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Comparation of specific equation of fat percentage in Brazilian military women with bioimpedance and infrared interactance methods

Comparação de equação específica de percentual de gordura em mulheres militares brasileiras com os métodos de bioimpedância e interactância infravermelha

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Abstract – In Brazil, the beginning of the 21st century has seen the expansion of work groups that focus their academic and professional activities on the analysis of body composition. This study aimed to: Compare the values estimated by the specific equation developed, with the values obtained by the methods of Bioimpedance - BIA (tetrapolar MALTRON 900), Infrared Interactance - NIR (FUTREX 5000 A/ZL) and Hydrostatic Weighing (like Gold Stand). Study is characterized as correlational descriptive research. In the sample, 16 women were used, with an average age of 31.6 (± 6.4), weight (MCT) of 59.6 (± 7.8), height of 165.60 (± 5.6), BIA (tetrapolar MALTRON 900) DE 24.5 (± 5.6), NIR (FUTREX 5000 A/ZL) 22.3 (± 5.0) and Hydrostatic Weighing 22.2 (± 5.7). In the statistical treatment, Student's t-test, paired method and Pearson's Correlation Method were used. The regression model used in this comparison was % F = 0.334 x P. ABD. + 0.315x DC. BICEPS + 0.246 x DC. THIGH – 2.543 x D. BIEST. With EPE (Standard Estimate Error) of 2.7, r (Correlation Index) of 0.99 and R2 (Coefficient of Determination) of 0.99. Comparing the model with the BIA method (tetrapolar MALTRON 900), an r = 0.8 and R2 = 0.7 was obtained, while comparing with the NIR (FUTREX 5000 A/ZL), an r = 0.6 was obtained and R2 = 0.4. It is concluded that, the results seen together, determine that the model presents a greater degree of significance with the BIA method than with the NIR.

Key words: Body measures; Eletric impedance; Military women.

Resumo – *No Brasil, o início do século XXI tem visto a expansão de grupos de trabalho que concentram suas atividades acadêmicas e profissionais na análise da composição corporal. Este estudo teve como objetivo: Comparar os valores estimados pela equação específica desenvolvida, com os valores obtidos pelos métodos de Bioimpedância – BIA (tetrapolar MALTRON 900), Interactância Infravermelha – NIR (FUTREX 5000 A/ZL) e Pesagem Hidrostática (como Gold Stand). Estudo caracteriza-se como uma pesquisa do tipo descritivo correlacional. Na amostra foram utilizadas 16 mulheres, apresentando em média idade de 31,6 (± 6,4), peso (MCT) de 59,6 (± 7,8), estatura de 165,60 (± 5,6), BIA (tetrapolar MALTRON 900) de 24,5 (± 5,6), NIR (FUTREX 5000 A/ZL) de 22,3 (± 5,0) e Pesagem Hidrostática de 22,2 (± 5,7). No tratamento estatístico foram utilizados o Teste t de Student (método pareado) e o Método de Correlação de Pearson. O modelo de regressão utilizada nessa comparação foi: % F = 0,334 x P. ABD. + 0,315 x DC. BÍCEPS + 0,246 x DC. COXA – 2,543 x D. BIEST. Com EPE (Erro Padrão de Estimativa) de 2,7, r (Índice de Correlação) de 0,99 e R^2 (Coeficiente de Determinação) de 0,99. Ao comparar o modelo com o método BIA (tetrapolar MALTRON 900), obteve-se r = 0,8 e R^2 = 0,7. Já na comparação com NIR (FUTREX 5000 A/ZL), obteve-se r = 0,6 e R^2 = 0,4. Conclui-se que os resultados, vistos conjuntamente, determinam que o modelo apresenta um maior grau de significância com o método BIA que com o NIR.*

Palavras-chave: *Medidas corporais; Impedância elétrica; Mulheres militares.*

INTRODUCTION

In Brazil, the beginning of the 21st century has seen the expansion of work groups that focus their academic and professional activities on the analysis of body composition. In the academic field, in one of the Directory of Research Groups of CNPq, held in October 2018, 125 lines of research were counted aimed at investigations related to body composition[1,2].

Body composition is the proportion between the different body components and the total mass, normally expressed by the percentages of fat and lean mass, where the measurement of skinfolds (two components) is a simple, low-cost and easy-to-use technique. handling with high reliability has been widely used by researchers[3-5].

According to De Rose et al.[6], in Brazil, the study of body composition in the discipline of applied biometrics began with the teaching of Physical Education. In this discipline, the content basically comprised the analysis of anthropometric indices, the determination of the viola biotype and notions of applied statistics. For forty years, this discipline did not change, until LABOFISE, in 1971, with the introduction of the fundamental concepts of body composition, that is, with the determination of the percentage of fat estimated by measuring skinfolds and by calculating bone mass. through bone diameters, started the renewal process.

According to Salem et al.[7], in the Brazilian Army, information on body composition has become useful for all sectors related to military functional activities. The Brazilian Army, despite being one of the oldest institutions in our country, has only been admitting women to its staff for a few years. With this advent, interest in their body composition has been growing, in view of the peculiarities of the missions performed, which have body weight as a limiting factor.

In the US, military body composition and physical standards have been formally used for over 100 years. These metrics promote adequate physical fitness, stylish appearance, and long-term health habits in soldiers, although many specific aspects of these standards have evolved as evidence-based changes have emerged[8].

There are several ways to determine body fat, these determination procedures can be classified into direct, indirect and double indirect methods[3,9,10]. Level I or direct method is represented by the technique of physical dissection or physical-chemical analysis of cadavers. Level II or indirect, is based on quantitative assumptions, obtained by the direct technique. Being those where there is no manipulation of the components separately, but based on chemical and physical principles, such as absormetry, plethysmography, hydrometry, hydrostatic weighing, among others[11-13]. Level III, or doubly indirect, use estimating equations generally derived from level II, specifically hydrostatic weighing. The double indirect techniques have a better practical application and a lower financial cost. We highlight as an example: anthropometry, bioimpedance and Infrared Interactance (FUTREX)[3,10,11,14].

Thus, this study aimed to compare the values estimated by the specific equation for female soldiers of the Brazilian Army, with the values obtained in the BIA (tetrapolar MALTRON 900) and in the NIR (FUTREX 5000 A/ZL).

METHOD

This study is characterized as correlational descriptive research[6]. The sample consisted of 16 military women from the Brazilian army with an average age equal to 31.6 (+ 6.7) years, average Total Body Mass (MCT) equal to 59.6 (+ 7.78) kilograms and average height equal to at 165.6 (+5.6) centimeters.

The sample selection was carried out systematically and at random, as women who were adapted to the liquid environment and who met the inclusion and exclusion criteria were chosen at random. All women voluntarily participated and signed the Term of Consent Participation, obeying the Norms for Conducting Research on Human Beings, Resolution 466/12, of the National Health Council of 12/12/2012[15] and was approved by the Ethics at Castelo Branco University – UCB/RJ – Brazil, with process nº 1508/2007.

Regression model used

The approved and validated regression model is the following: %F = 0.334 x P_ABD + 0.315 x DC_BICEPS + 0.246 x DC_THIGHLIGHT -2.543 x D_BIEST[16].

Hydrostatic weight measurement

The materials and procedures used in this study followed the recommendations of Petroski and Pires[1], Heyward and Stolarczyk[3], Lohman[17], Pollock and Wilmore[18] and Norton and Olds[19].

Regarding the problems reported by Pollock and Wilmore[18], when reading the weighing in water, caused by water oscillation, some measures were taken in this study, namely:

- The scale was tared at each start of weighing;
- The tank was built above the ground and has a 50 × 60 cm glass in the front for communication between the appraised and the appraiser;
- The chair was attached to the scale by a covered stainless-steel cable, being fixed to a hardwood beam, positioned 50 cm from the top of the tank;
- Submerged Weight (SP) – The individuals were evaluated in the sitting position, as described by Pollock and Wilmore[18];
- Before carrying out the weighing procedures, the practice of submerged expiration was allowed. The individuals were evaluated in the morning and in the late afternoon, with a maximum limit of up to 5 subjects per day.

The determination of weight in water was performed using what Behnke & Wilmore prescribe, presented in Pollock and Wilmore[18].

%BF measurement using the MALTRON BF 900 tetrapolar BIA

The subject was positioned on a non-conductive surface. Adhesive electrodes were attached to the right side of the body in the dorsal region of the hand and foot, following the determinations of Pollock and Wilmore[18].

%F measurement through FUTREX 5000 A/ZL

All procedures determined by the manufacturer, cited by Pollock and Wilmore[18], were followed.

Statistical treatment

In the present statistical treatment, Pearson's correlation tests and the paired t test were used[20]. Pearson's correlation test sought to verify and quantify the

degree of parallelism between the crossed data and Student's t test in the paired method, sought to verify the degree of collinearity, that is, of proximity between the two families of curves. Such statistical procedure was developed separately for each method in particular, Regression Model x BIA and Regression Model x NIR. In all statistical treatment, a significance $p < 0.05$ was observed.

RESULTS

The present study compared the regression model developed and validated by Silva and Fernandes[16], with the BIA (tetrapolar – MALTRON 900) and NIR (FUTREX 5000 A/ZL) methods (Table 1).

Table 1. Comparison of correlation coefficients and determination between the developed model and the four-pole BIA methods Maltron 900 and NIR Futrex 5000 A/ZL.

	Statistical	
R	0.8	0.6
R2	0.7	0.4
Sig.p Test t Par	0.3	0.5

Note. R: correlation index, R^2: determination coefficient; Sig.p: significance of variables.

The results denote that the Model when crossed with the BIA Method, present a significant correlation index (r = 0.8), being superior to that found in the comparison with the NIR method (r = 0.6). Also, when crossing by Student's t test using the paired method, we have that the sig.p calculated in the BIA was 0.3 and NIR was 0.5.

In summary, the results seen together, denote that the Model presents a greater degree of parallelism and collinearity with the BIA Method than with the NIR. As shown in Figures 1 and 2.

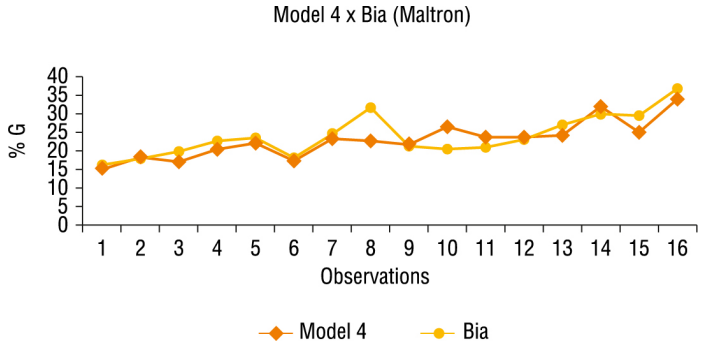

Figure 1. Comparison graph between the model developed and the four-pole Maltron 900 BIA, %G (% Body Fat).

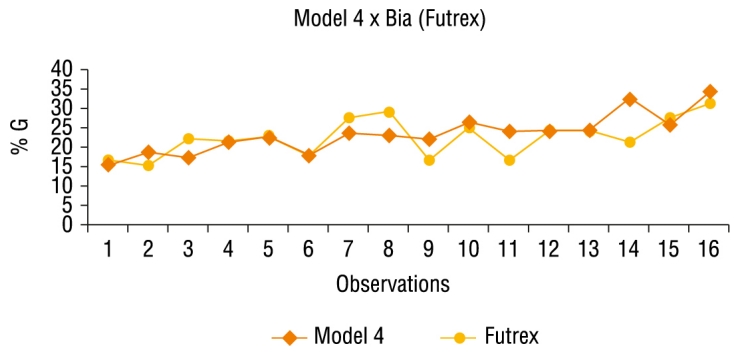

Figure 2. Comparison graph between the developed model and the NIR Futrex 5000 A/ZL, %G (% Body Fat).

DISCUSSION

If we compare the results obtained by the present study with those carried out internationally that are cited by Petroski and Pires[1], Heyward and Stolarczyk[3], Salem et al.[7], and Norton and Olds[19], such as: Segal in 1985, with 41 women aged between 17 and 59 years, presented r = 0.9 and EPE = 3.1; Lukaski in 1988, with 151 women aged between 19 and 50 years, presented r = 0.99 and EPE = 2.1; Kushner and Schoeller in 1986, with 20 women aged between 19 and 65 years, obtained r = 0.98 and EPE = 1.4; Van Loan and Mayclin in 1987 with 65 women aged between 16 and 64 years obtained r = 0.97 and EPE = 3.1; Lukaski in 1988, with 59 women aged between 20 and 73 years, obtained r = 0.98 and EPE = 1.5; Segal in 1988, with 498 women aged between 17 and 62 years, obtained r = 0.9 and EPE = 2.5; Gray in 1989 with 62 women aged between 17 and 74, obtained an r = 0.9; Heitman in 1990 with 67 women aged between 35 and 65 years obtained r = 0.9 and EPE = 3.5; Deurenberg in 1990 with 37 women aged between 60 and 83 years, obtained an r = 0.9 and EPE = 2.5; Rising in 1991 with 56 women aged between 60 and 83 years, obtained an r = 0.9 and EPE = 3.3 and Deurenberg in 1991 with a sample of 661 individuals between men and women aged between 16 and 83 years, obtained an r = 0.9 and EPE = 2.6. We can conclude that the previously mentioned international results presented a higher correlation coefficient and a smaller estimated standard error than those obtained in the present study.

Rodrigues et al. mentioned by Salem et al.[7], carried out a study where they compared the estimate of body fat through bioimpedance equipment (A-310 from Biodynamics; BF-900 and BF-906 from Maltron and A-101 from RJL inc.) with skinfolds and hydrostatic weighing. It was observed that in the Maltron model (BF-900), it presented a Correlation Index (r = 0.6) and Standard Estimate Error (EPE = 5.9). As the Maltron BF-900 model was the same instrument used in this study, comparing the results, it was observed that the present study presented both the correlation coefficient and the estimated standard error indices much higher than those presented by the study by Rodrigues et al mentioned by Salem et al.[7].

A study carried out by Monteiro and Fernandes[10], where he compared the two methods with a group of Brazilian military women, with the same characteristics, had a correlation index of r = 0.7, indicating a lower index than that of the present study. The study by Albertin and Bertucci[20], consisted of 14 individuals, 26.8 ± 3.3 years old, 68.3 ± 8.5 kilograms of body mass and 168 ± 0.07 centimeters of height, residing in the city of Monte Santo de Minas – MG. When compared with the BIA, the protocol by Jackson and Pollock did not show a significant difference, but when we compared the protocol by Petroski with the BIA, a statistical difference was observed. Finally, it can be concluded that all methods, equations by Jackson and Pollock (3 skinfolds), Petroski 1995 (4 skinfolds) and BIA are effective in measuring the percentage of fat in the studied population.

According to Lopes et al.[21], they developed a study, where BIA using the equation proposed by Houtkooper was the only one that did not present statistically significant difference in the estimate of %BF, FM and FFM compared to DXA and presented good agreement with DXA in estimating %BF (-1.9 ± 3.3%), FM (1.5 ± 2.6 kg) and FFM (1.4 ± 2.6 kg), as well as good reproducibility for %BF (ICC = 0.8), MG (0.96) and FFM (0.9). A study by

Leal[22], which aimed to validate anthropometric and BIA prediction equations to estimate the body composition of classical ballet practitioners, being a cross-sectional study, in which 37 classical ballet practitioners from the female gender at an intermediate/advanced level. Body composition assessment tests included anthropometric assessment and BIA assessment using a tetrapolar apparatus. Twenty different prediction equations were tested, 8 equations for FFM using anthropometry and 12 for FFM prediction using BIA data. The correlation between FM or FFM results given by the equations and by DXA was performed using Pearson's correlation (r). The one sample T-test was used to verify whether the mean differences between the results of the equations and the DXA differed significantly from zero. The validity between the different equations and the DXA was determined through the Bland-Altman analysis, using simple linear regression to test the presence of proportional bias between the tested equations and the DXA. The sample studied had a mean age of 28.4 (7.0) For FM determined by anthropometric equations, the equation proposed by Durnin & Womersley in 1974 showed good agreement with DXA ($r = 0.85$, $p < 0.00$, and one sample T-test $p = 0.60$), showing no proportional bias ($R^2 = -0.06$, beta = 0.02, $p = 0.93$). For FFM by BIA, none of the tested predictive equations showed.

Through the study by De Melo and Rocha[23], who evaluated the agreement between the methods of electrical bioimpedance and skinfolds. The sample consisted of 25 university physical education students with a mean age of 23.5 ± 3.7 years, BMI 25.6 ± 3.2 kg/m^2, height 171.9 ± 7.3 cm and MCT 72.9 ± 11.2 kilograms. Estimates of the percentage of fat were performed through Bioimpedance (BIA) and skinfolds. To compare the different methods, one-way analysis of variance (ANOVA) was performed, the relationship was determined by Pearson's correlation and the analysis of agreement using the Bland-Altman method with a significance level of $p<0.05$. In joint analysis, the methods did not differ significantly ($p>0.05$) and showed good correlation (0.8 to 0.9). There was no difference between the BIA x DCs methods ($p>0.05$). Corroborating the present study, it is also concluded that the BIA and DOC methods are in agreement among university students.

For the NIR technique (Futrex 5000), the reliability reported by Heyward and Stolarczyk[3], ranges from r = 0.9 – 0.95, which was not confirmed in this study because the reliability was r = 0.6.

The literature reports that the manufacturer's equation for Futrex 5000 A/ZL systematically underestimates the mean body fat from 2% to 10%F (30.3), which was confirmed in this study, where the difference between the %BF means via PH and NIR (Futrex 5000 A/ZL) was 3.58% for MMEB (military women of the Brazilian Army).

Regarding the correlation between %F via PH and NIR (Futrex 5000 A/ZL) reported in the literature, we can verify that the one found in this study was superior to studies such as Heyward and Stolarczyk[3], r = 0.6; Eaton et al.[24], r = 0.5; similar to the study by McLean and Skinner[25], r = 0.6 and lower than the study by Eckerson et al.[26], r = 0.96. Bearing in mind that the sample of the present study was made up of military women from the Brazilian army, with characteristics previously presented.

A study carried out by Monteiro and Fernandes[10], where he compared the two methods with a group of Brazilian military women, with the same characteristics, had a correlation index of r = 0.7, indicating a higher index than that of the present study.

Some limitations in this study may be found due to the factors presented below, such as: the difficulty in training evaluators to assist in data collection makes the process very slow, regarding the correct exhalation of air at the time of hydrostatic weighing, the testimony of the subjects evaluated regarding the technical requirements for performing a correct weighing in a liquid medium, the impossibility of directly determining the residual volume, the lack of conditions for identifying problems such as bone demineralization, which cannot be determined through the initial anamnesis performed by the physician.

Given the limitations above, any findings cannot be generalized to other military women.

CONCLUSIONS

Based on the results presented, on the consulted literature and on the objective of this study, which is to compare the regression model with the BIA and NIR methods, using Pearson's correlation test and Student's t Test in the paired method, we arrived at if the following conclusions: the results seen together, determine that the regression model presents a stronger degree of significance with the BIA method than with the NIR, confirming the presented results. It is advisable that other studies be carried out with more heterogeneous groups.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the Research Ethics Committee of Universidade Castelo Branco/RJ and the protocol (no. 1508/2007) was written in accordance with the norms established by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interest to declare.

Author Contributions

Conceived and designed the experiments: PAPS; Conducted the experiments: PAPS; Data analyzed: PAPS, JFF; Wrote and proofread the paper: PAPS, JFF.

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