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Influence of neck circumference, waist circumference and body mass index among children with overweight and normal weight

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ABSTRACT

OBJECTIVE

To compare the measurements of neck circumference, waist circumference, and body mass index (BMI) between obese and eutrophic children.

METHODS

Cross-sectional research, using primary and case control data, with a comparative approach of anthropometric variables, carried out with 218 students, 119 girls and 99 boys, from a municipal elementary school in São Paulo. Data collected were sex, age, body weight, height, neck circumference (NC), and waist circumference (WC). The BMI was calculated and classified using the BMI growth curve, according to age, in percentiles. For data analysis, non-parametric tests were applied.

RESULTS

According to the BMI, 36.2% of the children were overweight when the agreement test was performed between all physical circumference measurements. However, there was a weaker agreement between BMI and NC and between BMI and WC measures. The correlation between the measures was greater between BMI and WC (62%), compared to between BMI and WC and between NC and WC.

CONCLUSIONS

The use of the NC measure, as an additional measure for anthropometric assessment in pediatric patients, is suggested, due to its practicality and as a complement for screening and monitoring childhood obesity.

DESCRIPTORS

Circumference, Anthropometry, Child, Obesity.

RESUMO

OBJETIVO

Comparar as medidas de circunferência do pescoço, circunferência da cintura e índice de massa corporal (IMC) entre crianças com obesidade e eutróficas.

MÉTODOS

Pesquisa do tipo transversal, por meio da coleta de dados primários e caso controle, com abordagem comparativa das variáveis antropométricas, realizada com 218 escolares, 119 meninas e 99 meninos, de uma escola municipal de ensino fundamental em São Paulo. Foram coletados dados como: gênero, idade, peso corporal, estatura, circunferência do pescoço (CP) e circunferência da cintura (CC), calculado e classificado o IMC pela curva de crescimento IMC por idade em percentil. Para análise dos dados foram aplicados testes não paramétricos.

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RESULTADOS

De acordo com o IMC, 36,2% das crianças apresentavam excesso de peso; quando realizado o teste de concordância entre todas as medidas de circunferências físicas. No entanto, observou-se concordância mais fraca entre entre as medidas IMC e CP e entre IMC e CC. A correlação entre as medidas foi maior entre IMC e CC (62%), mostrando-se novamente mais fraca entre IMC e NC, bem como para CP e CC.

CONCLUSÃO

O uso da medida da CP, como uma medida adicional para avaliação antropométrica do grupo pediátrico é sugerido, devido à sua praticidade e complementação para triagem e monitoramento da obesidade infantil.

DESCRITORES

Circunferência, Antropometria, Criança, Obesidade.

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INTRODUCTION

For some time, childhood obesity has been growing significantly worldwide, being a determining factor in several complications in childhood and adulthood[1] and considered by the World Health Organization (WHO) as an epidemic of the 21st century[2]. It is considered a disease characterized by excess body fat that affects one in three Brazilian children, with different incomes and from different regions. According to the latest Family Budget Survey (POF) 2008-2009, 33.5% of children aged five to nine years are overweight, being greater in urban than in rural areas, 37.5% and 23.9 % for boys and 33.9% and 24.6% for girls, respectively, with emphasis on the Southeast region, where 40.3% of boys and 38% of girls are overweight[3]. Several factors are considered in the genesis of obesity, with emphasis on genetic, physiological, and metabolic factors, as well as which, environmental factors are becoming increasingly important[4].

During child development, the onset of obesity can occur at any stage of growth, often triggered by early weaning, inadequate introduction of food, altered eating behavior, and compromised family relationships, especially in the period of growth acceleration[4]. In addition, there is high consumption of foods rich in fat and with high caloric values, added to sedentary behavior[5]. Childhood obesity is a risk factor for chronic non-communicable diseases (NCDs), such as arterial hypertension, diabetes mellitus, and cardiovascular diseases, which result in decreased quality of life and high health care costs[6]. Thus, all disorders resulting from obesity can be insidious and become chronic, requiring constant monitoring of body mass during childhood, in order to prevent long-term effects[7].

The most used criterion to determine overweight and obesity is the Body Mass Index (BMI), defined by the weight in kilograms divided by the height squared, in meters[7,8]. Although BMI is associated with adiposity in childhood, the association varies with age and sex, making it necessary to use child growth curves. Recently new curves have been proposed by the WHO, which provide a unique international standard, better representing children's physiological growth[8,9]. In addition, BMI is not considered a good marker for defining body fat distribution, either for total body fat or for assessing the surface area of body fat distribution. Thus, the measurement of waist circumference has been proposed to assess visceral obesity, alone or associated with BMI[7,8,10].

The association between obesity and metabolic syndrome (dyslipidemia, hypertension, and hyperinsulinemia) is even stronger if the adiposity is abdominal or central[11,12]. Recently, some studies have linked neck circumference with determination of the distribution of body fat in children and adolescents, not only sleep disorders, obesity, and cardiovascular disease in adults, as seen previously. Although there are few studies in this area, the findings highlight the importance of neck circumference when composing the anthropometric measurements of children to monitor their nutritional status[7,10].

The measurement of neck circumference is easy and practical in the clinical routine, and it can be used to assess the distribution of upper body fat. The measurement presents good intra-observer reliability/agreement, as it does not require multiple precision measurements, such as waist circumference[7,10]. The first researcher to realize that different body morphologies are related to a health risk factor, was Jean Vague[13], who in 1956 used the measurement of the neck of obese men to assess the distribution of upper body fat, and identified that upper body fat is more strongly associated with glucose intolerance, hyperinsulinemia, diabetes, hypertriglyceridemia, gout, and kidney stones than lower body fat[14]. In addition, lipolysis of adipose tissue varies between the upper and lower body fat.

Free fatty acid release is lower from the lower body fat than from the upper body, compared to an in vivo study carried out with obese and non-obese men and women. Layers of adipose tissue have different uptakes of fatty acids, as well as different mobilizations. These differences vary between men and women, and between obese and non-obese individuals. Although there is much to be studied about the regulation of lipolysis, there is little evidence in vivo that regional differences in lipolysis play an important role in determining the distribution of body fat[15]. This fact reinforces the relevance of the, subcutaneous, measurement of upper body adipose tissue deposits[14]. These observations indicate that neck circumference can be used to identify overweight and obese patients, and as an index of upper body fat distribution[14].

Studies have also verified the association of neck circumference with diabetes in women, regardless of the degree of excess weight and insulin resistance, suggesting that the measurement of neck circumference may be useful in the clinical screening of people at an increased risk of insulin resistance[16,17]. In view of the above, the purpose of this study is to verify whether neck circumference alone can be a good marker of overweight and obesity in Brazilian children, since the few studies directed at this theme are with children from other countries. We also propose to evaluate a new tool for use in health services, contributing to the advancement of techniques used by professionals in the detection of childhood obesity. Thus, the objective of this research was to compare the measurements of neck circumference, waist circumference, and BMI between overweight and eutrophic children.

METHODS

Quantitative, cross-sectional research through the collection of primary data (Survey) and case control data, with a comparative approach of anthropometric variables, carried out at the Municipal School of Elementary Education (EMEF) Carlos de Andrade Rizzini in 2011. The sample consisted of 218 children of both sexes, aged between 6 and 10 years, corresponding to 119 girls and 99 boys received had authorization from their parents or guardians to participate in the research and separated into those who were overweight, obese, and severely obese (overweight group - case) and eutrophic (control group).

All children (93) under 6 years and over 10 years, as well as those who were absent at the time of the research, with physical and / or motor impairment, who were severely thin or thin, or who refused to participate, were excluded from the search. The overweight group (cases) corresponded to 79 children and the eutrophic group (control) was composed of 139 children.

The present study is in accordance with Resolution No. 196/96 of the National Health Council - Ministry of Health[20]; and was approved by the Research Ethics Committee of the University of Santo Amaro, under number 184/2010. The current research did not offer risks to the participants because no invasive procedures were performed; the investigation was based on the collection of some personal data and anthropometric measures. As a benefit, the research contributes to the advancement of techniques adopted by health professionals to detect childhood obesity, as well as for monitoring child development.

Procedures for data collection and analysis

A data collection instrument was applied, containing variables such as: sex, age (years), body weight (Kg), height (cm), neck circumference (NC - cm), and waist circumference (WC - cm). Data collection was performed by a nutritionist with a technical qualification. The mean of two measurements was adopted for all variables, to obtain greater reliability in the measurement and precision in the results. Body weight was measured with a digital scale of the G-Tech brand, with a capacity of 150 kg and divisions of 0.1 kg, and height was measured with a portable Cardiomed stadiometer, up to 3.00 meters in height with a 0.1 cm scale.

For both anthropometric measures, the measurement techniques proposed by the Food and Nutritional Surveillance System - SISVAN (2004)[21] were adopted, which advocate that the scale should be calibrated on a flat, firm, smooth surface, and the child positioned in the center wearing the minimum possible clothes, barefoot, erect, with the feet together and the arms extended along the body. For height, the child should be positioned barefoot in the center of the equipment and with their head free of props, remaining upright, with the arms extended along the body, head raised looking at a fixed point at eye height, with the inner bones of the heels touching, as well as the inside of both knees, and the feet together at a right angle with the legs. The lower mobile part of the equipment is then fixed against the head with enough pressure to compress the hair.

After collecting these variables, the Body Mass Index (BMI) was calculated using the weight / height equation[2] and classified according to the parameters established by the new WHO child growth curves (2007)[9], using the Index of Body Mass by age (BMI / a) expressed as a percentile. As a way of assisting this process, the WHO Anthro Plus¤ program, version 3.122 was used.

The Neck Circumference (NC) was measured with a 150cm inelastic tape with a 0.1cm scale. The child remained standing with their head up, and the measurement was taken in the middle of the neck, between the cervical middle column and the anterior middle of the neck, that is, at the level of the largest prominent portion of the thyroid cartilage, using the technique proposed by Ben-noun et al., (2001)[14] and adopting the classification of Nafiu et al (2010)[10]. Waist circumference (WC) was measured using the same tape measure, starting with the narrowest part of the trunk between the costal margin and the iliac crest as a measurement point. The children were positioned upright, free of clothes in the abdominal region, and the measurement was performed at the end of a normal expiration, without compressing the skin, and with the tape remaining comfortably wrapped around the region. The reference of Mccarthy et al., (2001)[23] was adopted, considering the 90th and 95th percentiles to identify overweight and obesity, respectively.

Among the existing references for WC, the one by Mccarthy et al., (2001)[23] was adopted in the present study, because according to Pereira et al., (2010)[11], who compared four references of WC as an indicator of body fat and metabolic alterations in adolescents, this proposal is the most adequate as a predictor of excess body fat in population evaluations. After the diagnoses, the authors compared the methods, and the data were tabulated with the aid of the Epinfo program, version 6.0424.

To analyze the results, the Chi-square test or Fisher's exact test[25] was applied to study possible associations between the variables analyzed. The Kappa test was used to study the agreements or McNemar[25] test for discrepancies between the measures adopted. Spearman's correlation coefficient[25] was adopted to study the relationships between the measures studied. The level of rejection of the null hypothesis was set at 0.05 or 5%, and the BioEstat program, version 5.0 was used.

A spreadsheet was prepared for the school, containing all the anthropometric measurements of each class, with their respective classifications. This highlighted the children with any nutritional deviation, enabling follow-up and monitoring of the children's nutritional status. An educational leaflet was sent to the parents or guardians containing the ten steps for healthy child nutrition from the MINISTRY OF HEALTH[26], together with the child's weight, height, and nutritional status, to indicate whether the child presents an adequate weight, overweight, or underweight.

Children who presented any nutritional deviation were referred to the Basic Health Unit in the region.

RESULTS

The sample consisted of 218 children, which corresponds to 70% of the children in the school, 45.4% boys and 54.6% girls, with homogeneity between sexes and age, and a mean age of 8.4 ± 1.3 years.

According to the BMI, 36.2% of the children are overweight, which demonstrates the sensitivity of the method to detect excess weight early, as some of the children with excess weight were not visually overweight. The results of WC classified 39.0% of the children as presenting central adiposity, demonstrating the sensitivity of the measure. These results corroborate the childhood obesity epidemic currently found in Brazil and worldwide. NC showed a lower proportion of overweight, presented by 23.4% of the sample. This fact can be justified, since some of the children evaluated were within the normal range, but according to the classification criteria they were considered normal. Perhaps if they had different values for overweight and obesity, as for NC, that is, more specific values, some children would not be classified as normal according to NC.

Tables 1 and 2 present the classification of children's nutritional status among the methods studied. The agreement between them can be seen diagonally, with 78.9% agreement between BMI and NC and 74.3% between BMI and WC.

Table 1. Nutritional status of children attending EMEF, according to the Body Mass Index (BMI) and Neck Circumference (NC) methods.

BMI	NC Eutrophic	Overweight / Obesity	Total
Eutrophic	130	9	139
Overweight / Obesity	37	42	79
Total	167	51	218

Test Kappa Kw= 0.51; Z= 7.83 (p<0,0001); 2- Test McNemar X^2= 18.28 (p<0,0001)
% Agreement = 78.9% Disagreement = 21.1% Above the diagonal = 4.1% Below the diagonal = 17.0

Table 2. Nutritional status of children attending EMEF, according to the methods of Body Mass Index (BMI) and Neck Circumference (NC).

BMI	NC			Total
	Eutrophic	Overweight	Overweight	
Eutrophic	120	13	6	139
Overweight	13	9	23	45
Overweight	0	1	33	34
Total	133	23	62	218

1- Test Kappa Kw= 0.65; Z= 10.96 (p<0,0001) 2- Test McNemar X^2= 14.00 (p<0,0001)
% Agreement = 74.3% Disagreement = 25.7% Above the diagonal = 19.3% Below the diagonal = 6.4

Agreement is weaker between BMI and NC when compared to BMI and WC. These data are confirmed in tables 3 and 4, which show the analysis of agreement between the methods. Significant agreement values were not obtained between sexes and age.

Table 3. Presence or absence of agreement between the Body Mass Index (BMI) and Neck Circumference (CP), according to age group and gender.

Age	Female		Male		Total
	Presence	Absence	Presence	Absence	Female vs. Male
6	11	3	11	2	p= 0.54
7	10	5	14	6	p= 0.56
8	11	12	11	3	X^2=3.41
9	25	11	19	13	X^2=0.75
10	20	11	12	8	X^2=0.11
Total	X^2= 4.43 (p>0.05)		X^2= 4.06 (p>0.05)		

Table 4. Presence or absence of agreement between the Body Mass Index (BMI) and Waist Circumference (WC), according to age group and gender.

Age	Female		Male		Total
	Presence	Absence	Presence	Absence	Female vs. Male
6	9	5	11	2	p= 0.22
7	10	5	15	5	p= 0.43
8	16	7	12	2	p= 0.24
9	25	11	24	8	X^2=0.26
10	23	8	15	5	X^2=0.004
Total	X^2= 0.56 (p>0.05)		X^2= 1.18 (p>0.05)		

When the correlation was performed between the BMI and NC, BMI and WC, and NC and WC (table 5), agreement was again greater for BMI and WC (62%) compared to BMI and NC (53%). The disagreement remained significantly greater.

Table 5. Spearman's Correlation Coefficient between the methods of Body Mass Index (BMI), Neck Circumference (CP) and Waist Circumference (WC), according to nutritional status.

Nutritional status	BMI x NC			BMI x WC			NC x WC		
	r	p	r^2	r	P	r^2	r	P	r^2
Eutrophic	0.56	0.0001	0.31	0.69	0.0001	0.48	0.63	0.0001	0.40
Overweight	0.50	0.0005	0.25	0.79	0.0001	0.62	0.56	0.0001	0.31
Overweight	0.73	0.0001	0.53	0.74	0.0001	0.55	0.61	0.0001	0.37

DISCUSSION

Obesity is an important public health problem in the world, especially childhood obesity, which in addition to presenting a rapid increase in this population, is associated with metabolic and cardiovascular diseases. Appropriately, obesity has been described as a potential cause for the decline in life expectancy. Studies show that greater central fat deposition in children is correlated with hypercholesterolemia and arterial hypertension[7,10,27]. Thus, the diagnosis of central adiposity appears to be more relevant than total body fat[7].

One of the first steps for the prevention and early treatment of childhood obesity is careful monitoring, using available tools that are low-cost, fast, easy-to-use, and acceptable for both patients and health professionals[7,10]. Despite the ease of use, low cost, and popularity of BMI as an anthropometric tool, it is increasingly clear that it is a marker of inferior quality, as it does not provide accurate information on the distribution of body fat[7,10].

WC is considered an indicator of visceral adipose tissue, suggesting cardio-metabolic risk. However, its measurement requires caution, mainly due to the differences in results between evaluators. This occurs due to factors such as: standardization of the measurement point; the child's difficulty in exhaling smoothly; differing measures of the pre- and post-prandial period (distension); measurement difficulty in winter (clothing needs to be removed from the abdominal region for greater measurement accuracy); and child's embarrassment, especially when they are overweight. In addition, there is still no international standardization of cut-off points for classifying abdominal adiposity specific to the pediatric group[7,10,11].

Several studies have documented NC as a simple screening tool in adults to identify overweight individuals, in addition to reporting an association of NC with central obesity and metabolic disorders, and stipulating cut-off points for overweight/obesity, being ≥ 37cm and ≥ 34cm for men and women, respectively[14]. Other researchers assessed the relationship between NC and cardiovascular risk factors, and found that WC, as a single indicator of cardiovascular risk, is less effective for epidemiological studies and, therefore, there is a positive relationship between changes in body composition, including neck circumference, and changes in cardiovascular risk factors[28,29].

In the study by Ben-noun and Laor (2006)[30], a positive correlation was identified between NC and metabolic syndrome and a probable cardiovascular risk factor. Few studies have explored the use of NC as an index for measuring body fat when screening children. A study carried out with Turkish children revealed an association between NC and BMI in both sexes, and, therefore, NC could be a useful screening tool to identify excess weight in older children, that is, in school age children. In addition, the NC measurement could be important to identify obstructive sleep apnea, especially in obese children[7,10,31].

According to NAFIU et al., (2010)[10], who used this tool in a large sample of North American children (1102), measuring NC is clinically relevant for professionals who care for children with a high BMI. The authors reported that the NC correctly identified a high proportion of children and adolescents who were overweight or obese. Therefore, the cut-off points established for NC could be used as a reference for boys and girls aged 6 to 18 years.

In another study Nafiu et al., (2011)[32], found a high prevalence (24.3%) of high NC, among 1102 patients, being positively correlated with age and other anthropometric parameters. Children with a high NC were more likely to snore loudly and have a history of bronchial asthma, hypertension, and type 2 diabetes. Adverse airway events were more frequent in children with a higher NC.

Hatipoglu et al., (2010)[7], also found a positive correlation of BMI with NC and WC, in the pre-pubertal and pubertal periods, for both sexes. For this study, 412 overweight children and 555 healthy children, aged 6 to 18 years, were recruited. The authors considered that NC can be used as an additional and practical tool to assess overweight and obesity, according to sex and age. A study of 2,334 Chinese children aged 6 to 7 years, revealed that all anthropometric measures studied (height, weight, body mass index, neck and hip circumference) and all blood pressure measurements performed (systolic, diastolic, and high blood pressure) increased with increasing waist circumference[33].

However, in the present study, no good agreement was observed between BMI and NC; a greater agreement was observed between BMI and WC. Although the data found in this study do not corroborate other studies, the use of the NC as an additional tool for anthropometric assessments of the pediatric groups is suggested, due to its practicality and as a complement for screening and monitoring childhood obesity, since significant results have been presented in other studies.

There are certain limitations in this study that must be considered when interpreting the data, such as sampling, although the sample studied is representative of the population of children in the selected school, ethnicity, and cut-off points established for overweight / obesity.

Although there was a weak correlation between the diagnostic methods of BMI and NC, a more positive proportion was noticed between BMI and WC. However, the use of NC is considered as an additional and practical tool to assess excess weight in children, as it does not require multiple measurements. It is suggested that further studies be carried out on this topic, with a representative sample. For greater credibility, more schools and teenagers should be involved, and specific cut-off points for neck circumference should be created.

CONCLUSION

The use of the NC measure is suggested, as an additional measure for anthropometric assessment in pediatric patients, due to its practicality and as a complement for screening and monitoring childhood obesity.

REFERENCES

1. Mello ED, Luft VC, Meyer F. Obesidade infantil: como podemos ser eficazes? J Pediatr. 2004;80(3):173-82.
2. WHO - World Health Organization. Diet, nutrition, and the prevention of chronic diseases. Geneva; 2003.
3. IBGE – Instituto Brasileiro de Geografia e Estatística. Pesquisa de Orçamentos Familiares 2008-2009: Antropometria e Estado Nutricional de Crianças, Adolescentes e Adultos no Brasil. Rio de Janeiro; 2010.
4. Lopes PCS, Prado SRLA, Colombo, P. Fatores de risco associados à obesidade e sobrepeso em crianças em idade escolar. Rev Bras Enferm. 2010;63(1):73-8.
5. Costa AGM, Gonçalves AR, Suart DA, Suda G, Piernas P, Lourena LR et al. Avaliação da influência da educação nutricional no hábito alimentar de crianças. Rev Inst Ciênc Saúde. 2009;27(3):237-43.
6. Poeta LS, Duarte MFS, Giuliano ICB. Qualidade de vida relacionada à saúde de crianças obesas. Rev Assoc Med Bras. 2010;56(2):168-72.
7. Hatipoglu N, Mazicioglu MM, Kurtoglu S, Kendirci M. Neck circumference: an additional tool of screening overweight and obesity in childhood. Eur J Pediatr. 2010;169:733-9.
8. Sociedade Brasileira de Cardiologia. I Diretriz de Prevenção da Aterosclerose na Infância e na Adolescência. Arq Bras Cardiol. 2005;85(6 Supl):4-36.
9. Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bulletin of the World Health Organization. Research. 2007;85(9): 660–7.
10. Nafiu OO, Burke C, Lee J, Voepel-Lewis T, Malviya S, Tremper KK. Neck circumference as a screening measure for identifying children with high body mass index. Pediatrics. 2010;126(2):306-10.
11. Pereira PF, Serrano HMS, Carvalho GQ, Lamounier JA, Peluzio MCG, Franceschini SCC, et al. Circunferência da cintura como indicador de gordura corporal e alterações metabólicas em adolescentes: comparação entre quatro referências. Rev Assoc Med Bras. 2010;56(6): 665-9.
12. Preis SR, Massaro JM, Hoffmann U, D'Agostino RB, Levy D, Robins SJ, et al. Neck Circumference as a Novel Measure of Cardiometabolic Risk: The Framingham Heart Study. J Clin Endocrinol Metab. 2010;95(8):3701-10.
13. Vague J. The degree of masculine differentiation of obesities: a factor determining predisposition to diabetes, atherosclerosis, gout, and uric calculous disease. Am J Clin Nutr. 1956;4(1):20–34.
14. Ben-noun L, Sohar E, Laor A. Neck circumference as a simple screening measure for identifying overweight and obese patients. Obes Res. 2001;9(8):470-7.
15. Jensen MD. Lipolysis: contribution from regional fat. Annu Rev Nutr. 1997;17:127–39.
16. Freedman DS, Rimm AA. The relation of body fat distribution, as assessed by six girth measurements, to diabetes mellitus in women. Am J Public Health. 1989;79(6):715–20.
17. Laakso M, Matilainen V, Keinänen-Kiukaanniemi S. Association of neck circumference with insulin resistance-related factors. Int J Obes. 2002;26:873-5.
18. Turato ER. Métodos qualitativos e quantitativos na área da saúde: definições, diferenças e seus objetos de pesquisa. Rev
19. Saúde Pública. 2005;39(3):507-14.
Vieira S, Hossne WS. Noções Básicas. Rio de Janeiro: Elsevier; 2001. Metodologia científica para a área de saúde; p.13-26.
20. Ministério da Saúde. Conselho Nacional de Saúde. Resolução nº 196, de 10 de outubro de 1996. Diretrizes e normas regulamentadoras de pesquisas envolvendo seres humanos. Brasília, DF; 1996. 12p.
21. Ministério da Saúde. Sistema de Vigilância Alimentar e Nutricional. Antropometria: como pesar e medir. Brasília, DF; 2004. 62p (Série A. Normas e Manuais técnicos).
22. Anthro Plus, version 3.1 [software in Internet]. Programmes and Projects. Child growth standards: World Health Organization; 2010 [cited 2010 3 Nov]. Available from: http://www.who.int/childgrowth/software/en/.
23. McCarthy HD, Jarrett KV, Crawley HF. The development of waist circumference percentiles in British children aged 5.0 - 16.9 y. Eur J Clin Nutr. 2001;55:902–7.
24. Epi InfoTM for DOS, version 6.04 [software in Internet]. United States Department of Health and Human Services: Centers for Disease Control and Prevention – Division of Public Health Surveillance and Informatics; 2004 [cited 2010 3 Nov]. Available

from: http://www.cdc.gov/epiinfo/epi6/ei6dnjp.htm.
25. Siegel S, Castellan NJ. Estatística não paramétrica para ciências do comportamento. Porto Alegre: Artmed; 2006.
26. Ministério da Saúde. Coordenação Geral da Política de Alimentação e Nutrição. Alimentação Saudável para Crianças: siga os dez passos (Série temática "Os dez passos para uma alimentação saudável"). [acesso em 24 nov 2011]. Disponível em: http://nutricao.saude.gov.br/pas.php?conteudo=habilidades_pessoais
27. Owens S, Gutin B, Ferguson M, Allison J, Karp W, Le NA. Visceral adipose tissue and cardiovascular risk factors in obese children. J Pediatr. 1998;133(1):41-5.
28. Sjöström CD, Håkangård AC, Lissner L, Sjöström L. Body compartment and subcutaneous adipose tissue distribution-risk factor patterns in obese subjects. Obes Res. 1995;3(1):9–22.
29. Sjöström CD, Lissner L, Sjöström L. Relationships between changes in body composition and changes in cardiovascular risk factors: the SOS Intervention Study: Swedish obese subjects. Obes Res. 1997;5(6):519 –30.
30. Ben-Noun L, Laor A. Relationship between changes in neck circumference and cardiovascular risk factors. Exp Clin Cardiol. 2006;11(1):14-20.
31. LaBerge RC, Vaccani JP, Gow RM, Gaboury I, Hoey L, Katz SL. Inter- and intra-rater reliability of neck circumference measurements in children. Pediatr Pulmonol. 2009;44:64–9.
32. Nafiu OO, Burke CC, Gupta R, Christensen R, Reynolds PI, Malviya S. Association of neck circumference with perioperative adverse respiratory events in children. Pediatrics. 2011;127(5):1198-1205.
33. Choy CS, Chan WY, Chen TL, Shih CC, Wu LC, Liao CC. Waist circumference and risk of elevated blood pressure in children: a cross-sectional study. BMC Public Health. 2011;11(613):1-7.