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Desarrollo de una ecuación antropométrica para estimar la masa muscular en adultos sanos brasileños

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ABSTRACT

Introduction: anthropometry is a practical and low-cost method for assessing body composition, capable of estimating body compartments. Skeletal muscle mass (SMM) is an important tissue for decision-making in clinical practice and for monitoring the health status of individuals. However, anthropometric equations that estimate SMM have limitations according to the specificities of the samples from which they were developed.

Objective: the objective of this study was to develop a predictive anthropometric equation capable of estimating SMM in a sample of healthy Brazilian adults.

Method: cross-sectional study using anthropometric and bioelectrical impedance analysis (BIA) data from 499 volunteers. To develop the equation, linear regression method was used, calculating adjusted R^2 and standard error of estimate (SEE), in addition to the intraclass correlation coefficient (ICC) and the Bland-Altman test.

Results: the final equation was: SMM (kg) = Height (cm) x (0.219 + 0.00001 x corrected thigh circumference^2 [cm] + 0.00005 x corrected arm circumference^2 [cm] + 0.00002 x corrected calf circumference^2 [cm]) + 1.96 x Sex (Women = 0; Men = 1) + 0.079 x Weight (kg) - 26.98 (R^2adj = 95.4 % and SEE = 1.522), which presented high agreement with SMM by BIA and the highest ICC, compared to other equations from literature (CCI = 0.988, 95 % CI [0.986-0.990]). The Bland-Altman analysis showed that the equation presented good agreement with the values obtained by BIA.

Conclusion: the equation presented satisfactory diagnostic performance for estimating SMM in relation to BIA and uses parameters commonly collected in clinical practice.

Keywords: Body composition. Body size. Muscles. Anthropometry. Predictive models.

RESUMEN

Introducción: la antropometría es un método práctico y de bajo coste para evaluar la composición corporal, capaz de estimar los compartimentos corporales. La masa muscular esquelética (MME) es un tejido importante para la toma de decisiones en la práctica clínica y para monitorear el estado de salud de los individuos. Sin embargo, las ecuaciones antropométricas que estiman la MME tienen limitaciones de acuerdo con las especificidades de las muestras a partir de las cuales se desarrollaron.

Objetivo: el objetivo de este estudio fue desarrollar una ecuación antropométrica predictiva capaz de estimar la MME en una muestra de adultos sanos brasileños.

Método: estudio transversal utilizando datos antropométricos y de análisis de impedancia bioeléctrica (BIA) de 505 voluntarios. Para desarrollar la ecuación, se utilizó el método de regresión lineal, calculando R2 ajustado y error estándar de estimación (SEE), además del coeficiente de correlación intraclase (ICC) y la prueba de Bland-Altman.

Resultados: la ecuación final fue: MME (kg) = altura x (0,217 + 0,00001 x circunferencia del muslo corregida^2 + 0,00005 x circunferencia del brazo corregida^2 + 0,00002 x circunferencia de la pantorrilla corregida^2) + 1,934 x Sexo (Mujeres = 0; Hombres = 1) + 0,079 x Peso - 26,73 (R^2adj = 95,4 % y SEE = 1,522), que presentó una alta concordancia con la MME por BIA y el mayor ICC, en comparación con otras ecuaciones de la literatura (ICC = 0,977, IC 95 % [0,972-0,980] $p < 0,001$). El análisis de Bland-Altman mostró que la ecuación presenta una buena concordancia con los valores obtenidos por BIA.

Conclusión: la ecuación presentó un desempeño diagnóstico satisfactorio para estimar la MME en relación con la BIA y utiliza parámetros co0múnmente recolectados en la práctica clínica.

Palabras clave: Composición corporal. Tamaño corporal. Músculos. Antropometría. Modelos predictivos.

INTRODUCTION

In order to study body composition, it is necessary to understand three interrelated areas: the levels of body composition, the techniques used to measure body composition, and the biological factors that influence it. Regarding the levels of body composition, there are five levels of increasing complexity: atomic, molecular, cellular, tissue system, and whole body. The first level (atomic) refers to the chemical elements that constitute our body, such as oxygen, carbon, hydrogen molecules. The second level, or molecular, refers to the components of our body, formed from the combination of molecules from the first level, such as water, proteins, glycogen, minerals, and lipids. Likewise, the components of the third level, cells, extracellular fluid, and extracellular solids, are organized and form the tissue level (or fourth level), divided into tissues, organisms, and systems. Finally, the whole-body level (fifth level) includes characteristics that are unique to the human body. This 5-level model presents us with a structure that facilitates the study and understanding of the composition of the human body beyond an individual compartment or level (1).

In this sense, the methods for assessing body composition consider different chemical elements that constitute a living organism and can be divided into three categories: direct, indirect, and doubly indirect. The dissection of cadavers, the only truly direct method, despite providing high precision in the analysis of composition, it is difficult to

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apply (2,3). Indirect methods, such as DXA, computed tomography, and magnetic resonance imaging, allow the quantification and evaluation of body components in a detailed, precise manner, however, they have limited applicability due to the high cost, low portability, and high complexity-required of the equipment for the analyses (4-6). In clinical practice and for population assessments, doubly indirect forms of assessment are preferred, which, despite being less rigorous and precise, are less costly and require less training for their application (3), such as bioelectrical impedance analysis (BIA) and anthropometric assessments.

BIA is a two-compartment body composition model-based method: fat mass and fat-free mass (7). To determine the body compartments, the equipment applies a low-intensity, painless electric current that circulates through the human body and measures the opposition imposed by the body components to the passage of the current (8,9). The different components of the body impose different resistances to the passage of the electric current (9). Fat tissue presents greater resistance to the passage of the current due to its low water content, while fat-free tissue presents less resistance to the flow of the current because it concentrates a higher amount of water and electrolytes (10). BIA is a widely-used tool in clinical practice because of its low cost, portability, easy application, and acceptable levels of reliability and accuracy in body composition estimates (7). However, BIA is not always available in health services and the feasibility of its usage is limited by various standardized conditions regarding body position, food intake, previous exercise performance, and body temperature, which all must be met aiming to reduce errors and obtain accurate results (8,11).

Nonetheless, anthropometry is an inexpensive method that requires little equipment, easy to use, available in most health services, and it allows assessment in different environments (7,10). This assessment tool uses anthropometric measurements of the human body as weight, standing height, skinfold thickness (ST), circumferences,

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lengths, and widths of the limbs to estimate body size and proportions (7,12). This estimate is made throughout predictive equations, using both anthropometric parameters and regression analysis from other laboratory methods (13). Therefore, given the limitations imposed by other body assessment methods, including BIA, the use of predictive anthropometric equations is a low-cost, an effective alternative for measuring muscle mass in clinical practice and population studies.

Depending on the method chosen, body composition assessment can be performed with one, two, or several compartments. Skeletal muscle mass (SMM), the main and critical component of fat-free mass, is a metabolically active tissue (7) that is very important and related to different health outcomes. When in decline, muscle mass is associated with impaired immune function, physical disability, low quality of life, and negative clinical outcomes (14,15). Thus, accessing and assessing muscle mass become an important way to monitor an individual's health status since its analysis can provide relevant information for clinical decision-making, predicting survival outcomes, and determining the patient's quality of life (16).

Some previous studies have developed predictive anthropometric equations (Table I) using individual anthropometric measurements related to muscle mass and other important variables as sex, age, level of physical activity, and ethnicity. Although relevant, these few studies suggest models with limited applicability to the population in which they were developed and/or validated, since the mathematical model of the equation carries the specificities of each sample that the equation was created from (7). Given the above, the present study aims to develop a predictive equation to estimate muscle mass in a sample of healthy Brazilian adults.

MATERIALS AND METHODS

Participants

This is a cross-sectional study that uses anthropometric and bioelectrical impedance analysis data collected during the period of 2021 and 2022 from individuals who voluntarily participated in the Iris Project, a project whose objective was to create a method for assessing human body composition through a computer vision system that uses artificial intelligence (AI). The sample consists of 499 individuals, of both sexes, between 18 and 62 years old. Participants were recruited through partnerships with public and private institutions, through issued virtual announcements. Before data collection began, participants received instructions on how to prepare for the BIA and signed the Free and Informed Consent Form (CAAE protocol number: 45544221.6.0000.5421).

Anthropometric measurements

Anthropometric measurements were collected by an evaluator and researcher who underwent international accreditation for the standardization of anthropometric measurements at an international level and, then, holds the ISAK (International Society for the Advancement of Kinanthropometry) level I anthropometrist certificate. In addition, measurements were performed using properly calibrated equipment such as a tape measure (Sanny, TR4010, SECA 201), caliper (Lange), stadiometer (SECA 217), high-precision digital scale (InBody 270), and caliper (Cescorf Innovare).

Among the measurements collected that hold interests for the present study there are weight (kg), height (m), arm, thigh and calf circumferences (cm), and triceps, thigh, calf skinfold measurements (mm). For height, the individual was instructed to stand upright, with his/her heels together and the upper part of his/her back in contact with the stadiometer scale, used to determine height in meters (m). Body mass was determined in kilograms (kg) using the scale present in the bioelectrical impedance analysis equipment, and, for this purpose, the volunteer was instructed to position himself/herself in the center of the equipment.

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Circumference measurements were obtained by using a tape measure. To obtain arm and calf circumference, the subject was first instructed to stand with arms hanging along the trunk and feet slightly apart. The tape measure was then positioned at the level of the acromial-radiale medial anatomical point and at the level of the calf fold, respectively. For thigh circumference, the volunteer remained standing with arms crossed over the chest and the tape measure was positioned at the level of the trochanterion-tibiale lateraled medial point.

To obtain the triceps skinfold, the individual was instructed to remain with the right arm hanging down along the trunk and the researcher palpated the location of the fold measurement parallel to the longitudinal axis of the arm, at the location of the triceps fold. To measure the mid-thigh fold, the individual sat upright on the edge of an anthropometric bench, with the knee extended and the heel on the floor and supported the hamstrings, elevating the posterior femoral region enabling the measurement being performed with the plicometer. And for the calf skinfold, the volunteer was instructed to position the right knee flexed at a 90° angle while the anthropometrist obtained the fold value parallel to the longitudinal axis of the leg. In addition to anthropometric measurements, before starting the procedures the volunteers were asked about their age, gender, physical activity, and self-classified ethnicity.

Bioelectric impedance analysis

To perform the bioelectrical impedance analysis (BIA), the InBody 270 equipment from Biospace Co (Seoul, Korea) was used. It is a tetrapolar, multifrequency device with frequencies of 20 kHz and 100 kHz and lasts 45 seconds. To perform the BIA, the volunteers received a preparation protocol that included the following instructions: fast for 4 hours for solids and 2 hours for liquids, empty the bladder before going for collection, do not do intense physical exercise for 24 hours before the exam, remain standing for 5 minutes before the test, do not take the exam after a long hot bath or one day after a sauna or during the menstrual period, and hydrate normally in the previous days. At the time of the exam, the volunteers stood on the scale barefoot, wearing light clothing free of metal ornaments, and placed their hands and feet on the electrodes.

Statistical analysis

To develop the equations, a t-test for independent samples was performed to analyze the distribution pattern of the means of sex and race regarding the mean values of SMM. Then, the Pearson correlation coefficient was calculated between the anthropometric and individual variables and the SMM obtained by BIA. To calculate the correlation coefficient, we used anthropometric parameters applied to equations of circumference corrected by skinfold (Circumference corrected by skinfold = circumference of the limb - (skinfold of the same limb x π)) and applied to equations of circumference corrected by skinfold adjusted to the three-dimensionality of the body (parameter adjusted to three-dimensionality = circumference corrected by skinfold^2 x height). These equations are used in studies aimed at developing predictive equations for muscle mass since they aim to estimate SMM more directly (17-19).

From the results obtained in the initial analyses, an anthropometric equation was developed using the linear regression model and some mathematical adjustments were made to maintain only significant variables in the predictive models and to reduce and adapt the VIF (Variance Inflation Factor).

To analyze the diagnostic performance of the equation, the R^2adj values, which demonstrate the accuracy of the model, and the SEE, that indicates the adjustment of the equation in relation to the muscle mass values obtained by BIA, were analyzed. Then, the Pearson correlation test and a paired t-test were applied to verify the relationship between the muscle masses obtained by the proposed equation and the existing equations regarding the muscle mass values obtained by the BIA equipment.

We also use the ICC and the Bland-Altman test as tools for analyzing diagnostic performance. The ICC is a parameter, whose results range from 0 to 1, that measures the precision of a measuring instrument; the closer it is to 1, the greater the interclass correlation between the instruments. The Bland-Altman test, on the other hand, aims to evaluate the agreement of two different methods (anthropometric equations and BIA) in measuring SMM.

RESULTS

About the 499 participants of the present study, the average age of women is 28.1 ± 9.2 years old and of men 28.1 ± 8.6 years old, while the average SMM by BIA of women is 22.8 ± 3.2 kg, being lower than of men, 34.6 ± 5.4 kg. The other information of the sample used is presented in table II.

To develop the equation, the results of the t-test for independent samples showed that although there was a significant difference between the sexes ($p < 0.001$), there were no significant differences between the races ($p = 0.45$). Meanwhile, the results of the Pearson correlation coefficient, applied to check the relationship between the SMM obtained through BIA and the individual and anthropometric variables (Table III), indicate that, apart from age, all other variables had a high correlation with the SMM (between 0,792 and 0,910, with $p < 0.001$). Based on the test results, we differentiated the sexes in the equation and included the parameters weight and arm, calf and mid-thigh circumferences, corrected and adjusted for height. Thus, mathematical models were developed through linear regression, and the model with good adjusted R^2 and SEE values was chosen, which is:

SMM (kg) = Height (cm) x (0.219 + 0.00001 x corrected thigh circumference^2 [cm] + 0.00005 x corrected arm circumference^2 [cm] + 0.00002 x corrected calf *circumference^2 [cm]) + 1.96 x Sex (Women = 0; Men = 1) + 0.079 x Weight (kg) - 26.98 (R^2adj = 95.4 % and SEE = 1.52 kg)*

Regarding the diagnostic performance of the new model, the results of the Pearson correlation coefficient, established between the SMM obtained by the new and existing anthropometric equations, and SMM by BIA, displayed in table IV, showed that all equations have a high correlation with the SMM by BIA (*r* between 0.900 and 0.977). However, the new model presented a greater correlation with the SMM by BIA in relation to the other equations (*r*: 0.977). About the paired t-test applied, table V shows that only the predictive model developed by the current study did not present a significant difference in relation to the estimate made by BIA (*p*: 0.426) while the other equations presented $p < 0.001$. The ICC values, also calculated (Table VI), demonstrate that the SMM estimated by all models presents a strong correlation with the SMM of BIA (ICC values greater than 0.6). Finally, the interpretation of the graphs obtained by the Bland-Altman test (Fig. 1) allows us to observe that the agreement value was higher for the SMM obtained by the new equation developed.

DISCUSSION

This study was dedicated to the development of a predictive equation using anthropometric parameters and personal information commonly collected in clinical practice, aiming to obtain a simple method capable of estimating SMM in healthy Brazilian adults.

Access to body composition allows to develop some broader understanding of the body's metabolic and disease processes (20) and the identification of changes in nutritional status (8). Skeletal muscle mass is a compartment that has been the target of studies as its both quantity and quality regulate the metabolic health of the

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entire body (21). Furthermore, once reduced, SMM is associated with adverse clinical outcomes and it is a defining criterion for the diagnosis of sarcopenia, cachexia, and malnutrition (14). Thus, access to this compartment has become essential in investigations and in the clinical context (7).

Being a simple method that appears to be least affected by everyday factors, such as food intake, hydration status, and daily activities (10), anthropometry is widely used in clinical practice to assess body compartments (7). In this context, anthropometric equations predictive of muscle mass have gained prominence and have been developed over the years, each one aimed at a different population, since the equation carries in the model the characteristics of the sample from which it was developed (7). The classic equations by Martin et al. (19) and Doupe et al. (18) were developed and validated in a sample of 12 cadavers using the cadaveric dissection method. Despite being a direct method and, therefore, highly accurate (3), the sample, in both projects, was small and the individuals were between 55 and 83 years old. Setting that, Gobbo et al. (22) identified significant differences between the prediction of SMM obtained by the equations of Martin et al. (19) and Doupe et al. (18) and reference values obtained by DXA ($p < 0.05$) for the sample of Brazilian men aged 18 to 36 years.

Unlike the authors aforesaid, Heymsfield et al. (23) proposed an equation from the arm muscle area as an anthropometric parameter and using the indirect method of computed tomography as a reference. Despite being a simple equation that used the gold standard method for determining SMM (24), the sample included volunteers between 20 and 70 years of age with a history of chronic diseases and malnutrition in addition to being healthy. Moreover, the later study by Martin et al. (19) found that the equation underestimated the SMM estimate compared to cadaveric dissection data when applied to a sample of cadavers. Another study by Kawakami et al. (25) used an indirect method, DXA, as reference,

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whose equation was designed to include anthropometric parameters commonly collected in health screenings in Japan (equation F). Although the sample of their project is large, made up of 1262 volunteers, the volunteers are Japanese age ranging from 40 and to 87, a specific population with different characteristics from Brazilians.

Finally, the equation by Lee et al. (17) aimed to create two predictive models of SMM in healthy individuals, throughtout magnetic resonance imaging as reference. The sample used in that study was large, including 244 participants, aged from 20 to 81 years from 4 different racial groups. When applying the equation to a sample of Brazilian male college students, Gobbo et al. (22) reported that the equation by Lee et al. (17) had no significant difference ($p > 0.05$) from the SMM estimated by DXA. Despite the good performance in young men, the equation by Lee et al. (17) was developed with adults and elderly people as well as the equations by Martin et al. (19), Doupe et al. (18), Heymsfield et al. (23), and Kawakami et al. (25). Considering that aging is marked by progressive changes in body composition, especially a progressive reduction in SMM (26), the equations developed with elderly people may not be suitable when applied to young and adult populations.

The model developed in this study was conducted mostly with adults aged from 18 to 59 (98.6 %), with 94.45 % being individuals under 49, an age Jassen et al. (27) have identified a noticeable reduction in the absolute SMM. This makes the sample more homogeneous in terms of age, possibly reducing the influence the participation of a portion of elderly people could have on the predictive model. Furthermore, the sample is settled entirely on Brazilians, which is a difference in relation to the other equations presented here.

Regarding the structure of the equation, we started from general concepts, as well as those of Lee et al. (17) and other authors (18,19), that limb circumferences corrected for skinfolds provide a measure of the corresponding circumferences of appendicular lean tissue, appendicular lean tissue circumferences squared estimate lean tissue area, and the product between the sum of the estimated areas of appendicular lean tissue and height provides a measure of total body muscle mass. In addition, we selected parameters that could reflect the SMM, understanding that the anthropometric parameters of a muscle group reflect the muscle mass of that group and that the muscle mass of one or more muscle groups is directly related to the SMM (19). To select the muscle groups, we observed the equations already existing in the literature. Kawakami et al. (25) reported a strong correlation between calf circumference and SMM (*r*: 0.82), Lee et al. (17), and Doupe et al. (18) included calf, arm, and thigh circumferences in their respective equations. All these observations led to the inclusion of upper and lower body limb parameters, as done by Doupe et al. (18).

In summary, the developed model had better diagnostic performance in comparison with previously-mentioned equations, with lower Standard Error of Estimate (SEE: 1.52) and higher Interclass Correlation Coefficient (ICC: 0.977; $p < 0.001$) and Pearson's correlation values in relation to BIA (*r*: 0.977) and it includes parameters with a strong correlation with SMM in the formulation. Furthermore, it used a more homogeneous sample regarding age and nationality. Therefore, the new predictive mathematical model can be used as a new tool for assessing skeletal muscle mass in the population in question. It is noteworthy that, although it provides good diagnostic performance, it remains the necessity of validating the equation in the population from which it was developed and in other populations.

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Table I. Anthropometric equations predictive of muscle mass present in the scientific literature

Equation	**Study**	**Predictive anthropometric equation**
A	Heymsfield et al. (1982) (23)	SMM (kg) = Ht x [0,0264 + (0,0029 x CMMA)]
B	Doupe et al. (1997) (18)	SMM (g) = Ht x (0,031 x MTC^2 + 0,064 x CCC^2 + 0,089 x $CUAC^2$) - 3006
C	Martin et al. (1990) (19)	SMM (g) = Ht x (0,0553 x TC^2 + 0,0987 x FC^2 + 0,0331 x CCC^2) - 2445
D	Lee et al. (2000) (17)	SMM (kg) = Ht x (0,00744 x $CUAC^2$ + 0,00088 x CTC^2 + 0,00441 x CCC^2) + 2,4 x S - 0,048 x Ag + Rd + 7,8
E	Lee et al. (2000) (17)	SMM (kg) = 0,244 x BW + 7,8 x Ht + 6,6 x S - 0,098 x Ag + Re - 3,3
F	Kawakami et al. (2021) (25)	SMM (kg) = 2,955 x S + 0,255 x BW - 0,130 x WC + 0,308 x CC + 0,081 x Ht - 11,897

SMM: skeletal muscle mass; Ht: height; CMMA: corrected mid-arm muscle area; MTC: modified thigh circumference; CCC: corrected calf circumference; CUAC: corrected upper arm circumference; TC: thigh circumference; FC: forearm circumference; CTC: corrected thigh circumference; S: sex (H = 1, M = 0); Ag: age; Rd: race referring to equation d (Asian descent = -2.0; African descent = 1.1; Caucasians = 0.0); BW: body weight; Re: race referring to equation e (Asian descent = -1.2; African descent = 1.4; Caucasians = 0.0); WC: waist circumference; CC: calf circumference.

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Table II. Anthropometric characterization of the 499 study volunteers, divided by sex

Sample characterization			
	All volunteers (*n* = 499)	**Women (*n* = 309)**	**Men (*n* = 190)**
Age (years)	28.1 ± 9.2	28.1 ± 9.2	29.1 ± 8.6
Body weight (kg)	67.4 ± 13.9	61.7 ± 10.7	76.8 ± 13.7
Height (cm)	168.2 ± 8.9	163.3 ± 6.1	176.1 ± 7.0
BMI (kg/m^2)	23.7 ± 3.7	23.1 ± 3.6	24.7 ± 3.8
Arm circumference (cm)	29.7 ± 4.2	28.0 ± 3.5	32.4 ± 3.8
Thigh circumference (cm)	51.7 ± 5.0	51.0 ± 4.9	52.8 ± 4.9
Calf circumference (cm)	35.9 ± 2.9	35.3 ± 2.9	36.8 ± 2.9
Triceps ST (mm)	17.9 ± 7.5	21.4 ± 6.2	12.2 ± 5.7
Thigh ST (mm)	29.1 ± 11.9	34.8 ± 9.7	20.0 ± 9.3
Calf ST (mm)	17.3 ± 8.3	21.0 ± 7.4	11.3 ± 5.6
Muscle mass by BIA	27.3 ± 7.1	22.8 ± 3.2	34.6 ± 5.4

BMI: body mass index; ST: skinfold thicknesses; BIA: bioelectrical impedance analysis. Results expressed as mean ± standard deviation. *p*-Value calculated through Student's t-test and considering the differences between males and females.

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Table III. Pearson's correlation coefficient between age and anthropometric parameters and whole-body skeletal muscle mass obtained by bioelectrical impedance analysis

Pearson's correlation coefficient in relation to SMM obtained by BIA *(n* = 499)	***r***
Age (years)	0.043
Body weight (kg)	0.816
Height (m)	0.833
Corrected arm circumference*	0.878
Corrected thigh circumference†	0.792
Corrected calf circumference‡	0.806
Corrected arm circumference adjusted to three-dimensionality	0.910
Corrected thigh circumference adjusted to three-dimensionality	0.864
Corrected calf circumference adjusted to three-dimensionality	0.880

*Arm circumference corrected by triceps skinfold thickness; †Thigh circumference corrected by thigh skinfold thickness; ‡Calf circumference corrected by calf skinfold thickness.

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Table IV. Pearson's correlation coefficient between whole-body skeletal muscle mass obtained by anthropometric equations, new model and models already existing in the scientific literature, and whole-body skeletal muscle mass obtained by BIA

Pearson correlation coefficient between SMM by BIA and anthropometric equations		
	r	***n***
Heymsfield et al. (1982) (A) (kg)	0.900	499
*Doupe et al. (1997) (B) (kg)**	0.914	190
Martin et al. (1990) (C) (kg)	0.936	499
Lee et al. (2000) (D) (kg)	0.949	499
Lee et al. (2000) (E) (kg)	0.936	499
Kawakami et al. (2021) (F) (kg)	0.931	499
New anthropometric equation (kg)	0.977	499

BIA: bioelectrical impedance analysis; SMM: whole-body skeletal muscle mass, in kg. *Doupe et al.'s (1997) equation was compared only with the male sample (n = 190).

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Table V. Paired t-test between whole-body skeletal muscle mass obtained by anthropometric equations, new model and models already existing in the scientific literature, and whole-body skeletal muscle mass obtained by BIA

Paired t-test between the SMM values obtained by the equations and the SMM obtained by BIA				
	95 % CI			
	Lower	**Superior**	**t**	***p***
Heymsfield et al. (1982) (A)	-3.46	-2.68	-15.37	< 0.001
Doupe et al. (1997) (B)	3.28	4.30	14.71	< 0.001
Martin et al. (1990) (C)	2.74	3.31	21.07	< 0.001
Lee et al. (2000) (D)	-2.66	-2.26	-24.41	< 0.001
Lee et al. (2000) (E)	-1.32	-0.88	-9.75	< 0.001
Kawakami et al. (2021) (F)	-6.43	-5.85	-42.04	< 0.001
New anthropometric equation	-0.08	0.19	0.79	0.426

BIA: bioelectrical impedance analysis; SMM: whole-body skeletal muscle mass, in kg; 95 % CI: 95 % confidence interval.

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Table VI. Interclass correlation coefficient of predictive anthropometric equations already existing in the literature and of the new predictive model

Interclass correlation coefficient of SMM obtained by BIA and anthropometric equations			
		95 % CI	
	ICC	**Lower**	**Superior**
Heymsfield et al. (1982) (A)	0.894	0.699	0.947
Doupe et al. (1997) (B)	0.852	0.179	0.946
Martin et al. (1990) (C)	0.922	0.577	0.970
Lee et al. (2000) (D)	0.941	0.523	0.980
Lee et al. (2000) (E)	0.957	0.928	0.972
Kawakami et al. (2021) (F)	0.718	-0.208	0.914
New model of anthropometric equation	0.988	0.986	0.990

BIA: bioelectrical impedance analysis; SMM: whole-body skeletal muscle mass, in kg; 95 % CI: 95 % confidence interval.

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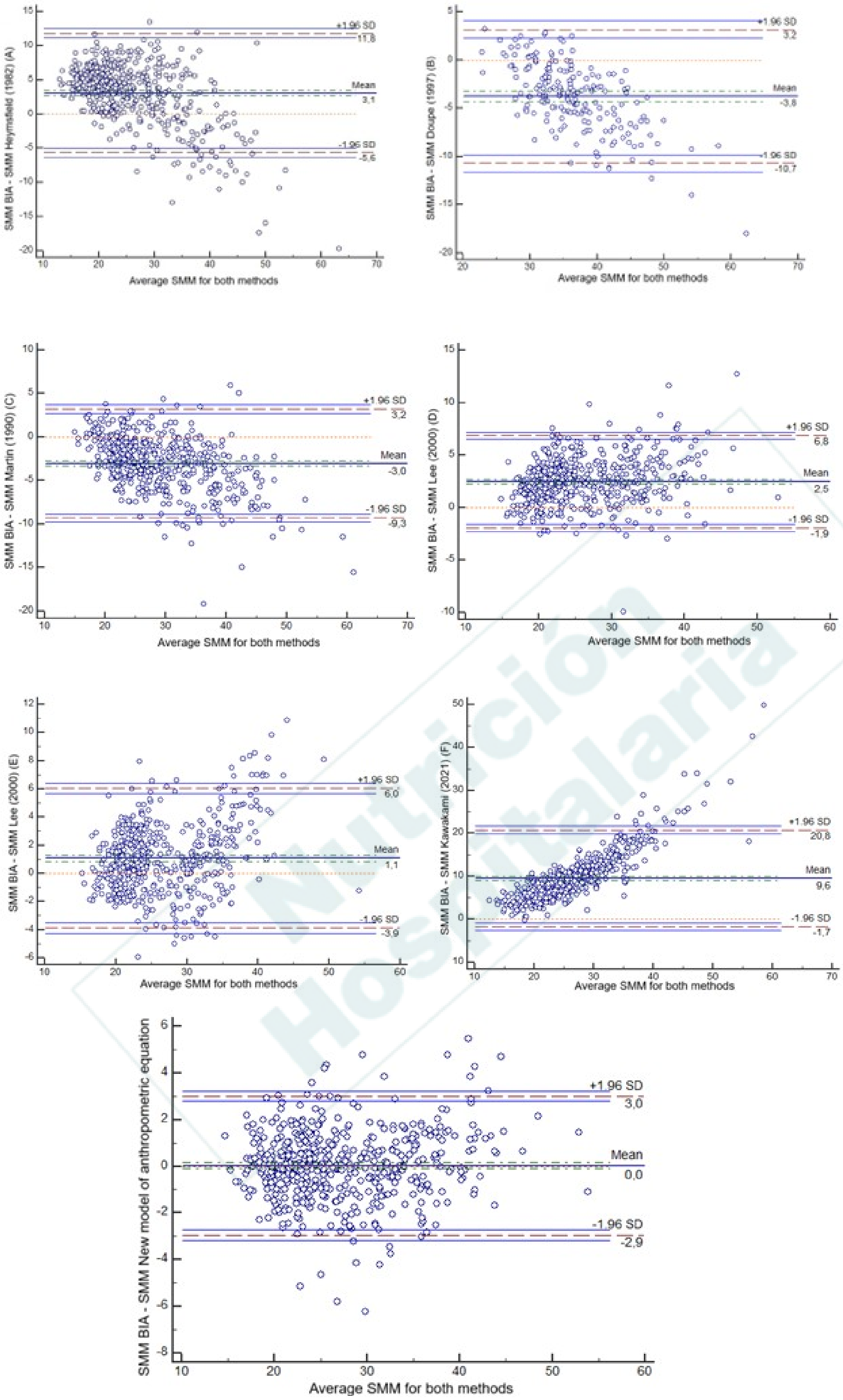

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Figure 1. Bland and Altman plot for comparison between muscle mass obtained by anthropometric equations and by BIA (SMM: whole-body skeletal muscle mass, in kg; BIA: bioelectrical impedance analysis).