage of schoolchildren classified as not overweight by the BMI classification criteria and the criterion standard. PPV was the probability of schoolchildren being overweight according to the BMI classification criteria and the criterion standard, whereas NPV was the probability of not being overweight according to the two criteria and the criterion standard.

Results

A total of 585 schoolchildren were enrolled in the study; their mean age was 7.5 (standard deviation=1.0) years, and 50.4% were boys. The prevalence of overweight in this study was 28.9% (31.2% in boys and 26.6% in girls) according to the Conde & Monteiro[9] criterion and 20.7% (20.7% in boys and 20.7% in girls) according to the cut-off points described by Cole *et al*[8]. The prevalence of overweight based on SSF

was 19.7% (21.7% in boys and 17.6% in girls) considering the 85th percentile of the NCHS reference[21].

The descriptive characteristics and two-way ANOIVA for body mass, height and BMI are presented in Table 1. There were no differences in any of the variables under analysis between sexes. However, there was an interaction between sex and age for the variable height, and there was a difference between all ages for both boys and girls. There was a difference in body mass between ages, and the older children had a higher body mass value than the younger children. Six-year-old children had a BMI below that of eight- and nine-year-old children, and seven-year-old children had a BMI below that of the nine-year-old children.

Table 2 shows SSF means and standard deviations for the sample under analysis and for the NCHS reference[21], as well as the values corresponding to the 85th percentile of that reference. The SSF values were very similar from six to eight years of age for both boys and girls, and about 2mm below the reference at nine years when compared with the NCHS reference[21].

Table 3 shows the results of sensitivity, specificity, PPV and NPV of the criteria under evaluation according to age and sex. Findings show that sensitivity of the Brazilian criterion was superior to that of the international criterion, particularly for boys. In contrast, the Cole *et al*[8] cut-off point had a greater specificity than those described by Conde & Monteiro[9]. The results using the Conde & Monteiro[9] criterion showed higher NPV than the Cole *et al*[8] criterion for boys in all age groups under analysis. However, except for six years of age, PPV for the international criterion was higher for both boys and girls. The same NPV was found for both criteria at eight and nine years for girls. At seven years of age, the Brazilian criterion yielded higher values.

The Cole *et al*[8] criterion was less efficient according to the number of false negative cases. The Conde & Monteiro[9] criterion did not diagnose 13 boys (4.4%) as having overweight, and the Cole *et al*[8] criterion, about twice that number (7.5%). The Brazilian criterion had fewer false negatives than the international criterion for girls (n=7 vs. 10). The analysis of false positive results revealed that the Brazilian and the international criteria misclassified 12.6% (13.9% of the boys and 11.4% of the girls) and 6.5% (6.4% of the boys and 6.6% of the girls) of the children, respectively.

Table 1 - Body mass, height and body mass index (BMI) in boys and girls according to age group

Age (years)	Body mass (kg)		Height (cm)		BMI (kg.m^{-2})	
	Boys	Girls	Boys	Girls	Boys	Girls
6	22.9±3.4#	22.7±4.8	119.3±5.1	118.3±6.5	16.0±1.6	16.1±2.2
7	26.8±5.4	24.8±5.0	126.1±5.6	123.8±6.2	16.7±2.5	16.1±2.1
8	28.8±5.9	28.6±7.3	130.6±6.2	128.5±6.8	16.8±2.6	17.1±3.2
9	32.1±7.2	33.0±10.2	135.2±6.4	137.8±9.5	17.5±3.1	17.1±3.2
p_{sex}	0.149		0.107		0.330	
p_{age}	0.001		0.001		0.001	
$p_{sex\ x\ age}$	0.277		0.014		0.354	

#Mean±SD. p_{sex}: two-way ANOVA significance level for differences between sexes for body mass, height and BMI; p_{age}: two-way ANOVA significance level for differences between ages for body mass, height and BMI; $p_{sex\ x\ age}$: two-way ANOVA significance level for differences between the interaction of sex and age for body mass, height and BMI

Table 2 - Subscapular skinfold (SSF) of the population under study and of the NCHS reference[21], and the values corresponding to the 85th percentile of the NCHS reference[21] for sex and age

Age (years)	SSF (mm)				SSF 85th percentile (mm)	
	Our study		NCHS[21]		NCHS[21]	
	Boys	Girls	Boys	Girls	Boys	Girls
6	5.3±2.0#	6.4±3.6	5.1±2.4	6.0±2.8	6.0	7.0
7	6.0±3.9	7.0±4.6	5.5±3.0	6.2±3.3	7.0	9.0
8	6.7±4.6	8.1±5.1	5.1±2.3	7.7±5.5	6.0	12.5
9	7.1±4.6	8.1±5.8	7.1±5.1	8.5±5.0	11.0	13.0

#Mean±SD. NCHS[21]: National Center for Health Statistics. SSF: subscapular skinfold

Table 3 - Sensitivity (SEN), specificity (SPE), positive predictive value (PPV) and negative predictive value (NPV) for the Cole *et al*[8] and Conde & Monteiro[9] criteria according to age and sex

Sex and age	BMI classification criteria							
	Cole et al[8]				Conde & Monteiro[9]			
	SEN (95%CI)	SPE (95%CI)	PPV (%)	NPV (%)	SEN (95%CI)	SPE (95%CI)	PPV (%)	NPV (%)
Boys								
6	33.3 (11.9–61.6)	92.7 (80.1–98.4)	66.1	76.4	53.3 (26.6–78.7)	90.2 (76.9–97.2)	70.1	81.9
7	92.3 (63.9–98.7)	87.3 (77.3–94.0)	75.7	96.4	100.0 (75.1–100.0)	74.6 (62.9–84.2)	62.8	100.0
8	69.0 (49.2–84.7)	98.4 (91.4–99.7)	94.9	88.1	82.8 (64.2–94.1)	92.1 (82.4–97.3)	81.7	92.6
9	71.4 (29.3–95.5)	89.3 (78.1–95.9)	74.1	87.9	85.7 (42.2–97.6)	75.0 (61.3–85.6)	59.5	92.5
Total	65.6 (52.7–77.0)	91.8 (87.5–95.0)	77.4	86.2	79.7 (67.8–88.7)	82.3 (76.7–87.0)	65.8	90.4
Girls								
6	68.4 (43.5–87.3)	93.5 (82.1–98.6)	81.8	87.4	68.4 (43.5–87.3)	93.5 (82.1–98.6)	81.8	87.4
7	75.0 (47.6–92.6)	94.7 (86.9–98.5)	85.8	89.8	93.7 (69.7–99.0)	92.0 (83.4–97.0)	83.4	97.2
8	100.0 (73.4–100.0)	88.2 (78.1–94.8)	78.5	100.0	100.0 (73.4–100.0)	77.9 (66.2–87.1)	66.0	100.0
9	100.0 (40.2–100.0)	92.0 (80.7–97.7)	84.3	100.0	100.0 (40.2–100.0)	82.0 (68.6–91.4)	70.4	100.0
Total	80.4 (66.9–90.2)	92.1 (87.9–95.1)	81.3	91.6	86.3 (73.7–94.3)	86.2 (81.2–90.3)	72.8	93.6

SEN: Sensitivity; SPE: Specificity; PPV: positive predictive value; NPV: negative predictive value

Discussion

According to the study results, there were no differences in body mass, height and BMI between sexes. However, younger schoolchildren had lower BMI than the older children. These findings are in agreement with the literature, in relation to both sex[23] and age[24], which suggests that age may be more relevant to BMI than sex during childhood. However, several studies to evaluate the performance of different criteria to classify BMI in young individuals have conducted their analyses by grouping ages[12-15,25]. According to this study, the analysis of both sexes together would result in a lower result interpretation error than if ages were grouped.

The criterion developed by Conde & Monteiro[9] for the nutritional evaluation of the Brazilian population yielded a lower number of false negative results and higher sensitivity values than those found when using the Cole *et al*[8] criterion. The lower the number of false negative results, the better the test. To screen changes in the nutritional status of the population, BMI cut-off points should be defined to identify the highest numbers of overweight individuals, because the adoption of sensitive criteria may contribute to the early establishment of measures to reduce overweight. An overweight person has greater chances of regaining normal weight than a person that is already obese[26].

Considering all the characteristics analyzed in this study, the Brazilian criterion had more advantages in the evaluation of overweight in children, particularly due to its sensitivity. The lower cut-off points (except for boys at six years) result in a smaller number of false negative results and indicate that this criterion is the most adequate for Brazilian children. Therefore, the main advantage of the Brazilian criterion was its greater capacity to accurately classify overweight children according to the criterion standard. However, the specificity of the international criterion was higher than that of the Brazilian criterion, and its sensitivity, although lower in many cases, was also satisfactory.

The results of comparisons between the two criteria to classify BMI for Brazilian children are controversial. Two recent studies[16,25] compared the BMI criteria developed by Conde & Monteiro[9] and by Cole *et al*[8]. Dumith and Farias Júnior[25] evaluated the agreement between the Brazilian and the international criteria using kappa statistics; they enrolled a group of 525 schoolchildren aged seven to 15 years in the city of Rio Grande, Brazil, and found that the agreement between criteria was relatively strong for children seven to nine years. However, the Cole *et al*[8] criterion resulted in a lower prevalence of overweight than the Conde & Monteiro[9] criterion for both sexes, and the difference was statistically significant for girls. The analyses made by Dumith and Farias Júnior[25] did not separate age groups, which may result in an imprecise evaluation of BMI as a marker of overweight because both height and body mass change with growth and development as in children and adolescents grow older[27]. Moreover, sensitivity and specificity were not analyzed, and

the numbers of false negative and false positive results were not reported. These differences in methods make it impossible to compare their findings and the results of our study. The second study was conducted by Silva *et al*[16] and enrolled 1570 schoolchildren aged 7 to 12 years in João Pessoa, Brazil. The authors evaluated sensitivity and specificity of the Brazilian and international criteria using the percentage of body fat using skinfold measurement as the criterion standard. Their findings for children (seven to nine years) revealed elevated and very similar values for both criteria: sensitivity ranged from 86.2 to 100.0, and specificity, from 77.1 to 95.2. The comparison of our study with their findings shows that both found that the two criteria had a good performance in identifying overweight children. However, our study found a greater sensitivity for the Brazilian criterion and a higher specificity for the international criterion. The differences in the results of the two studies may be explained by the choice of standard criterion to identify overweight and the geographic region where data were collected. Similarly to our findings, the study conducted by Silva *et al*[16] was the only one in the literature that evaluated sensitivity and specificity of the Brazilian and international BMI criteria for Brazilian children in separate age groups.

In our study, the criterion standard to diagnose overweight was the SSF measurement, an efficient index of truncal fat[28] with a robust associated with cardiovascular risk factors in young individuals[4]. Moreover, SSF has a strong correlation with measurements of body adiposity using ultrasound, CT, dual-energy x-ray absorptiometry and underwater weighing[29,30]. However, skinfold values tend to underestimate adiposity in thinner children and overestimate it in those with greater overweight, which suggests that our study results should be interpreted carefully.

The cut-off point used to classify SSF was the 85th percentile of the reference distribution for sex and age according to the reference curve of the NCHS[21]. This percentile has been used to describe overweight in studies conducted with children[22] and adolescents[11]. The NCHS reference[21] was developed based on a sample in the 1970s, which may generate concerns when used as a reference for current data. However, we believe that the choice of this reference was adequate because: (1) reference data were not affected by obesity, seen in recent data; and (2) mean SSF for ages six to nine years for both sexes in our study was very similar to that of North American children at that time. Therefore, we believe that the results were neither overestimated, nor underestimated.

One of the limitations of our study was the fact that it did not determine the technical measurement error, responsible for the greatest incidence of variability in the measurement of anthropometric parameters. However, the examiners were trained before data collection, and the chance of measurement errors was minimized. Another limitation was the fact that the study did not evaluate the biological stage of maturation of the children, considered to be a variable that affects the amount and distribution of body fat in young individuals. However, as no children 10 years or older participated in the study, we believe that this might not have influenced results, except in cases of early maturation that tend to affect a small percentage of the population, particularly in the age group under analysis in this study.

The major contributions of this study are: the advancement of knowledge about BMI classification criteria to evaluate overweight in Brazilian children, as few studies have compared the international and Brazilian criteria for Brazilian children; and the separation into groups according to age, a factor that has been neglected in many studies, because changes occur as a result of physical growth and development within age groups. However, this study sample was representative of a midsized city in southern Brazil, which makes it difficult to generalize results. Therefore, studies with samples from other Brazilian regions should be conducted to confirm our findings.

In conclusion, both the international and the Brazilian criteria yielded satisfactory results for the diagnosis of overweight in Brazilian children. The Conde & Monteiro criterion[9], however, was more sensitive and yielded a smaller number of false negative results.

References

1. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. JAMA 2006;295:1549-55.
2. Grillo LP, Crispim SP, Siebert AN, Andrade AT, Rossi A, Campos IC. Lipid profile and obesity in low income school children. Rev Bras Epidemiol 2005;8:75-81.
3. Cuestas Montañés C, Geraud AA, Sardiña NG, Bustos CL. Circunferencia de cintura, dislipidemia e hipertensión arterial en prepúberes de ambos sexos. An Pediatr (Barc) 2007;67:44-50.
4. Ribeiro RQ, Lotufo PA, Lamounier JA, Oliveira RG, Soares JF, Botter DA. Additional cardiovascular risk factors associated with excess weigth in

children and adolescents. The Belo Horizonte Heart Study. Arq Bras Cardiol 2006;86:408-18.
5. Srinivasan SR, Myers L, Berenson GS. Predictability of childhood adiposity and insulin for developing insulin resistance syndrome (syndrome X) in young adulthood: the Bogalusa Heart Study. Diabetes 2002;51:204-9.
6. Venn AJ, Thomson RJ, Schmidt MD, Cleland VJ, Curry BA, Gennat HC *et al*. Overweight and obesity from childhood to adulthood: a follow-up of participants in the 1985 Australian Schools Health and Fitness Survey. Med J Aust 2007;186:458-60.
7. No authors listed. Physical status: the use and interpretation of anthropometry physical status. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser 1995;854:1-452.
8. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240-3.
9. Conde WL, Monteiro CA. Body mass index cutoff points for evaluation of nutritional status in brazilian children and adolescents. J Pediatr (Rio J) 2006;82:266-72.
10. Monteiro MFG, Cervini R. Perfil estatístico de crianças e mães no Brasil. Aspectos de saúde e nutrição de crianças no Brasil. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística/UNICEF; 1992.
11. Malina RM, Katzmarzyk PT. Validity of the body mass index as an indicator of the risk and presence of overweight in adolescents. Am J Clin Nutr 1999;70:131S-6.
12. Abrantes MM, Lamounier JA, Colosimo EA. Comparison of body mass index values proposed by Cole *et al*. (2000) and Must *et al*. (1991) for identifying obese children with weight-for-height index recommended by the World Health Organization. Public Health Nutr 2003;6:307-11.
13. Vitolo MR, Campagnolo PD, Barros ME, Gama CM, Ancona Lopez FA. Evaluation of two classifications for overweight among Brazilian adolescents. Rev Saude Publica 2007;41:653-6.
14. Fernandes RA, Costa Rosa CS, Silva CB, Bueno DR, Oliveira AR, Freitas Júnior IF. Desempenho de diferentes valores críticos de índice de massa corporal na identificação de excesso de gordura corporal e obesidade abdominal em adolescentes. Rev Assoc Med Bras 2007;53:515-9.
15. Farias Júnior JC, Konrad LM, Rabacow FM, Grup S, Araújo VC. Sensitivity and specificity of criteria for classifying body mass index in adolescents. Rev Saude Publica 2009;43:53-9.
16. Silva KS, Lopes AS, Silva FM. Sensivity and specificity of different classification criteria for excess weight in schoolchildren from João Pessoa, Paraíba, Brazil. Rev Nutr 2010;23:27-35.
17. Silva NN. Amostragem probabilística: um curso introdutório. 2 ed. São Paulo: Edusp; 2008.
18. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. JAMA 2002;288:1728-32.
19. Gordon CC, Chumlea WC, Roche AF. Stature, recumbent length, and weight. In: Lohman TG, Roche AF, Martorell R, editors. Anthropometric standardization reference manual. Champaign: Human Kinetics Pub; 1988. p. 3-8.
20. Harrison GC, Buskirk ER, Carter JE, Johnston FE, Lohman TG, Pollack ML *et al*. Skinfold thicknesses and measurement technique. In: Lohman TG, Roche AF, Martorell R, editors. Anthropometric standardization reference manual. Champaign: Human Kinetics Pub; 1988. p. 55-70.
21. Johnson CL, Fulwood R, Abraham S, Bryner JD. Basic data on anthropometric measurements and angular measurements of the hip and knee joints for selected age groups 1-74 years of age, United States, 1971-1975. Washington: National Center for Health Statistics; 1981.
22. Bedogni G, Iughetti L, Ferrari M, Malavolti M, Poli M, Bernasconi S *et al*. Sensitivity and specificity of body mass index and skinfold thicknesses in detecting excess adiposity in children aged 8-12 years. Ann Hum Biol 2003;30:132-9.
23. Roman ER. Estudo do crescimento, composição corporal e desempenho motor de escolares de 7 a 10 anos de diferentes níveis socioeconômicos da cidade de Cascavel - Paraná [tese de doutorado]. Campinas (SP): Unicamp; 2004.
24. Ronque ER, Cyrino ES, Dórea VR, Serassuelo Júnior H, Galdi EH, Arruda M. Prevalence of overweight and obesity in schoolchildren of high socioeconomic level in Londrina, Paraná, Brazil. Rev Nutr 2005;18:709-17.
25. Dumith SC, Farias Júnior JC. Sobrepeso e obesidade em crianças e adolescentes: comparação de três critérios de classificação baseados no índice de massa corporal. Rev Panam Salud Publica 2010;28:30-5.
26. Wisemandle W, Maynard LM, Guo SS, Siervogel RM. Childhood weight, stature, and body mass index among never overweight, early-onset overweight, and late-onset overweight groups. Pediatrics 2000;106:E14.
27. Ogden CL, Fryar CD, Carroll MD, Flegal KM. Mean body weight, height, and body mass index, United States 1960-2002. Adv Data 2004;27:1-17.
28. Moreno LA, Fleta J, Mur L, Feja C, Sarría A, Bueno M. Indices of body fat distribution in Spanish children aged 4.0 to 14.9 years. J Pediatr Gastroenterol Nutr 1997;25:175-81.
29. Forslund AH, Johansson AG, Sjödin A, Bryding G, Ljunghall S, Hambraeus L. Evaluation of modified multicompartment models to calculate body composition in healthy males. Am J Clin Nutr 1996;63:856-62.
30. Rodrigues MN, Silva SC, Monteiro WD, Farinatti PT. Comparison of body fat estimation by bioelectric impedance, skinfold thickness, and underwater weighing. Rev Bras Med Esporte 2001;7:125-31.