FOOD AND
NUTRITION IN
COLLECTIVE HEALTH

DOI: 10.12957/demetra.2019.35793

DEMETRA
Alimentação, Nutrição & Saúde

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Analysis of weight and height estimation formulas in young adults

Análise de fórmulas de estimativa de peso e altura em adultos jovens

Abstract

Introduction: Anthropometric measurements are widely used because they are simple, non-invasive and with fast results. Weight and height can be obtained by measurement or by estimation formulas. Few studies have been evaluated the similarity of the values obtained through the formulas of estimation with the values measured. ***Aim:*** Compare the weight and height measured with the resultant values by estimation formulas, in order to analyze which of them presents better results in brazilian adults. ***Method:*** This is a cross-sectional study carried out with 100 students between 19 and 35 years of age. The correlation and the concordance between weight and height measured and the estimated values were analyzed. ***Results:*** The weight estimation formulas of Chumlea et al. and formula C of Rabito et al. presented a very strong correlation, only Chumlea et al. had good agreement and homogeneity. Formulas A and B of Rabito et al. presented strong correlation, good agreement and heterogeneity. The height estimation formulas of Chumlea et al. and Rabito et al. obtained a strong correlation with the measured height and heterogeneity, being that of Rabito et al. presented good agreement. *Conclusion:* There was good correlation between all the formulas and the measures evaluated. However, only the height estimation formula of Rabito et al., those of weight estimation by Chumlea et al. and Formulas A and B of Rabito et al. presented good agreement.

Keywords: Anthropometry. Body weight. Body height.

Resumo

Introdução: As medidas antropométricas são muito utilizadas por serem técnicas simples, pouco invasivas e com resultados rápidos. O peso e a altura podem ser obtidos por meio da aferição ou de fórmulas de estimativa. Poucos estudos têm sido realizados para avaliar a similaridade dos valores obtidos por meio das fórmulas de estimativa e dos valores aferidos. *Objetivo:* Comparar o peso e a altura aferidos com os valores encontrados nas fórmulas de estimativa, a fim de analisar quais apresentam melhores resultados em adultos brasileiros. *Método:* Trata-se de um estudo transversal, realizado com 100 estudantes entre 19 e 35 anos. Analisaram-se a correlação e a concordância entre os valores de peso e altura aferidos e os valores estimados. *Resultados:* As fórmulas de estimativa de peso de Chumlea et al. e a fórmula C de Rabito et al. apresentaram correlação muito forte, sendo que apenas a de Chumlea et al. teve boa concordância e homogeneidade. As fórmulas A e B de Rabito et al. apresentaram forte correlação, boa concordância e heterogeneidade. As fórmulas de estimativa de altura de Chumlea et al. e Rabito et al. obtiveram forte correlação com a altura aferida e heterogeneidade, sendo que a de Rabito et al. apresentou boa concordância. *Conclusão:* Houve boa correlação entre todas as fórmulas e as medidas aferidas. No entanto, apenas a fórmula de estimativa de altura de Rabito et al., as de estimativa de peso de Chumlea et al. e as fórmulas A e B de Rabito et al. apresentaram boa concordância.

Palavras-chave: Antropometria. Peso corporal. Estatura.

INTRODUCTION

Anthropometry is the scientific study of the measurements and proportions of the human body, which results in an adequate anthropometric classification for each phase of an individual's life.[1,2] Because individuals present different body types and body composition, anthropometry is essential in performing body assessment. Depending on the situation and the objective, a variety of measurements are applied for a better assessment. In clinical practice, anthropometric measurements are widely used because they are simple, inexpensive, and adaptable to different workplaces as they can be performed using portable equipment and have fast results.[3,4]

Nutritional assessment, weight, and height, which are measured using techniques that are easy to understand and perform, are the most evaluated anthropometric measures. Weight represents the sum of all components present in the body, and its changes are considered a consequence of the imbalance between the value of the individual's total energy expenditure and the caloric amount that he/she actually consumed.[5,6] Height is related to the intrinsic and extrinsic factors and reflects the relationship between an individual's genetic factors and daily living conditions, such as his/her health and socioeconomic status from gestation to the end of the growth spurt phase.[7-9]

Weight and height values can be obtained by either measurements or estimation formulas.[3,10] Measurements of weight and height are performed on individuals who are able to walk or lie down. In performing these measurements, a balance and an anthropometer are used.

The estimation formulas use different body measurements to calculate the weight and height of individuals. They were developed to be able to perform the body assessment of bedridden or unable-to-stand individuals.[10-12]

The most commonly used estimation formulas are those of Chumlea et al.[13] and Chumlea et al.[14] to estimate weight and height, respectively. These were developed from a population of adult and elderly Americans. Since Rabito et al.[15] believed that the formulas of Chumlea et al. could not be applied in the Brazilian population, they conducted a study with Brazilian adults and proposed formulas to estimate their weight and height. In 2008, the authors[16] conducted another study, also with Brazilian adults, to validate the estimation formulas developed in 2006.

Considering the information presented above, new studies that confirm the applicability of the anthropometric estimation formulas for weight and height are notably required. This requirement is due to the fact that the studies used as reference have been published for a long time and the main reference was conducted in the North American population, which leads us to reconsider that these formulas may not be applied in the Brazilian population.

The present study aimed to compare the weight and height measured with the estimation formula values to analyze which of them shows the highest agreement.

METHODS

This was a cross-sectional study of a continuous character named "Nutritional Diagnosis in Young Adults: Nutrition Students of the Universidade Federal de Ouro Preto (Federal University of Ouro Preto), MG," with the aim of elaborating the historical series of nutritional evaluation performed each semester between 2014 and 2017.

The sample was composed of 100 students, 93 women and seven men, aged between 19 and 35 years. Explanations about the project were given to the participants, and their questions were answered. All participants provided signed informed consent for inclusion in the study. The inclusion criteria were as follows: participants should have enrolled in the Nutrition course, have studied Nutrition Assessment I, and have signed the informed consent.

Weight and height values were calculated using the estimation formulas to measure calf circumference (CC), knee height (KH), arm circumference (AC), subscapular skinfold (SSSF), arm length (AL), and waist circumference (WC), considering 1 for men and 2 for women. Sample characterization was performed using the absolute and relative frequency of sex and the mean and standard deviation of age.

The weight was measured using a calibrated digital balance Welmy®, with a capacity of 150 kg and a precision of 100 g. The students wore as minimum clothing as possible and stood with their bodies straight and their arms freely hanging in the sides of their body.[1] The height was measured using an anthropometer with the digital scale, Welmy®, expressed in millimeter, with a precision of 1 mm in all extensions. The students stood with their arms freely hanging in the sides of their body; head held high, looking at a fixed point at eye level; and feet joined at right angles to the legs. The heels, scapulae, and buttocks were positioned in contact with the anthropometer's vertical backboard.[1] To measure AC, students kept their nondominant arm flexed at an angle of 90° to measure the distance between the prominence of the olecranon and the acromion, and then, the midpoint was marked. Subsequently, the students relaxed their arm, and the measurement was made by passing the arm with the tape measure at the midpoint.[1] During CC measurement, students had their legs flexed at 90°, and then the tape was passed in the largest leg circumference.[1] In the WC measurement, the tape was passed at the midpoint between the last rib and the iliac crest of the students. At the time of the measurement, students stood straight and looked at a fixed point at eye level.[17] In the AL measurement, students had their arms relaxed, and the evaluator measured their two fingers below the lower angle of the scapula in diagonal measurement.[1] KH was measured by

measuring the medial part of the patella to the sole of the foot, with the students sitting at a 90° angle between the foot and the leg.[14] The SSSF was measured with the students' arm abducted, forming a 90° angle with the trunk, and the tape measured the distance between the tip of the middle finger and the spine.[18]

In this study, the following weight estimation formulas were used:

Chumlea et al.[13]:

Women: Weight (kg):(1.27 × CC)+(0.87×KH)+(0.98 ×AC)+(0.4 ×SSSF)-62.35

Men: Weight (kg):(0.98×CC)+(1.16 ×KH)+(1.73×AC)+(0.37 ×SSSF)-81.69

Rabito et al.[16]:

Formula A: Weight (kg):(0.5030 ×AC)+(0.5634 ×WC)+(1.318 ×CC)+(0.0339 ×SSSF)-43.156

Formula B: Weight (kg):(0.4808 ×AC)+(0.5646 ×WC)+(1.316 ×CC)-42.2450

Formula C: Weight (kg):(0.5759×AC)+(0.5263×WC)+(1.2452×CC)-(4.8689×Sex)-32.9241*

*1 for men and 2 for women

Moreover, the following height estimation formulas were used:

Chumlea et al.[14]:

White women: Height (cm):70.25+(1.87×KH)-(0.06×age)

Black women: Height (cm):68.1+(1.86 ×KH)-(0.06 ×age)

White men: Height (cm):71.85+(1.88 ×KH)

Black men: Height (cm):73.42+(1.79 ×KH)

Rabito et al.[16]:

Height (cm):63.525-(3.237×Sex)-(0.06904 ×age)+(1.293 ×SSSF)*

*1 for men and 2 for women

Sample characterization was performed using the absolute and relative frequency of sex and the mean and standard deviation of age. For nonparametric data, such as measured weight, estimated weight using the formulas of Chumlea et al.,[13] estimated weight using the formulas of Rabito et al. al.,[16] and the estimated height using the formulas of Rabito et al.,[16] the medians, 25th percentile, and 75th percentile were calculated. For parametric values, such as height and height estimated using the formulas of Chumlea et al.,[14] the mean and standard deviations were calculated. Student's t-test was performed to verify the relationship between the measured and estimated weight and height. The Bland-Altman test was used to analyze the agreement.[19] The correlations were tested using the Pearson correlation coefficient for the parametric values and the Spearman correlation coefficient for the nonparametric values after checking for normality using the Kolmogorov-Smirnov test.

Correlations were classified as "very strong" when p-value ≥ 0.9 and "strong" when 0.89> p-value ≥ 0.7.[20] To analyze the homogeneous or heterogeneous distribution of Bland-Altman agreement, a linear regression analysis was performed. Statistical analyses were performed using Predictive Analytics Software 18.0 Statistics software, and for all the tests, p-value ≤ 0.05 was considered statistically significant.

This study was conducted at the Laboratório de Avaliação Nutricional da Escola de Nutrição (Nutrition Evaluation Laboratory of the School of Nutrition) and was approved by the Comitê de Ética em Pesquisa da Universidade Federal de Ouro Preto (Research Ethics Committee of the Federal University of Ouro Preto), MG, registered under CAAE:51660215.0000.5150, nº 1.464.262.

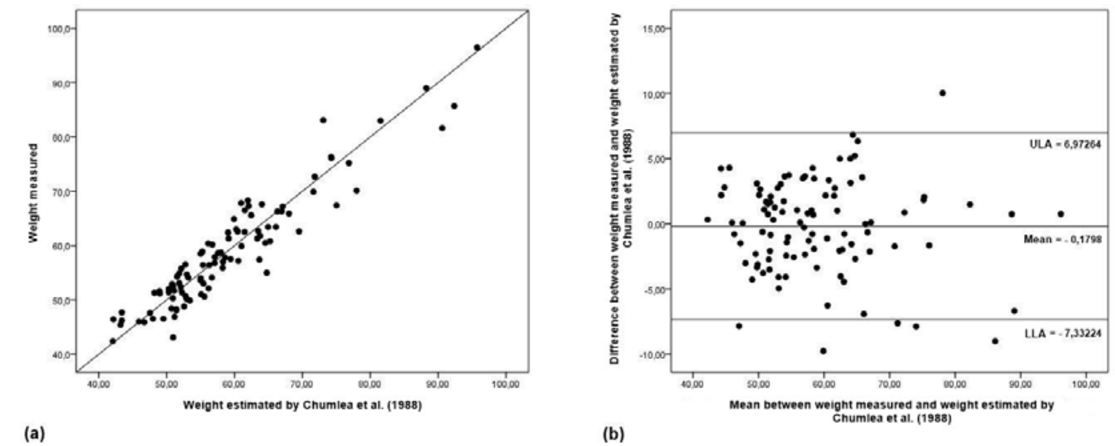
RESULTS

The study was composed of 100 students, where 93% were women. The mean age among these students was 22.27 ± 2.65 years old, with the age of 19 and 35 years as the minimum and maximum age, respectively.

The weight medians were 56.90 kg (51.40–63.40 kg) for the measured weight, 56.70 kg (51.46–63.74 kg) for the formula of Chumlea et al.,[13] 57.20 kg (52.31–64.92 kg) for formula A of Rabito et al.,[16] 57.16 kg (52.48–64.54 kg) for Formula B of Rabito et al.,[16] and 54.05 kg (30–61.40 kg) for Formula C of Rabito et al..[16] In relation to height values, the mean values were 163.98 cm (± 0.07) for the measured heights and 161.96 cm (± 5.51) for the heights estimated using the formulas of Chumlea et al.,[14] being the median height estimate of 162,99 cm (160,14–166,71 cm) using the formulas of Rabito et al..[14]

When comparing the measured weight with the estimated weight using the formulas of Chumlea et al.,[13] a very strong correlation (correlation coefficient, 0.926) (Figure 1a), a good agreement using the Bland-Altman test (Figure 1b) (p-value, 0.616), and a spatial distribution of homogeneous points (p-value, 0.475) (Figure 1b) were observed.

Figure 1. Correlation analysis (a) and agreement analysis (b) between measured and estimated weight using the formulas of Chumlea et al. (1988). ULA, upper limit of agreement; LLA, lower limit of agreement. Data source: Study data.



Considering that there are three formulas of weight estimation created by Rabito et al.,[16] the correlation coefficients, the levels of agreement, and the spatial distributions between them and individually can be simultaneously analyzed.

When comparing the measured weight with the formulas of estimation of Rabito et al.,[16] formula A presented a strong correlation (correlation coefficient, 0.894) (Figure 2a), good agreement (p-value, 0.529), and a heterogeneous spatial distribution of points (Figure 2b). Moreover, formula B had a strong correlation (correlation coefficient, 0.894) (Figure 3a), good agreement (p-value, 0.529), and heterogeneous point distribution (Figure 3b). Different from the previous formulas, formula C showed very strong correlation (correlation factor, 0.903) (Figure 4a), did not have good agreement (p-value ≤ 0.001), and heterogeneous distribution of points (Figure 4b).

Thus, among the weight estimation formulas proposed by Rabito et al.,[16] the formula that showed the best correlation coefficient was formula C (Figure 4a), with a very strong correlation (correlation coefficient, 0.903), and formula B (Figure 3b) presented the best agreement (p-value, 0.864). Both formulas presented heterogeneous spatial distribution of points.

Figure 2. Correlation analysis (a) and agreement analysis (b) between measured and estimated weight for formula A by Rabito et al. (2008). ULA, upper limit of agreement; LLA, lower limit of agreement. Data source: Study data.

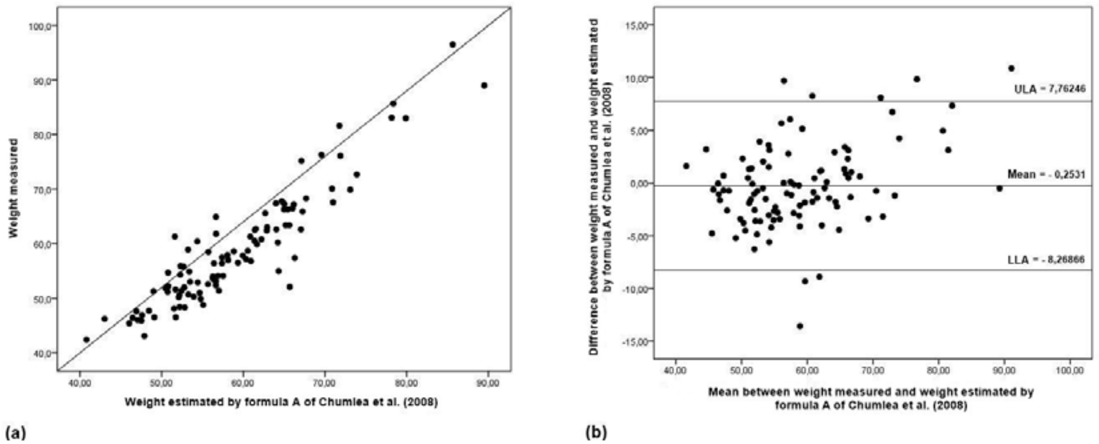


Figure 3. Correlation analysis (a) and agreement analysis (b) between measured and estimated weight for formula B by Rabito et al. (2008). ULA, upper limit of agreement; LLA, lower limit of agreement. Data source: Study data.

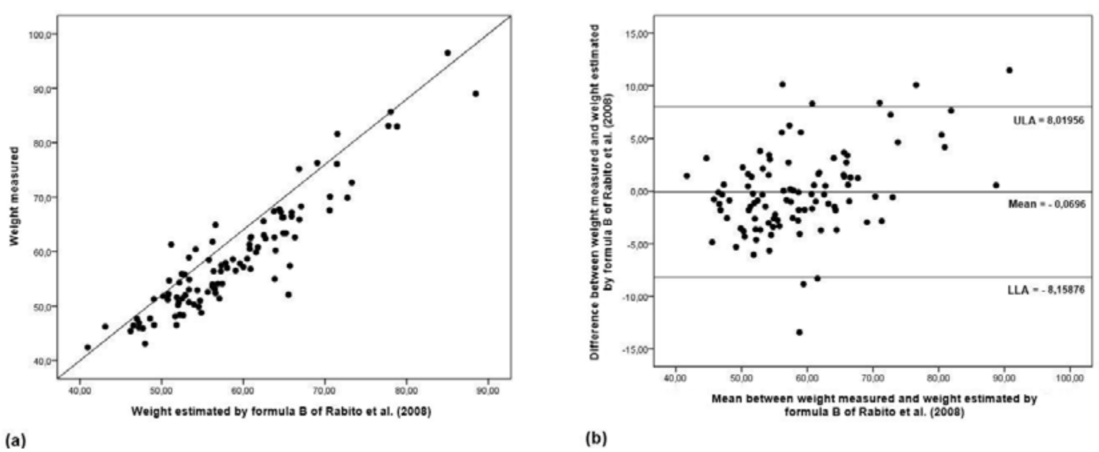
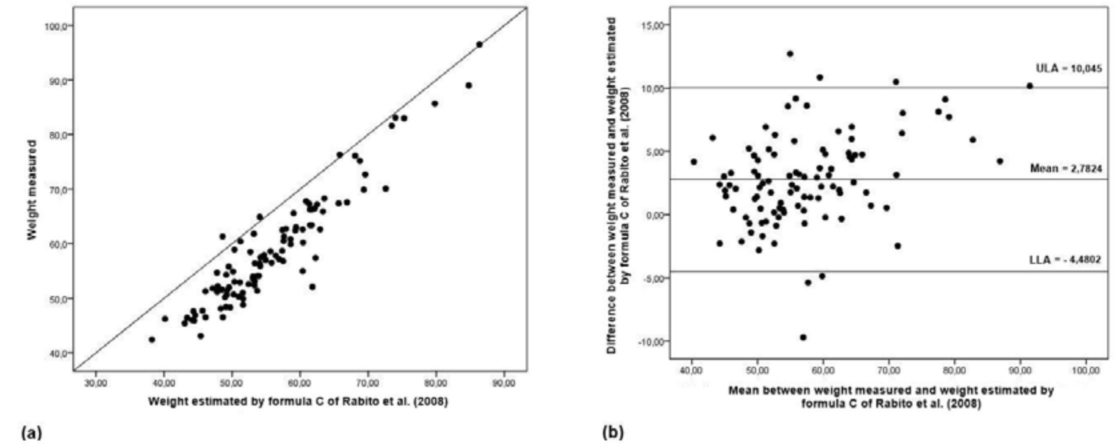
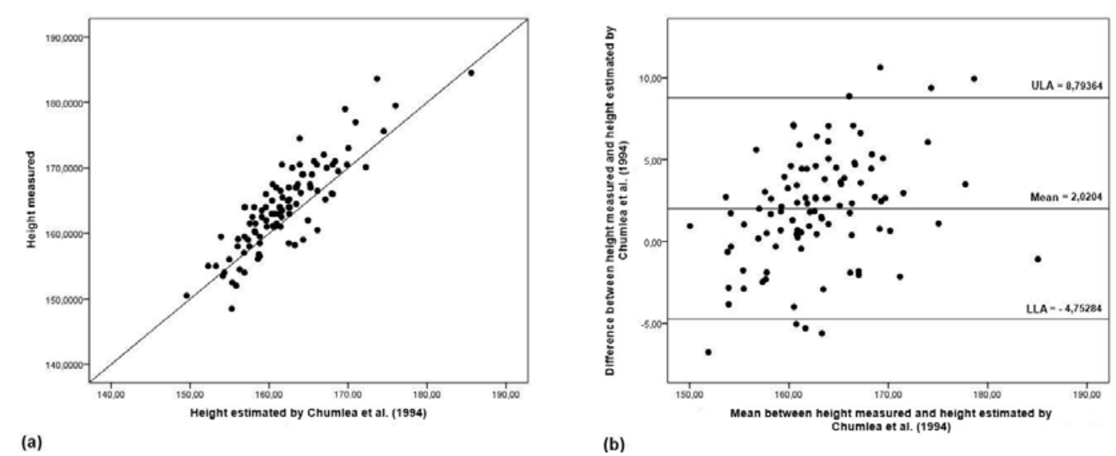


Figure 4. Correlation analysis (a) and agreement analysis (b) between measured and estimated weight for formula C by Rabito et al. (2008). ULA, upper limit of agreement; LLA, lower limit of agreement. Data source: Study data.



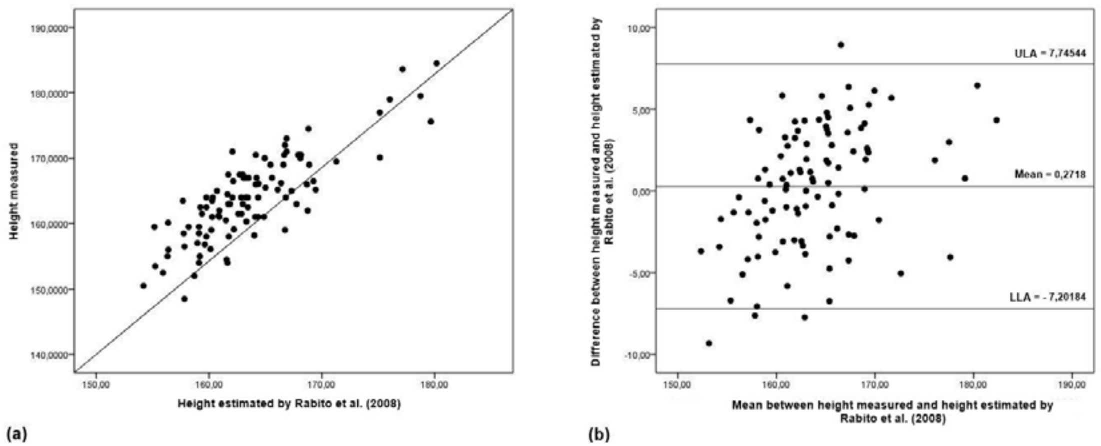
When the measured height and height estimated using the formulas of Chumlea et al.[14] were analyzed, a strong correlation was observed (correlation coefficient, 0.864) (Figure 5a). However, there was no good agreement (Figure 5b) between these measures, since the mean was not close to zero and was statistically significant (p-value ≤ 0.001). There was a heterogeneous spatial distribution of points (p-value ≤ 0.001).

Figure 5. Correlation analysis (a) and agreement analysis (b) between measured and estimated height by Chumlea et al. (1994). ULA, upper limit of agreement; LLA, lower limit of agreement. Data source: Study data.



When the measured height is compared to the height estimated using the formulas of Rabito et al.,[16] a strong correlation (correlation coefficient, 0.783) (Figure 6a) and good agreement (p-value, 0.469) (Figure 6b) were observed, but there was a heterogeneous spatial distribution of points (p-value ≤ 0.001).

Figure 6. Correlation analysis (a) and agreement analysis (b) between measured and estimated height by Rabito et al. (2008). ULA, upper limit of agreement; LLA, lower limit of agreement. Data source: Study data.



DISCUSSION

Among the estimated measures, the weight estimation formula of Chumlea et al.,[13] the weight estimation formulas A and B of Rabito et al.,[16] and the height estimation formula of Rabito et al.[16] showed good agreement with the measured values.

Using the Spearman correlation coefficient, a strong correlation between the measured weight and the weights estimated using the formulas of Chumlea et al.[13] and Rabito et al.[16] was observed. The results of previous studies by Rodrigues et al.[21] and Lima et al.[22] in the Brazilian population were similar to the present study.

Rodrigues et al.[21] conducted a study in 100 individuals aged between 20 and 59 years and found a correlation of 0.92 between the measured weight and the estimated weight using the formulas of Chumlea et al.[13] A good correlation (correlation coefficient, 0.837) was also noted using the formula of Chumlea et al.[13] in the study conducted by Lima et al.[22] in 409 elderly individuals. The same study showed a strong correlation between the measured weight and the formulas of Rabito et al.,[16] with a correlation coefficient of 0.837 for formula A, 0.819 for formula B, and 0.835 for formula C. The best results of estimation of weight were obtained using the

formula of Chumlea et al.[13] because it had very strong correlation, good agreement, and a homogeneous spatial distribution.

To analyze the correlation between the height measured with the formulas of Rabito et al.[16] and Chumlea et al.,[14] both estimation formulas presented a good correlation, and the formulas of Rabito et al.[16] presented better agreement (p-value, 0.469) compared to the formulas of Chumlea et al.[14] (p-value ≤ 0.001). Contrary to that found by Campos et al.,[23] the correlation of the measured height in relation to the height estimated using the formulas of Chumlea et al.14 was considered moderate (correlation coefficient, 0.5967) and had a good agreement (p: 0.72). The study by Campos et al.[23] was realized in Jaú with cancer patients older than 18 years. Rezende et al.[24] conducted a study in 98 men aged 20 and 60 years and found a strong correlation (correlation coefficient, 0.828) between the estimation formula of Chumlea et al.[14] and the height measured. In this study, it was noted that the height estimation formula of Rabito et al.[16] provided values closer to those measured.

Although most of the cited studies evaluated the formulas only in relation to the correlation coefficient, it is also important to evaluate the agreement between values.[25,26] Thus, for a correct comparison between methods, or between the estimation method and the standard method, it is necessary to analyze the correlation coefficient and the agreement (Bland-Altman test), taking into account the mean and the confidence interval.[27]

CONCLUSION

When comparing the formulas of weight estimates with the measured values, it is noted that the formula of Chumlea et al.[13] and formula C of Rabito et al.[16] underestimated the measured values, while formulas A and B of Rabito et al.[16] overestimated these values. However, it is worth mentioning that all the formulas presented a strong correlation. Regarding the height estimation formulas, all of the formulas underestimated the measured height, but as in the formulas of weight estimation, they presented a strong correlation.

Considering all the formulas evaluated, it was observed that the best formula for weight was that of Chumlea et al.[14] because it had a very strong correlation, good agreement, and homogeneity. In relation to the height formulas evaluated, the one that presented the best results was that of Rabito et al.[16] because of its strong correlation and good agreement.

We can conclude that due to a relatively small number of studies in the Brazilian population, it is still not possible to define an estimation formula as the standard. Further studies are needed to analyze these formulas in different population groups.

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Contributors

Rodrigues RMF worked at all stages from the conception of the study until the revision of the final version of the article. Fajardo VC worked at all stages from the design of the study until the revision of the final version of the article. Nimer M worked at all stages from the conception of the study until the revision of the final version of the article.

Conflict of Interest: The authors declare no conflicts of interest.

Received: July 06, 2018
Reviewed: March 27, 2019
Accepted: May 07, 2019