Study of body composition in elderly active women by the anthropometric and deuterium oxide methods

Estudo da composição corporal de idosas ativas pelos métodos óxido de deutério e antropométrico

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Abstract – Aging is accompanied by changes in body composition, including a decrease the free fat mass (FFM) and a progressive increase in the body fat (FM). The objective this study was to report the body composition in elderly active women, using the anthropometric and deuterium oxide methods, and to analyze the concordance between them, the last one being considered the gold standard. Twenty two non-dependent elderly women aging 65-75 years old were evaluated. Body weight was assessed using a digital scale (Filizola) and height was measured with a vertical bar stadiometer. The level of physical activity was evaluated using the international physical activity questionnaire (IPAQ-long version). Body composition was assessed by anthropometry, using the equations of Jackson et al. and Durnin and Womersley, and by the deuterium oxide (^2H_2O). Statistical analysis was done using the Lin concordance correlation coefficient and the Bland and Altman graphs. Mean age was 69.3 ± 3.6 years, weight 67.2 ± 10.6 kg, height 1.55 ± 0.04 m and body mass index 27.9 ± 5.0 kg/m^2. The concordance correlation coefficient obtained by the equations of Jackson et al. and Durnin and Womersley, compared with the deuterium were: %FM 0.72 and 0.71; FM 0.90 and 0.91; and FFM 0.46 and 0.57. The equations used in this study showed good concordance between the anthropometry and deuterium, but the equation of Durnin and Womersley showed better results in the assessment of body composition in elderly active women.

Key words: Anthropometry; Body composition; Deuterium, Elderly.

Resumo – *Com o envelhecimento, ocorrem alterações na composição corporal, observando--se uma redução da massa magra (MM) e um aumento progressivo da massa gorda (MG). O objetivo deste estudo foi descrever a composição corporal de mulheres idosas ativas, pelos métodos de antropometria e óxido de deutério e verificar a concordância do método antropométrico com o método óxido de deutério, considerado como referência nesse estudo. Participaram do estudo 22 idosas independentes, com faixa etária entre 65 a 75 anos. O peso corporal foi avaliado usando balança digital e a altura usando um estadiômetro em barra vertical. Para identificar o nível de atividade física foi usado o questionário internacional de atividade física (IPAQ, versão longa). A composição corporal foi avaliada pela antropometria pelas equações de Jackson et al. e Durnin e Womersley e pelo método de óxido de deutério (^2H_2O). Para análise estatística, usaram-se o coeficiente de concordância de Lin e o gráfico de Bland e Altman. A média de idade foi 69,3±3,6 anos, o peso 67,2±10,6Kg, a altura 1,55±0,04m e o índice de massa corporal 27,9±5,0 kg/m^2. Os coeficientes de concordância obtidos pelas equações de Jackson et al. e Durnin e Womersley comparados ao deutério foram: %GC 0,72 e 0,71; MG 0,90 e 0,91; e MM 0,46 e 0,57. As equações utilizadas neste estudo apresentaram boa concordância com o deutério, sendo que, a equação de Durnin e Womersley apresentou melhores resultados para avaliar a composição corporal de idosas ativas.*

Palavras-chave: *Antropometria; Composição corporal; Deutério; Idoso.*

INTRODUCTION

The assessment of body composition in the elderly has gained increasing importance, since it is recognized that the excessive body fat has deleterious consequences for the development of conditions such as cardiovascular diseases, obesity and cancer, among others. Therefore, the accurate quantification of the body fat in the elderly is important to the development of intervention programs aiming a balanced distribution of the body compartments[1].

The aging process is accompanied by body changes that can influence the nutritional status of the elderly. Increase in the fat mass (FM), reduction of the free-fat mass (FFM), the mineral content and in the proportion of the intra and extra cellular water are observed[2]. Furthermore, trophic skin changes and the difficulties in the assessment of patients confined to bed may compromise the accuracy of the anthropometric measurements in the elderly.

Anthropometry is one of the most used methods for assessment of body composition in population studies, due to its low costs and relative simplicity when compared with other methods[3]. Measurement of the skinfold (SF) thickness can estimate the subcutaneous fat by evaluating certain body regions according to the protocols chosen for the analysis of body density. However, some difficulties such as the possible redistribution of the body fat, proper selection of the equation and the measurement technique are important issues that can affect this assessment and that may limit its accuracy in the elderly[4].

The deuterium oxide dilution (^2H_2O) is another method used to evaluate the body composition in different groups. It is based on the ingestion of a well known dose of deuterium oxide by the volunteers, followed by the determination by mass spectrometry of the deuterium enrichment in a sample of body water (saliva, urine or blood) before - considered the base level - and a few hours later. The water enriched with the deuterium is distributed throughout the body and reaches the equilibrium with the body water, when the enrichment enters the plateau phase. The difference in the enrichment before and after the deuterium dose can accurately determine the total body water[5]. The assessment of body composition by this method is based on the principle of the constant hydration of the FFM which states that, in mammals, 73.2% of the FFM is composed by water[6]. Therefore, by the quantification of the body water one can estimate the FFM.

The deuterium oxide is considered a highly accurate method for the determination of the FFM and the FM[7]. Nevertheless, it is expensive and not widely available, as it involves sophisticated analysis methods, such as mass spectrophotometry.

Physical activity is an important predictor of functionality in the elderly[8,9]. Individuals with higher levels of physical activity have better

performance in their daily functional activities when compared to the sedentary.

Based on the importance of analyzing the nutritional status, particularly in the active elderly population, for whom there are few data of specific anthropometric equations, this study aimed to report the percentage of body fat (%FM), the FFM and the FM of active elderly women by the methods of anthropometry and deuterium oxide, and to evaluate the concordance between both methods using the equations of Jackson et al. and During and Wormersley.

METHODS

Study population

We used a convenience sample composed of 22 non-dependent volunteers aging 65-75 years old, registered in the Family Health Program (Programa de Saúde da Família) of Faculdade de Medicina de Ribeirao Preto da Universidade de Sao Paulo, FMRP-USP. The individuals were classified as physically active according to the international questionnaire of physical activity (IPAQ, long version)[10] as well as the self-report, which confirmed that the activities were performed for one hour twice to three times a week, in the Community Integration Programs (Programas de Integração Comunitária – PIC) in Ribeirao Preto, state of Sao Paulo.

Volunteers with mobility difficulties, sedentary, amputees, those who used orthosis or prosthesis, those with skeletal muscle conditions, localized weakness or sequelae of stroke were excluded from the study.

The study was approved by the Research Ethics Committee of the Hospital das Clinicas da Faculdade de Medicina de Ribeirao Preto (Process HCRP 244/2008). The volunteers were informed of the methods to be used, and were included in the study after signing the written consent form.

Anthropometric evaluation

Body weight was determined using a digital scale (Filizola ID 500, Sao Paulo, Brazil), with a variation of 0.1 Kg with the individual wearing light clothing and barefoot. The body height was measured using an inextensible vertical bar stadiometer, graduated at each 0.5 cm.

Skinfolds (SF) were measured by the same researcher using a compass (Lange, Santa Cruz, CA) with the precision of 0.1 mm, in the right side of the body, in five different locations: biceps, triceps, subscapular, suprailiac and thigh, according to the standardization by Lohman et al.[11]. Each SF was measured three times, and the mean was used for calculations. Body density was obtained using two prediction equations:

1) Equation of Jackson et al.[12],

Body density (BD) (g/ml)= 1,0904921 - 0,0009929 (S 3 SF*) + 0,0000023 (S 3 SF *) ^{2} - 0,0001392 (age);
*SF: skinfolds: (triceps + suprailiac + thigh).

2) Equation of Durnin and Womersley[13]:

Body density (BD) (g/ml) = 1,1339 - 0,0645 (log.S 4 SF**); **SF (triceps + biceps + subscapular + suprailiac)

The percentage of body fat (%FM) in both equations was obtained using the equation of Siri[14]: %FM= (495/BD) - 450.

Deuterium oxide

For assessment of body composition by the deuterium oxide method, the volunteers were asked to fast for a period of 8 hours overnight. Then, each individual received 1 mL/kg of deuterium oxide (99.9% deuterium oxide Cambridge Isotope, EUA) diluted to 7%, followed by 50 mL of natural water for the complete intake of the deuterium and for mouth washing as well. some samples of saliva were obtained, before and three hours after of the ingestion oxide deuterium. The samples were frozen at -10 ºC until analysis.

The deuterium enrichment of the saliva samples was determined by the isotropic ratio mass spectrometry IRMS (Europe Scientific Hydra System, Cheshire, United Kingdom), after equilibration with 100% hydrogen by the method of platinum-aluminium catalysation. Body composition was determined according to the protocol by Schoeler et al.[15].

Statistical analysis

Data are presented as means ± standard deviations (SD). The Lin concordance correlation coefficient was used to achieve the objective of the study. This index evaluates the reproducibility of measurements, method or tools. The reproductbility of measurements relates to the degree of similarities between pairs of measurements. The Lin coefficient ranges from -1 to 1, and evaluates the level of agreement between two measurements, with levels closer to 1 showing a better agreement between the methods. The Bland and Altman test was also used to evaluate the concordance between the methods and equations compared to each other by graphs. To classify the level of concordance we used the categorizations proposed by Landis and Koch[17]. The analysis was done using the statistical program SAS/STAT (Version 9, Cary, NC, USA: SAS Institute Inc., 2002-2003).

RESULTS

Twenty two elderly women over 65 years old participated on the study. The sample characteristics are shown in table 1.

Table 2 shows the values of %FM, FM and FFM estimated by the deu-

terium dilution and by the equations of Durnin and Wormersley[13] and Jackson et al.[12]. This table shows an approximation of the mean values obtained by the equations of Durnin and Wormersley[13], Jackson et al.[12] and those estimated by the deuterium method.

Table 1. Physical characteristics of the study population.

Variables	Mean ± SD	Range
Age (years)	69.3 ± 3.6	65 - 78
Weigh (Kg)	67.2 ± 10.6	47.0– 82.5
Heigh (m)	1.55 ± 0.04	1.46 –1.64
BMI (Kg/m²)	27.9 ± 5.0	20.9 –37.2

BMI: Body mass index; SD: Standard deviation

Table 2. Percentage of body fat, fat mass and free fat mass estimated by the different methods. Values are expressed as mean (M) and standard deviation (SD)

Method	%FM	FM (Kg)	FFM (Kg)
Deuterium	42.4 ± 7,9	29.2 ± 9.3	37.9 ± 3.0
Durnin and Wormersley[13]	40.7 ± 4.3	27.7 ± 6.9	39.,4 ± 4.0
Jackson et al.[12]	38.7 ± 6.4	26.6 ± 8.0	40.5 ± 3. 5

%FM: percentage of body fat; FM: fat mass; FFM: free fat mass; M ± SD: mean ± standard deviation.
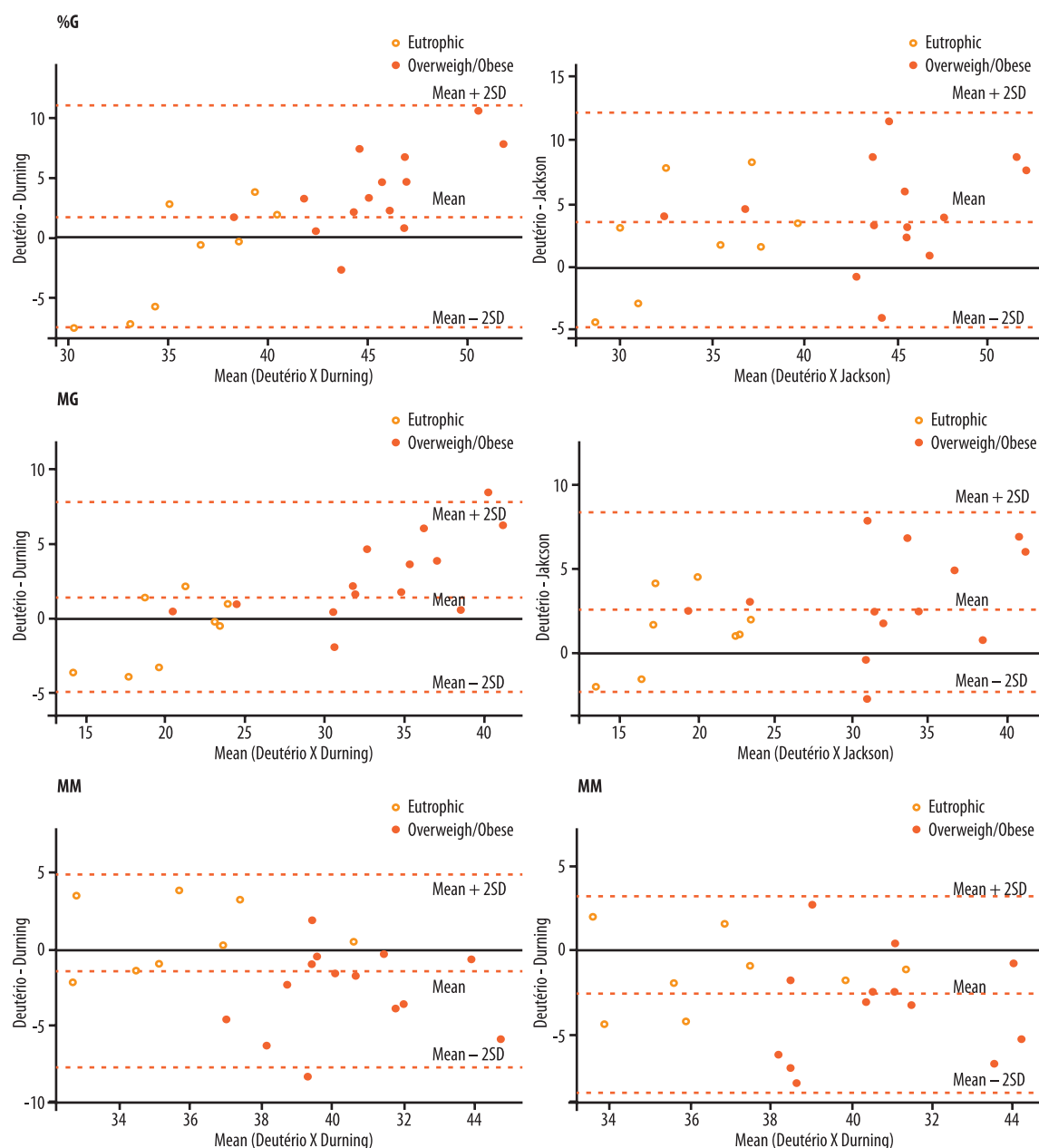
The concordance correlation coefficient of the Durnin and Wormersley [13] equation versus deuterium showed a slight superiority over the concordance coefficient of the Jackson et al.[12] equation versus deuterium, as shown in table 3. We also observed a better confidence interval when we compared de equation of Durnin and Wormesley[13] versus deuterium for all the variables.

Table 3. Concordance correlation coefficient between the deuterium and the anthropometric methods.

Variable	Method	Coefficient	CI (95%)
	Deuterium *vs* Durnin	0.71	0.52 – 0.83
% FM	Deuterium *vs* Jackson	0.72	0.49 – 0.86
	Deuterium *vs* Durnin	0.91	0.83 – 0.95
FM (Kg)	Deuterium *vs* Jackson	0.90	0.79 – 0.95
	Deuterium *vs* Durnin	0.57	0.24 – 0.78
FFM (Kg)	Deuterium *vs* Jackson	0.46	0.15 – 0.69

%FM: percentage of body fat; FM: fat mass; FFM: free fat mass.

Figure 1 shows that the Bland and Altman graphs confirmed the results obtained in table 3, and showed better agreement in the evaluation of the %FM, FM and FFM obtained by the equation of Durnin and Wormersley [1] versus deuterium.

Figure 1. Comparison of the %FM, FM and FFM between the deuterium and anthropometric methods (equations by Durnin and Wormersley [13] and Jackson et al.[12])

DISCUSSION

Due to the lack of specific anthropometric equations for the active elderly population, this study aimed to report the body composition in physically active elderly women by the deuterium oxide and anthropometric methods using the equations of Jackson et al.[12] and of Durnin and Wormersley[13], and also to analyze the agreement between these methods.

Some more sophisticated methods for assessment of body composition, such as the double X-ray absorptiometry[18] and the deuterium oxide[7], are often not feasible for use in field studies due to their high costs and the need

of specialized personnel for their analysis. Anthropometry is still the most widely used method, due to the low costs and simplicity. However, such method also requires specialized professionals to assure the reproducibility and reliability of the data[1,19,20].

In the present study we also observed that the equations used showed strong to moderate concordance with the deuterium, which corroborates the studies in the literature that evaluated populations different from ours, such as Chinese adults21 and post menopausal women[22]. In the study by Yao et al.[21] the authors demonstrated good concordance between the deuterium oxide and the anthropometric methods, using the equations of Durnin and Wormersley[13] in a population of 71 Chinese adults aged 35-49 years.

Regarding the methods used to assess body composition, the values obtained by the measurements of the SF, mainly by the equation of Durnin and Wormersley[13], showed better concordance with the deuterium oxide in comparison with the equation of Jackson et al.[12]. A previous study showed strong concordance between anthropometry using the equation of Durnin and Wormersley[13], and the DXA[2] method, which is considered an accurate method for estimating body composition in different populations[23,24].

The equation of Durnin and Wormersley[13] showed a slight superiority for estimation of body composition in comparison with the equation of Jackson et al.[12], possibly because the sample selected to validate that equation was also composed of elderly women and took into account the physiological changes that accompany the aging process. In the validation study, which included 209 men and 272 women aging 16-72 years, the hydrostatic weighting method was used as the gold standard[13]. The equation of Jackson et al.[12] was validated in a study that assessed the body composition of 331 Caucasian voluntary women from 18 to 55 years old, and therefore it did not include the elderly[12].

The anthropometric method estimates the body composition by measurements of the body mass, height, body circumpherences and SF thickness, and some methods also use the age to include the effects of aging[25]. General equations are used for the assessment of body composition in different age groups and genders, while specific equations are used in the elderly[5,12,13]. The equations used in this study are general, and the equation of Jackson et al.[12] adds the age for evaluation of changes in the body fat and bone density, which may justify the moderate concordance among the variables analyzed in our study.

Currently, several methods and equations are used to estimate body composition [26,27,28]; nevertheless, one of the main difficulties faced by the researchers who conduct studies on aging is to choose a method to evaluate body composition that is a simple, practical and reliable[29]. Anthropometry is still considered a practical and inexpensive method; its limitations, however, lie on the difficulty in choosing the best equation[30] and on the need of a skilled evaluator for the measurement of the SF.

In this study, the anthropometric measurements were performed by an experienced professional, and we believe that this may have been an

important factor for obtaining concordant results between the values estimated by the anthropometry and the deuterium methods.

Based on our results, we can infer that the equation of Durnin and Wormersley[13] was superior to assess the body composition of active elderly women, as the values of body composition showed strong concordance with those obtained by the deuterium.

It is important to notice that our sample is not representative of the elderly population because it was constituted exclusively of active individuals. Furthermore, the methods used are only some of those available for assessing body composition. Based on this assumption, we emphasize the need for further studies on body composition in a sample that is representative of the elderly population, so that reference values that take into account the changes related to aging can be established.

CONCLUSION

The anthropometric method proved to be suitable for evaluating the body composition of active elderly women as compared with the deuterium oxide method, and the equation of Durnin and Wormersley was superior to the equation of Jackson et al. to assess body composition in our sample.

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