



Body composition evaluation in obese adolescents: the use of two different methods

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ABSTRACT

Plethysmography is an easy and quickly method for the determination of the body composition that uses the inverse relation between pressure and volume. The objective of the present study was to compare the values obtained by plethysmography and DEXA in an obese adolescents population. The sample was composed of 88 adolescents of both genders, aged between 15 and 19 years (17.01 ± 1.6 years) engaged in a multidisciplinary physical activity program. The volunteers were submitted to a body composition evaluation in distinct days in the same week, through plethysmography and DEXA. When the different methods were compared, no significant correlation between parameters common to both methods (fat free mass, fat mass (kg) and fat mass (%), $r = 0.88$ $p < 0.05$; $r = 0.92$ $p < 0.05$; $r = 0.75$ $p < 0.05$, respectively) was observed. Our data suggest that for this specific population, plethysmography may be used as an important method of body composition evaluation.

INTRODUCTION

Plethysmography is an easy and quickly method for the determination of the body composition that uses the inverse relation between pressure (p) and volume (v), based on the Boyle law ($P1V1 = P2V2$) in order to determine the body volume. Once this volume is determined, the densitometry principles for the determination of the body composition through the body density calculation are possible to be applied ($D = \text{mass}/\text{volume}$)^(1,2).

During the evaluation, the individual must be barefoot and wear the minimum clothes as possible in order to avoid disparities⁽³⁾; the use of swimming cap is also recommended⁽⁴⁾. Other important parameters to be observed are: the body temperature, the air relative humidity⁽²⁾ and the use of metallic objects such as earrings, rings, chains, piercing, among others are not recommended.

Another aspect that emphasized the importance of the plethysmography is the limitation observed in other methods, for exam-

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ple, evaluations performed through bone densitometry (DEXA), once this method does not allow evaluating individuals with morbid obesity. Thus, the development of a new method for this population may be an important resource with regard both for the evaluation and prescription, treatment and follow-up of these individuals, even of those with limitations in relation to information on the fat percentage of the body segments.

Although this methodology has only been available in the last 10 years, several studies have been conducted with its utilization. Most of these works present comparisons between methodologies currently available⁽⁵⁻⁸⁾; however, other works were aimed at the verification of its validity as new evaluation method^(3,9,10).

Once other methods for the evaluation the body composition have already been compared and validated in comparison to DEXA, the objective of the present study was to compare values obtained through the plethysmography method with those obtained with DEXA method in an obese adolescent population, taking the limitations already mentioned into consideration.

METHODOLOGY

Ethic procedure: Before participating, all volunteers were informed about the procedures, discomforts and risks involving the evaluation procedures. Later, they signed the free and cleared consent term for their participation in this study. The project was previously approved by the Ethics Research Committee of the São Paulo Federal University (#0135/04).

Subjects: Eighty eight male and female post-pubertal obese adolescents with ages ranging from 15 and 19 years (17.01 ± 1.6) engaged in a multidisciplinary physical activity program were evaluated. The BMI (body mass index) was determined and used as inclusion criterion. To do so, the BMI above the 95th percentile of the Curve of Must *et al.* (1991)⁽¹¹⁾ was adopted. The volunteers were evaluated in our laboratory in different days from the same week.

Description of equipments: Bone densitometry – The bone densitometry was performed through computerized densitometry by the Dual Energy X-ray Absorptiometry method (DEXA). It deals about a high-technology imaging procedure that allows the fat and muscle quantification as well as the bone mineral content of the deepest bone structures of the body. The DEXA subjacent principle establishes that the bone areas and the soft tissues may be penetrated up to a depth of approximately 30 cm through two distinct energy peaks originated from a source of high gadolin affinity isotopes 153 (Gd). The penetration is analyzed through a scintillation detector. The test was conducted with individual lying down in dorsal decubitus position on a table, where the source and the detector were passed through the body at a relatively slow velocity of 1 cm/s. The full-body DEXA mapping took about 12 minutes. The model employed in this study was the DPX-IQ #5781 (Lunar Radiation, Madison, WI). In order to allow the image reconstruction of the subjacent tissues, thus obtaining the quantification of

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the bone mineral content, the total fat mass and the body mass free of fat, a specific software was used.

Full-body plethysmography (air displacement plethysmography, BOD POD® body composition system; Life Measurement Instruments, Concord, CA) – The evaluation was performed taking into consideration the criteria described in the equipment's handbook and criteria described by Fields *et al.*, 2000⁽³⁾, Higgins *et al.*, 2001⁽⁴⁾ and Fields *et al.*, 2004⁽²⁾. Thus, the equipment was calibrated before evaluations using a cylinder of known volume (50 liters). The scale connected to the device was also calibrated using a referential of 20 kg. After calibration, the volunteers were evaluated wearing the minimum clothes as possible. The use of a swimming cap during the evaluation was requested with the objective of fixing the hair. Each test lasted four minutes on average, and in this period, the measurement of the volume occupied by the volunteer was performed according to the Boyle principle. Thus, the variations between pressure and volume were measured in order to determine the body density. Based on these data, the body composition was measured based on the Siri equation (1961)⁽¹²⁾. Before starting the test, the data from the volunteer were included in the software of the equipment. Shortly after this procedure, the individual was weighted in scale of the own equipment that presents sensibility of three decimal places. During the entire test, the individual remained in sitting position inside the equipment and at each step of the evaluation the plethysmography door was opened in order to record the measures. In the last step of the evaluation, the volunteer was asked to perform three respiratory incursions; after this, the test was finished. In case these respiratory incursions were performed above an acceptable standard, the software refused the values obtained, therefore requiring new evaluation up to the value was considered as suitable. In order to avoid undesirable alterations on results and as described in literature, the use of metallic objects such as earrings, rings, chains, piercing, among others was not allowed.

Statistical analysis

The data were analyzed through the Statistics for Windows program version 5.5. A descriptive analysis of data was initially performed for the observation of averages and standard deviation. Later, a data normality test was performed through the Komolgorov-Smirnov (K-S) test. For the comparative analysis between both methods, the t-Student test for independent samples was used and linear correlation analyses were also performed (Pearson correlation). The significance level adopted was of $p \leq 0.05$.

RESULTS

The results obtained demonstrate body composition values of the obese adolescents according to two methods: DEXA and plethysmography.

Table 1 presents the physical characteristics of the adolescents who participated in the study. The adolescents were found at an age range between 15 and 19 years, all post-pubescent. Based on the BMI calculation, it was observed that the adolescents presented "III Degree Morbid Obesity", with BMI between 30 and 40 kg/m² (Must *et al.*, 1991)⁽¹¹⁾.

TABLE 1
Physical characteristics of the sample

Variables	N	Age (years)	Stature (m)	Body mass (kg)	BMI
All	88	16.25 ± 1.44	1.66 ± 0.07	97.81 ± 13.64	35.62 ± 4.36
Men	20	15.95 ± 1.54	1.74 ± 0.07	107.34 ± 8.10	35.58 ± 4.34
Women	68	16.34 ± 1.41	1.63 ± 0.06	95.01 ± 13.71	35.63 ± 4.40

Descriptive analysis, data presented as average ± standard deviation. BMI = body mass index (body mass/height²).

Table 2 presents the values of the body composition using two methods subdivided into lean mass and fat mass, both as relative values (%) and absolute values (kg). No significant differences were observed when methods were compared.

TABLE 2
Comparative values of body composition between DEXA and Plethysmography methods

		Plethysmography	DEXA	p
Lean Mass (kg)	Men	64.45 ± 4.77	62.37 ± 5.48	Ns
	Woman	50.87 ± 6.54	48.39 ± 5.17	Ns
Fat Mass (kg)	Men	42.66 ± 8.78	37.42 ± 6.02	Ns
	Woman	44.17 ± 9.21	40.87 ± 7.60	Ns
Fat Mass (%)	Men	40.0 ± 5.57	36.47 ± 4.92	Ns
	Woman	46.29 ± 4.49	45.02 ± 5.16	Ns

Ns – Non significant for $p < 0.05$.

Figures 1, 2 and 3 present the results of the linear correlation analysis between both methods. Figure 1 presents the result of the lean mass correlation analysis, and a positive significant correlation of this variable with significance level of $r = 0.88$ ($p \leq 0.05$) was observed. In relation to the fat mass (kg), the correlation value was of $r = 0.92$ ($p \leq 0.05$) (figure 2). The comparison of the body fat relative values shows a correlation of $r = 0.75$ ($p \leq 0.05$) (figure 3). Thus, when the DEXA and plethysmography methods were compared, the body composition values presented strong correlations.

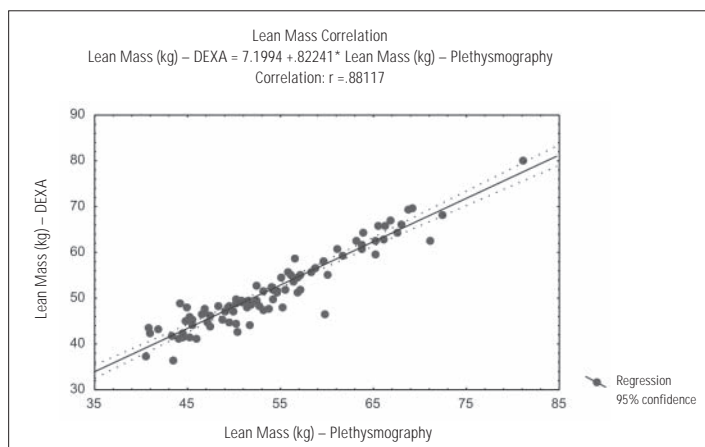


Fig. 1 – Correlation between Lean Mass (kg) observed in both methods

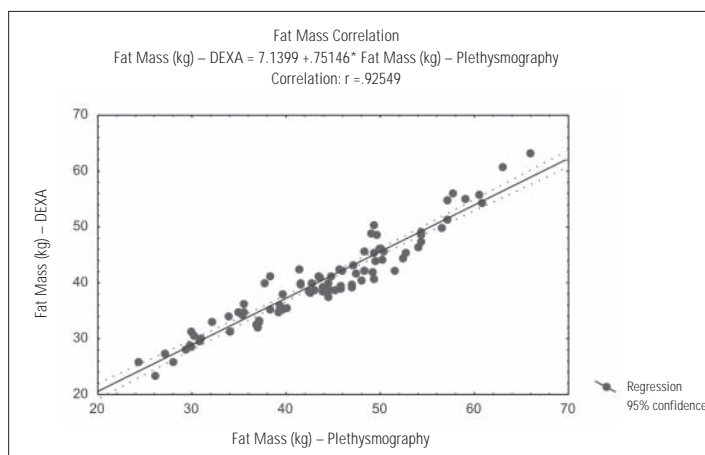


Fig. 2 – Correlation between Fat Mass (kg) observed in both methods

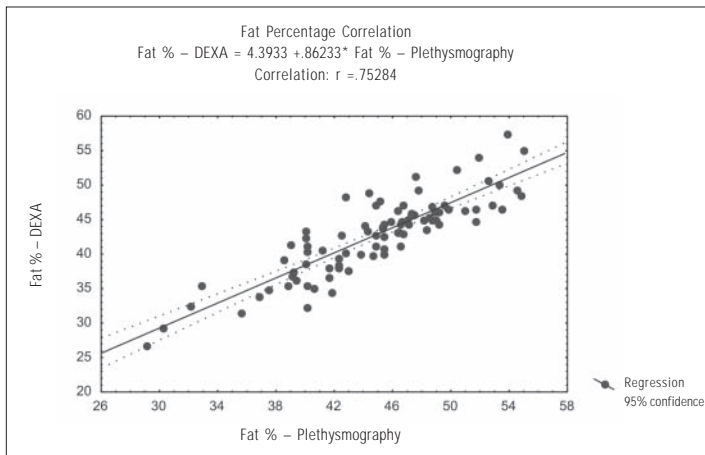


Fig. 3 – Correlation between Fat Mass (%) observed in both methods

DISCUSSION

Several studies have demonstrated the validity of the body composition results presented by the plethysmography method when compared with results obtained through the hydrostatic weighting method, thus determining the validity of this method for different populations^(13,14), once the hydrostatic weighting is considered as a “gold standard” method⁽¹⁵⁾.

The body composition estimated through the plethysmography method is not significantly different from the body composition determined through the hydrostatic weighting⁽¹⁾. This seems to be quite representative, once the performance of the hydrostatic weighting requires the individual to be immersed in water, what may represent a limitation for some individuals. On the other hand, the plethysmography method does not require this procedure, once the equipment is based on air displacement, indicating the increasing preference for this method due to the shorter time employed in its performance and the comfort it provides for the appraised.

Other authors compared plethysmography with the bone densitometry method especially in obese individuals populations, once this method presents limitations in relation to the body mass or even stature. In this context, it was verified that the body mass limit for DEXA evaluations is 120 kg, what hinders the evaluation of all extreme obese population. However, the plethysmography method does not present this limitation, and its evaluations include individuals with morbid obesity with BMI of 46.6 ± 7.7 (kg/m²). This strongly suggests that this method may produce reliable results for individuals with BMI above 40 kg/m²⁽¹⁶⁾.

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In his study, Lockner *et al.* (2000)⁽⁵⁾, evaluated 54 male and female non-obese adolescents. No significant difference between methods was observed when the body fat percentages were compared, although when the body density values were compared, the plethysmography method presented values significantly higher than those obtained through bone densitometry.

Ball and Altena (2004) compared both measurement methods using 140 men (32 ± 11 years). The results presented strong correlation ($r = 0.94$), indicating that the plethysmography method may be used as a method to estimate the body fat percentage in this population⁽⁷⁾. In research similar to the present study, Gately *et al.* (2003)⁽¹⁷⁾, determined the body composition of 30 male and female adolescents with BMI of 31.6 ± 5.5 (m/kg²) and fat percentage of $41.2 \pm 8.2\%$. The results of the fat percentage estimated by both methods presented strong correlation ($r = 0.95$), corroborating with our results, where a correlation of $r = 0.75$ was obtained (figure 3). The same results were not found in study conducted by Maddalozzo *et al.* (2002)⁽⁹⁾, when the authors compared both methods in 19-years-old women with BMI of 23.4 ± 2.3 (m/kg²). In this study, it was verified that out of the 43 patients evaluated, only 10 body composition results were considered as exact (23.3%), when both methods were compared, in relation to the body fat percentage values.

Thus, the literature already brings works that used the plethysmography method in different populations such as elderly people⁽¹⁸⁾, adults^(19,21), young people⁽²²⁾, children^(5,21), athletes^(8,13), morbid obese individuals⁽¹⁶⁾ and wrestlers⁽²³⁾, although we do not know about studies comparing and validating the plethysmography method in male and female obese adolescents (BMI > 30 kg/m²) using a sample so representative.

Our results demonstrated a strong correlation for the lean mass in kg ($r = 0.88$) and body fat percentage expressed as kg ($r = 0.92$), as well as in values expressed as total body mass percentage ($r = 0.75$). Even when the previous results between both methods were compared, no differences statistically significant were verified.

Thus, we suggest that for this specific population (adolescents with morbid obesity), the plethysmography method may be used as a reliable method for the body composition prediction.

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