INDIRECT METHODS FOR MEASURING BODY FAT IN ADOLESCENT STUDENTS

Métodos indiretos para mensuração da gordura corporal em adolescentes escolares

Métodos indiretos de mensuración de grasa corporal en adolescentes escolares

Original Article

Priscilla Alencar de Oliveira Morais[1]
Milla Gabriela Belarmino Dantas[1]
Ana Carolina Rodarti Pitangui[1]
Rodrigo Cappato de Araújo[1]
Paulo Adriano Schwingel[1]

ABSTRACT

Objective: To compare two different indirect methods for measuring body fat percentage in adolescent students. **Methods:** Analytical cross-sectional study conducted with 300 adolescent students from 12 to 17 years old in the city of Petrolina, state of Pernambuco. All patients underwent anthropometric assessment. The body fat percentage was estimated through skinfold thickness and bipolar bioelectrical impedance analysis (BIA). The tests followed recommended procedures and subjects were properly dressed for the assessment. The different body fat percentages were compared using the Wilcoxon nonparametric test and correlated by Spearman's rank correlation coefficient with a significance level of $p \leq 0.05$. **Results:** The median (interquartile range) age of the subjects was 13.0 (13.0–15.0) years with a total number of 214 (71.3%) girls. The compared methods showed strong positive linear correlation ($r=0.76$, $p<0.001$). However, the 26.9% (26.5–28.2) rate of fat obtained through skinfold thickness is statistically different ($p<0.001$) from the 22.3% (21.6–23.1) rate obtained through BIA. In both genders and at all ages the percentage of fat estimated through skinfold thickness was higher than the one estimated through BIA. However, the methods presented a good correlation ($p<0.0001$). **Conclusion:** The body fat percentage measured through anthropometric assessment (skinfold thickness) and bipolar bioelectrical impedance analysis have a strong significant correlation in adolescent students. In this context, BIA appears as an interesting option to monitor and assess changes in the nutritional status of this population.

Descriptors: *Body Composition; Skinfold Thickness; Electric Impedance; Adolescent; Obesity.*

RESUMO

Objetivo: *Comparar dois diferentes métodos indiretos de estimativa do percentual de gordura corporal em adolescentes escolares.* ***Métodos:*** *Estudo analítico, de caráter transversal, realizado com 300 escolares entre 12 e 17 anos na cidade de Petrolina, Pernambuco, Brasil. Todos foram submetidos à avaliação antropométrica, tendo os percentuais de gordura corporal estimados por dobras cutâneas e bioimpedância elétrica (BIA) bipolar. Os testes seguiram os procedimentos recomendados e os avaliados estavam vestidos segundo recomendações. Os distintos percentuais de gordura corporal foram comparados através do teste não paramétrico de Wilcoxon e correlacionados pelo coeficiente de correlação linear de Spearman, com nível de significância de p≤0,05.* ***Resultados:*** *A mediana (intervalo interquartil) de idade dos avaliados foi de 13,0 (13,0-15,0) anos, sendo 214 (71,3%) meninas. Os métodos comparados apresentaram forte correlação linear positiva (r=0,76; p<0,001). Porém, os 26,9% (26,5-28,2) de gordura obtidos por dobras cutâneas são estatisticamente diferentes (p<0,001) dos 22,3% (21,6-23,1) verificados por BIA. Em ambos os gêneros e em todas as idades, o percentual de gordura estimado por dobra cutânea foi maior que o estimado por BIA, entretanto, os métodos apresentam boa correlação (p<0,0001).* ***Conclusão:*** *Os percentuais de gordura corporal mensurados pelo método antropométrico (dobras cutâneas) e pela bioimpedância bipolar apresentam uma correlação forte e significativa em adolescentes escolares. Nesse âmbito, BIA configura-se como opção interessante para monitorizar e avaliar as alterações no estado nutricional desta população.*

Descritores: *Composição Corporal; Pregas Cutâneas; Impedância Elétrica; Adolescente; Obesidade.*

1) University of Pernambuco (*Universidade de Pernambuco – UPE*) - Petrolina (PE) - Brazil

Received: *11/18/2012*
Revised: *02/15/2013*
Accepted: *04/08/2013*

RESUMEN

Objetivo: *Comparar dos distintos métodos de estimación del porcentual de grasa corporal en adolescentes escolares.* **Métodos:** *Estudio analítico de carácter trasversal realizado con 300 estudiantes entre los 12 y 17 años en la ciudad de Petrolina, Pernambuco, Brasil. Todos fueron sometidos a la evaluación antropométrica con los porcentuales de grasa corporal estimados por pliegues cutáneos y bioimpedância eléctrica (BIA) bipolar. Las pruebas siguieron los procedimientos recomendados y los evaluados estaban vestidos según las recomendaciones. Los distintos porcentuales de grasa corporal fueron comparados a través de la prueba no paramétrica de Wilcoxon y correlacionados por el coeficiente de correlación linear de Spearman con nivel de significancia de p≤0,05.* **Resultados:** *La mediana (intervalo intercuartil) de edad de los evaluados fue de 13,0 (13,0–15,0) años siendo 214 (71,3%) niñas. Los métodos comparados presentaron fuerte correlación linear positiva (r=0,76; p<0,001). Sin embargo, el 26,9% (26,5–28,2) de grasa obtenidos por los pliegues cutáneos son estadísticamente diferentes (p<0,001) de los 22,3% (21,6–23,1) verificados por la BIA. En ambos géneros y en todas las edades el porcentual de grasa estimado por el pliegue cutáneo fue mayor que el estimado por la BIA, sin embargo, los métodos presentan buena correlación (p<0,0001).* **Conclusión:** *Los porcentuales de grasa corporal medidos por el método antropométrico (pliegues cutáneos) y por la bioimpedância bipolar presentan una correlación fuerte y significativa en adolescentes escolares. En ese ámbito, la BIA se configura como interesante opción para monitorear y evaluar las alteraciones en el estado nutricional de esa población.*

Descriptores: *Composición Corporal; Grosor de Pliegues Cutáneos; Impedancia Eléctrica; Adolescente; Obesidad*

INTRODUCTION

Obesity has recently emerged as a global health problem and may be associated with clinical disorders that represent high risk for chronic non-infectious diseases[1-3]. Critical stages in the development of obesity are childhood and adolescence; it is when the oscillation and the transition of adiposity occur. For this reason, it is recommended the development of appropriate assessment and prevention tools for this age group[3-5].

In order to reduce risks and losses arising from obesity, it is necessary to identify early changes in nutritional status and body composition. For this evaluation, different methods may be used, from the most accurate and high-cost ones to less expensive ones and easier to implement[4-5]. In this context, besides the popular calculation of body mass index, bioelectrical impedance analysis or bioimpedance analysis (BIA) and skinfold measurement, two indirect methods to assess total body fat[1,6,7], stand out.

The analysis by BIA estimates components and body fluids and is based on the principle that the flow of electric current through the body has different rates according to their composition. Adipose tissue, for instance, has a higher resistance to electrical current than the muscle tissue[1,5,8]. This technique is widely accepted as a safe, fast and reliable one to estimate the percentage of body fat (%BF). Furthermore, it is considered low cost compared to other methods of assessing body composition, such as the air displacement plethysmography through a camera commercially named Bod Pod™ and the Dual-energy X-ray absorptiometry (DXA)[8,9]. Nevertheless, its use is still not widespread in some populations, such as children and adolescents[1,5,8-12].

Although the measurement of body fat by skinfold is the most frequently used method to assess nutritional status of children and adolescents, its applicability is time consuming and demands proper technique[5,7,11,13]. Despite different patterning and forms of evaluation inherent to BIA and skinfolds methods for estimating body fat, they can be correlated significantly[5,7], so as to clarify the use of bioimpedance as an effective method for evaluating the %BF in large populations.

The use of anthropometric indicators is considered a good parameter for monitoring the health of children. Furthermore, the identification of obesity in childhood is recommended, once obese children are between 60% and 80 % more likely to remain in this condition during adolescence[14]. Thus, early diagnosis of significant weight change may influence the adoption of actions in different institutional spaces (family, school, health care provider) and the provision of suitable affective and sociocultural environments for the children, which is required for the formation of a healthy generation[15].

When considering the measurement of %BF during adolescence as an important tool to predict tendency to overweight and obesity, the present study aimed to compare two different indirect methods to estimate the percentage of body fat in adolescent students.

METHODS

This cross-sectional study was performed in an analytical approach, and involved 300 students at a public school in the city of Petrolina-PE, aged between 12 and 17 years. The schoolmaster received a formal request and information about the importance, objectives and methodology of the research, and authorized its performance.

All students who were within the specified age range were included. It was required that they submit the Informed Consent Form, duly dated and signed by the parent and/or guardian and they were asked to maintain restriction of solid

foods for 4 hours after breakfast. Adolescents presenting physical disabilities, articulation disorder or change in physical, behavioral and/or psychological condition that prevented the tests were excluded.

Data collection occurred between April and June 2011, in the school environment, in closed rooms with previously scheduled time and during school time. A team of previously trained professionals, members of the Laboratory of Research in Musculoskeletal Rehabilitation and Women's Health (*Laboratório de Pesquisa em Reabilitação Musculoesquelética e Saúde da Mulher – LAPRESM*), from the University of Pernambuco (*Universidade de Pernambuco – UPE*), carried out the assessment procedures.

The height was determined in portable scientific stadiometer (Seca, Hamburg, Germany) affixed to a wall, with an accuracy of 0.1 cm. It was evaluated the total body mass in an electromechanical scale W200/5 (Welmy Indústria e Comércio Ltda, Santa Bárbara d'Oeste, SP, Brazil), with an accuracy of 50 grams, properly calibrated (NBR ISO/IEC 17025:2005). The body mass index (BMI) was obtained by dividing the total body mass in kilograms by the squared value of the height in meters[2].

The skinfolds were measured by skinfold caliper Lange™ (Beta Technology Inc., Santa Cruz, CA, United States), with constant pressure of 10g/mm^2 on the contact surface, following the standardization of the International Society for the Advancement of Kinanthropometry (ISAK) [13]. The measurements were performed in triplicate and by only one professional in order to control the variability intra-rater and inter-raters. It was adopted the average of three measurements, provided there was not variation greater than 3mm between them. The percentage of body fat obtained by skinfolds was calculated using equation established in the literature[16]: from the average for the measurements of the triceps and mid-calf skinfold.

Immediately after that evaluation, following the recommended prior procedures[17], subjects underwent measurement of BIA by bipolar portable device HBF-306C (Omron Healthcare Inc., Lake Forest, IL, USA). All adolescents were hydrated without eating solid food for four hours after breakfast, having urination prior to evaluation, without the use of any diuretics, using light clothing and free of metal objects during the tests. The assessed subjects remained standing on an insulating platform holding the metal sensors of the appliance, elbows straight and arms at an angle of 90 degrees to the trunk.

The categorization of adolescent overweight was based on previously established cutoff points based on BMI[18] and %BF[19]. In both cases, the result obtained by the assessed subjects is compared to established values for each gender and age group.

Data were double entered into an Excel™ database (Microsoft Corporation, Redmond, WA, USA, 12.0.6662 Release, 2012), with automatic verification of consistency and range. It was then performed a descriptive statistical analysis with the aid of the computer program INSTAT (GraphPad Software, San Diego, CA, United States, Release 6.3, 2003). After verification of the data normality using the Kolmogorov-Smirnoff test, continuous variables were presented as median and interquartile range (first to third quartile). In the statistical analysis, the Wilcoxon nonparametric test compared measures of central tendency while the linear correlation coefficient of Spearman (r) checked the correlation between variables. All analyses were two-tailed; P values were calculated and the significance level adopted was 5%.

The adopted procedures met the assumptions of Resolution 196/1996 of the National Health Council. The study has been approved by the Research Ethics Committee of UPE and registered under number 258/2010 (CAAE: 0255.097.000-10).

RESULTS

The median (first quartile-third quartile) age of the analyzed group was 13.0 (13.0 to 15.0) years-old, among which 86 (28.7%) were boys and 214 (71.3%) girls. The boys had a total body mass of 52.6 (42.9 to 62.3) kg and height of 1.65 (1.57-1.71) meters, while girls showed 48.6 (43.3 to 55 5) kg and 1.59 (1.54 to 1.63) meters.

The results of the fat percentage estimated by the two doubly indirect methods, as well as the values of body mass index, are presented in Table I. The comparison revealed that the median values of both protocols for assessing body composition are statistically different ($p<0.001$). There was no similarity between the measures of central tendency of the two groups, even when they are separated by gender.

By analyzing adolescents' BMI according to age and gender, it appears that 48 (16.0%, confidence interval [CI] of 95%: 12.0-20.7%) subjects had higher values than the cutoff considered appropriate or recommended (overweight). In turn, 109 (36.3 %, 95% CI: 30.9 to 42.1%) students would be considered overweight according to the percentage of fat obtained by the method of skinfold, while 38 (12.7%, 95% CI: 9.1 to 17.0%) would have received the same diagnosis for BIA.

Despite the statistical difference between the protocols, it was noticed a strong positive linear correlation ($r=0.76$, $p<0.001$) between the different methods of assessing body fat for teens. However, when separated by gender, the correlation between these protocols becomes moderate ($r=0.61$ and $r=0.73$, $p<0.001$ for males and females, respectively), as illustrated in Figure 1.

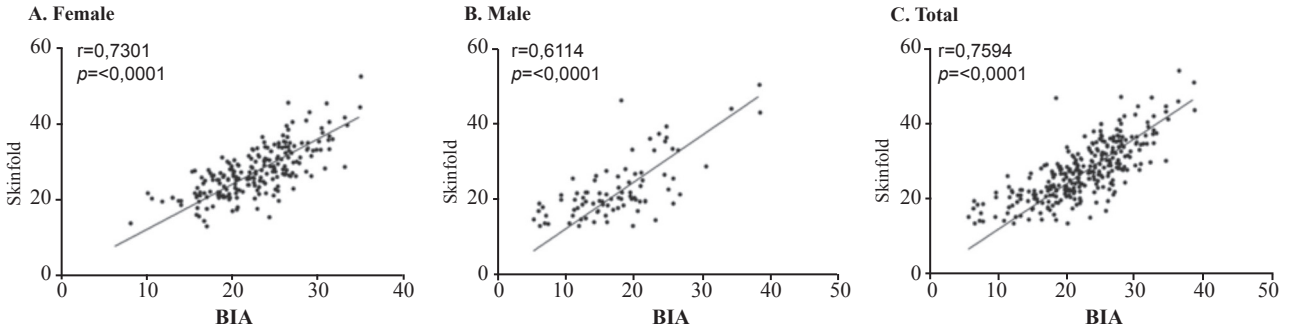

Figure 1 - Linear correlation between the percentage of fat estimated by skinfold method and portable bioelectrical impedance in adolescent students (n = 300). Panels A and B show results by gender, and the panel C, the values of the whole sample. Petrolina -PE, 2012.

Table I - Relationship between body fat percentage of adolescents estimated by two indirect methods of assessing body composition (n = 300). Petrolina-PE, 2012.

Gender	BMI	Bioimpedance	Skinfolds	Value of *p*
Male (n=86)	18.9 (17.3-21,9)	18.0 (13.3-21.4)	20.7 (18.3-26.1)	<0.0001
Female (n=214)	19.2 (17.8-21,3)	24.3 (20.8-27.6)	28.3 (24.2-32.8)	<0.0001
TOTAL	19.1 (17.6-21,3)	22.3 (21.6-23.1)	26.9 (26.5-28.2)	<0.0001

Values expressed in median (first quartile – third quartile).

Table II - Percentage of fat estimated by bioimpedance and skinfolds, categorized according to age range (n=300). Petrolina-PE, 2012.

Age range	Nº	BMI	Bioimpedance	Skinfolds	Value of *p*	r
12	69	18.0 (16.1-20.5)	24.1 (19.9-26.9)	24.2 (21.0-30.3)	<0,0001	0.72*
13	83	19.0 (17.4-20.7)	23.3 (19.1-27.1)	27.3 (25.6-32.0)	<0,0001	0.86*
14	56	18.9 (17.8-20.8)	22.4 (19.3-26.1)	26.6 (21.3-31.9)	<0,0001	0.78*
15	35	19.9 (18.6-21.7)	23.4 (15.1-26.7)	28.1 (21.3-31.9)	<0,0001	0.78*
16	36	19.9 (18.4-22.0)	21.3 (18.4-24.3)	27.4 (22.6-32.8)	<0,0001	0.82*
17	21	22.3 (19.4-23.9)	20.1 (16.3-24.1)	28.1 (23.6-34.6)	<0,0001	0.60*

Values expressed in median (first quartile – third quartile).*P<0,0001

The percentage of fat estimated by skinfold method was higher in both genders and all age groups. However, the values were strongly correlated, with the exception of the age groups between completed 12 years-old and incomplete 13 years-old, and between completed 17 years-old and incomplete 18 years-old (Table II). Moreover, both methods identified a higher percentage of fat in females.

DISCUSSION

The assessment of body composition is a field that has been extensively studied in recent years due to the increase in the prevalence of overweight, a fact that triggered population studies in the search for valid methods and good applicability[2,5,20,21]. In this context, there is a high correlation between the percentage of fat obtained by anthropometry and hand-to-hand bioelectrical impedance method in a sample of schoolchildren aged between 12 and 17 years. Although the present study did not analyze and discuss the nutritional profile, the results showed that the method of skinfold when compared to the rate estimated by BMI may overestimate the frequency of overweight in this population in two and a half times.

The outcomes are in line with another study[5], which assessed 1,286 children and preadolescents, finding a strong and statistically significant linear correlation (r=0.77 and r=0.89 for girls and boys, respectively). However, the authors used the method of leg-to-leg BIA, which analyzes a portion of the body different from the one assessed in this paper. Other works aimed to confront the BIA with various methods of evaluation of %BF[7,22-25] and, to do so, they used samples composite by adults only, limiting the comparison with the results of this research. However, this small number of published works with children under 18 years of age confirms the importance of studies conducted with adolescents.

Using a similar design to the present study, other researchers[7,23] compared the methods of measuring the percentage of fat by bioelectrical impedance and skinfold in different samples of adults. The results of both studies (r=0.88 and r=0.90 respectively) showed that both methods are highly correlated, reinforcing the use of BIA in the body composition identification.

In order to validate the use of bioelectrical impedance to assess body composition in children aged 6 to 13 years, research[12] compared the tetra polar (4-BIA) and octapolar (8-BIA) BIA with DXA, which is considered the most accurate technique for this purpose. The authors concluded that the 8-BIA is an accurate predictor and 4-BIA gives partially accurate predictions of %BF. Thus, as investigated in another study[25], 4-BIA and BIA bipolar portable device (same model used in the present study) have their results strongly correlated (r=0.859, p<0.001).

In order to compare the 8-BIA multi-frequency and DXA in 166 adolescents under 18, it was found[26] that although these methods do not exhibit equivalent values of %BF, 8-BIA can be used in clinical form in this population, because of its high accuracy. Still using DXA, another study[21] evaluated 5,235 children aged 9 to 12 years, and suggested that the use of this method increases the cost of evaluating a large sample, making it unnecessary at the possibility of using other procedures with similar efficacy.

These data are important to support and increase the frequency of anthropometric measurements in children and adolescents, because the increase in the accumulation of adipose tissue is associated with the presence of other changes in health status, which generates risk factors for severe disease and complications[1-4,6,20,21]. On the other hand, metabolic risk factors, and vascular concerning overweight cannot yet be predicted using the BIA[27].

The two evaluation techniques employed in this study do not relate directly by the different way which they measure body fat. However, several studies have shown a strong correlation between the results[5,7,22-25], bringing an efficient alternative to the diagnosis and monitoring of overweight related to accumulation of adipose tissue, especially in children and adolescents[26].

The air displacement plethysmography is another method for detecting body composition that can be trusted in. It is quick (3-5 minutes per test) and easy to apply[28] (demands less cooperation from the subjects). Nevertheless, as well as BIA, it may overestimate adiposity in cases of hyper-hydration[1,5,9,28]. Therefore, it is strongly recommended that the subjects follow the standardization of the test[17] and maintain normal fluid intake (good hydration) on the assessment day. Even so, both methods may represent an interesting alternative for the assessment of body composition in large samples, for the ease of implementation, lower cost and minor occurrence of inter-raters errors[5,7,12,22-25]. It is stated again, however, that the plethysmography device is costly and requires specialized manpower for its operation.

Due to the absence of a gold standard method in this comparison, it does not appertain to the present study to validate the use of BIA in the assessment of adolescent students. On the other hand, it is demonstrated that this method can be used in a clinical form on the studied population[26].

Other population-based studies with adolescents are still needed to identify, besides body composition, sociodemographic and behavioral factors influencing the clinical and nutritional status of these individuals. This will allow the creation of actions and policies to promote health aiming to avoid that they become sick adults and with restricted functionality.

CONCLUSIONS

The percentage of body fat measured by anthropometry (skinfolds) and bipolar bioimpedance are highly correlated in the group of adolescents studied. However, skinfold usually overestimated the subjects' body fat.

The method of assessment by BIA can be used in this population to monitor and evaluate changes in nutritional status over time, but in the specific interpretation of body composition, it may underestimate body adiposity.

To reduce risks and losses resulting from childhood obesity, we recommend the use of bipolar hand-to-hand bioimpedance equipment, HBF-306 model, in the implementation of protocols for nutritional care in schools.

ACKNOWLEDGEMENTS

To all parents and/or guardians, to the volunteers, to the school board (Teachers Maria do Socorro Nunes Ribeiro and Leilyane Conceição de Souza Coelho), to the teacher Rossana Regina Guimarães Ramos Henz (UPE),

to the students Alaine Souza Lima (UPE) and Mayra Ruana de Alencar Gomes (UPE) and to UPE's Academic Strengthening Program (*Programa de Fortalecimento Acadêmico – PFA*).

REFERENCES

1. Fujioka Y. How do we treat body fat percentages determined by bioelectrical impedance analysis? Circ J. 2012;76(10):2335-6.
2. World Health Organization - WHO. Obesity and overweight [internet; acesso em 2012 Jul 10]. Disponível em: http://www.who.int/mediacentre/factsheets/fs311/en/
3. Paschoal MA, Campos JF, Moraes FM. Perfil antropométrico e clínico de escolares e sua relação com a síndrome metabólica na infância. Rev Bras Promoç Saúde. 2012;25(2):202-8.
4. Ejike CE, Ijeh II. Obesity in young-adult Nigerians: variations in prevalence determined by anthropometry and bioelectrical impedance analysis, and the development of % body fat prediction equations. Int Arch Med. 2012;5(1):22.
5. Cocetti M, Castilho SD, Barros Filho AA. Dobras cutâneas e bioimpedância elétrica perna-perna na avaliação da composição corporal de crianças. Rev Nutr. 2009;22(4):527-36
6. Yamashita K, Kondo T, Osugi S, Shimokata K, Maeda K, Okumura N, et al. The significance of measuring body fat percentage determined by bioelectrical impedance analysis for detecting subjects with cardiovascular disease risk factors. Circ J. 2012;76(10):2435-42.
7. Martins KA, Monego ET, Paulinelli RR, Freitas-Júnior R. Comparação de métodos de avaliação da gordura corporal total e sua distribuição. Rev Bras Epidemiol. 2011;14(4):677-87
8. Eickemberg M, Oliveira CC, Roriz AKC, Sampaio LR. Bioimpedância elétrica e sua aplicação em avaliação nutricional. Rev Nutr. 2011;24(6):883-93
9. Mello MT, Dâmaso AR, Antunes HKM, Siqueira KO, Castro ML, Bertolino SV, Stella SG, Tufik S. Avaliação da composição corporal em adolescentes obesos: o uso de dois diferentes métodos. Rev Bras Med Esporte. 2005;11(5):267-70
10. Rech CR, Silva AT, Lunardi CC, Bohrer T, Petroski EL. Comparação da absortometria radiológica de dupla energia, antropometria e impedância bioelétrica na avaliação da composição corporal em mulheres. Lect Educ Fís Dep (Buenos Aires). 2005;10(91):32.
11. Thibault R, Pichard C. The evaluation of body composition: a useful tool for clinical practice. Ann Nutr Metab. 2012;60(1):6-16.
12. Kriemler S, Puder J, Zahner L, Roth R, Braun-Fahrländer C, Bedogni G. Cross-validation of bioelectrical impedance analysis for the assessment of body composition in a representative sample of 6- to 13-year-old children. Eur J Clin Nutr. 2009;63(5):619-26.
13. Marfell-Jones M, Olds T, Stewart A, Carter L. International standards for anthropometric assessment. Potchefstroom: International Society for the Advancement of Kinanthropometry; 2006.
14. Ronque ERV, Cyrino ES, Dórea VR, Serassuelo Júnior H, Galdi EHG, Arruda M. Prevalência de sobrepeso e obesidade em escolares de alto nível socioeconômico em Londrina, Paraná, Brasil. Rev Nutr. 2005;18(6):709-17.
15. Ministério da Saúde (BR). Obesidade. Brasília: Ministério da Saúde; 2006. (Cadernos de atenção básica, 12)
16. Slaughter MH, Lohman TG, Boileau RA, Horswill CA, Stillman RJ, Van Loan MD, et al. Skinfold equations for estimation of body fatness in children and youth. Hum Biol. 1988;60(5):709-23.
17. Lukaski HC. Requirements for clinical use of bioelectrical impedance analysis (BIA). Ann N Y Acad Sci. 1999;20(873):72-6.
18. Deurenberg P, Pieters JJ, Hautvast JG. The assessment of the body fat percentage by skinfold thickness measurements in childhood and young adolescence. Br J Nutr. 1990;63(2):293-303.
19. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320(7244):1240-3.
20. Ochiai H, Shirasawa T, Nishimura R, Morimoto A, Shimada N, Ohtsu T, *et al*. Relationship of body mass index to percent body fat and waist circumference among schoolchildren in Japan – the influence of gender and obesity: a population-based cross-sectional study. BMC Public Health. 2010;10:493.
21. Lawlor DA, Benfield L, Logue J, Tilling K, Howe LD, Fraser A, *et al*. Association between general and central adiposity in childhood, and change in these, with cardiovascular risk factors in adolescence: prospective cohort study. BMJ. 2010;341:c6224.

22. Carvalho ABR, Pires-Neto CS. Composição corporal através dos métodos da pesagem hidrostática e impedância bioelétrica em universitários. Rev Bras Cineantropom Desempenho Hum. 1999;1(1):18-23.

23. Rios DG, Ramos GP, Mendes TT, Barros CLM. Comparação de diferentes métodos de estimativa do percentual de gordura em estudantes universitários. Rev Min Ciênc Saúde. 2010;2(2):21-7.

24. Olivoto RR. Pregas cutâneas x impedância bioelétrica: mensuração da composição corporal. Lect Educ Fís Dep (Buenos Aires). 2004;10(71):e34.

25. Jambassi Filho JC, Cyrino ES, Gurjão ALD, Braz IA, Gonçalves R, Gobbi S. Estimativa da composição corporal e análise de concordância entre analisadores de impedância bioelétrica bipolar e tetrapolar. Rev Bras Med Esporte. 2010;16(1):13-7

26. Lim JS, Hwang JS, Lee JA, Kim DH, Park KD, Jeong JS, Cheon GJ. Cross-calibration of multi-frequency bioelectrical impedance analysis with eight-point tactile electrodes and dual-energy X-ray absorptiometry for assessment of body composition in healthy children aged 6–18 years. Pediat Int. 2009;51(2):263-8

27. Hemmingsson E, Uddén J, Neovius M. No apparent progress in bioelectrical impedance accuracy: validation against metabolic risk and DXA. Obesity. 2009;17(1):183-7

28. Cavernnec ML, Fagour C, Adenis-Lamarre E, Perlemoine C, Gin H, Rigalleau V. Body composition of obese subjects by air displacement plethysmography: the influence of hydration. Obesity. 2007;15(1):78-84.

Mailing address:
Paulo Adriano Schwingel
Universidade de Pernambuco (UPE) - Campus Petrolina - Departamento de Nutrição
BR 203, Km 2, S/N - Vila Eduardo
CEP: 56328-900 - Petrolina - PE - Brazil
E-mail: paulo.schwingel@upe.br