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Equation of height estimation from knee height: Performance in the composition of body adiposity INDICES in older adults

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S U M M A R Y

Aim: To propose an equation to estimate height and evaluate it's performance in the composition of adiposity indicators in community-dwelling older adults in Brazil.
Methods: It is a cross-sectional study with 675 community-dwelling older adults (≥60 anos). Interviews and anthropometric measurements were taken at subjects' homes. Body mass index (BMI), body adiposity index (BAI), waist height ratio (WHR), and conicity index (CI) were calculated. The height estimation equation was obtained by multiple linear regression. Concordance between height and the indicators measured and estimated was evaluated by the intraclass correlation coefficient (ICC) and Cohen's Kappa and Weighted Kappa indexes. Concordance was also evaluated by the Bland and Altman graphical approach.
Results: Equations of height estimation composed of knee height, sex, and schooling were proposed and stratified by age group (60−74 years and ≥75 years). In both age groups, almost perfect agreement (ICC ≥ 0.915 and Kappa ≥0.81) was found between height and adiposity indicators estimated and measured.
Conclusion: The equation proposed is suitable to estimate height of the older adults, and can be a valuable tool for the evaluation of the nutritional status of Brazilian older adults in the community.

1. Introduction

The process of population aging is accelerating in developing countries such as Brazil [1]. Projections suggest that in 2070 the proportion of the Brazilian older adults population will be higher than in several developed countries in Europe and North America, besides Australia and Japan [2]. In addition, it is clear that an expressive proportion of individuals aged 80 years or more present greater functional dependence [1,3]. At the same time, the scenario of increasing prevalence of chronic noncommunicable diseases (CNCD) stands out, including those related to nutrition [4]. In this context, the assessment of nutritional status is essential for the monitoring of health conditions and control of CNCDs in the older population [5].

Several physiological changes that take place in the aging process influence the nutritional and health status of individuals [6,7]. Body changes stand out among them, in which there is a reduction in height, which may be caused by the flattening of the plantar arch of feet and intervertebral discs, by reduction of muscle mass and strength and bone mineral density, or due to the arching of the lower limbs [8].

Height is used to determine important indicators of nutritional status, as well as to calculate drug doses and energy needs [9]. Thus, the reduction in height associated with the aging process, as well as the difficulty of measuring it in older persons, due to amputations and

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changes in posture and ambulation, show the need for greater attention to this anthropometric parameter among the older adults [7].

Viable methods to measure height have been proposed such as equations to estimate height from the knee height because this measure is not influenced by the aging process [10,11]. However, we need equations specific for the Brazilian population since the equations proposed for populations of other countries do not take its miscegenation into consideration [12]. Moreover, few studies have addressed the proposition and validation of equations for height estimation of the Brazilian older adults population [11,13,14]. From the foregoing, therefore, the study aims to develop an equation to estimate height and evaluate its performance in the composition of body adiposity indicators in older adults.

2. Methods

2.1. Design and study population

This cross-sectional study is part of the epidemiological research project "Health conditions, nutritional status, and drug use by older adults people in the city of Viçosa (Minas Gerais): a population-based survey" carried out in from 2009 to 2011.

A total of 675 community-dwelling older adults ($\geq$60 years old) selected by simple random sampling, were studied in the municipality of Viçosa (Minas Gerais). Details on the sample calculation are described in the statistical analysis section.

2.2. Data collection

Interviews and anthropometric evaluation were carried out in the participants' homes. A semi-structured questionnaire for sociodemographic information was used in the interview with pre-coded and multiple-choice questions.

For anthropometric measurements, weight was measured using a portable digital electronic scale, with maximum capacity of 199.95 kg and precision of 50 g. Height was measured with a portable stadiometer with a wall extension of 2.13 m, divided in centimeters and subdivided in millimeters. Weight and height measuring followed the protocols of Jelliffe (1968) [15] and the World Health Organization (1995) [16].

Waist and hip circumferences were measured using a flexible, inelastic measuring tape. Waist circumference was measured at the midpoint between the last costal arch and the iliac crest in the horizontal plane [16].

Hip circumference was measured at the largest perimeter at the gluteal level [16]. The knee height was measured on the left leg, in the position forming a 90° angle with the knee and ankle [10]. An anthropometer with a fixed ruler and sensitivity of 0.1 cm, consisting of a fixed part and a movable part, placed on the plantar surface of the left foot and on the kneecap, respectively.

Body mass index (BMI) was calculated based on the ratio body weight (in kilograms) and the height (in meters squared) - kg/m^2. WHR was calculated by dividing the waist circumference (cm) by the body height (cm). BAI and CI were calculated by the following equations, respectively:

$$\mathrm{BAI} = \frac{hip\ circumference\ (cm)}{height\ (m) x \sqrt{height}(m)} - 18$$

$$\mathrm{CI} = \frac{waist\ circumference\ (m)}{0.109\sqrt{weight\ (kg)/height\ (m)}}$$

These indicators were calculated with height measured and height estimated by the equation developed.

2.3. Study variables

The variables evaluated were height measured and height estimated (centimeter), sex (male and female), age (years and age group), schooling (never studied, up to 5 years of study, or more than 5 years of study), color/race, according to the Brazilian Institute of Geography and Statistics classification (white, black, or pardo) [17], knee height (KH) (centimeter), and nutritional status indicators such as BMI (kg/m^2), WHR, BAI, and CI.

The indicators were categorized as follows: BMI (low weight, eutrophy, preobesity, obesity) [18] and WHR (without cardiometabolic risk or with cardiometabolic risk) [19]. BAI and CI were divided into tertiles because we found no consensus in the literature regarding the best cutoff point for the older adults. BAI was classified as follows: 1st tertile: 0–28.3903; 2nd tertile: 28.3904–33.7367; 3rd tertile: $\geq$ 33.7368 and for CI: 1st tertile: 0–1.3165; 2nd tertile: 1.3166–1.3772; and 3rd tertile: $\geq$ 1.3773).

2.4. Ethical issues

The present study was carried out in accordance with the guidelines proposed by the Declaration of Helsinki. The study protocol was reviewed and approved by human research ethics committee of the Federal University of Viçosa (approval number: 027/2008).

2.5. Data analysis

The sample size was calculated considering a reference population composed of 7980 older adults, 95% confidence level, an estimated prevalence of multiple outcomes of 50%, and tolerated error of 4%. The minimum final sample should be composed of 714 older adults, plus 20% to cover possible losses, totaling 858 subjects to be studied. After excluding the losses (refusal to participate, change of address or death), 796 older adults were effectively interviewed. For the present study, 675 older adults, who had information about the height and knee height, were included in the sample.

A descriptive analysis of the data was performed, with frequency distribution for qualitative variables and estimates of central tendency and dispersion for quantitative variables. Then, to test whether the variables are normally distributed, we used the Kolmogorov Smirnov test, the graphical analysis (histograms, boxplot, and QQ plot normal, the asymmetry coefficients (a symmetrical distribution was assumed when the absolute value of the asymmetry coefficient was less than twice its standard error), and kurtosis (considering normal distribution the curves classified as mesokurtic) [20].

To propose the height estimation equation, first, we conducted a simple linear regression analysis, considering the height measured as the dependent variable and the height estimated from the KH and sociodemographic variables as independent variables. Subsequently, we performed the multiple linear regression analysis.

The selection of the final model was based on the non-automatic backward method, in which the variables with p value $\leq$ 0.20 in the simple regression analysis were included in the model. Then, the variable with the highest p-value was removed, and this procedure was repeated until all the independent variables of the model had p-value $\leq$0.05. Additionally, interactions between KH and sociodemographic variables were tested. The statistical significance of the final model was evaluated by the overall F test and the goodness of fit by the coefficient of determination (R^2). Residuals were tested for normality, homoscedasticity, linearity, and independence. The existence of outliers and influential points was assessed by the Cook's distance and DFBETAS estimates, and values smaller or very close to 1 were considered satisfactory. Multicollinearity among the variables included in the model was evaluated by calculating the Variance Inflation Factor (VIF), with values below 10 indicating absence of collinearity [20].

For the analysis of the concordance between the height measured and height estimated by the equation proposed, as well as among adiposity indicators calculated from the two heights (measured and estimated), we estimated intraclass correlation coefficients (ICC), Cohen's Kappa (for binary variables) and Weighted Kappa (for ordinal variables) indexes. Concordance was classified as proposed by Landis and Koch (1977): a) almost perfect: 0.81 to 1.00; b) substantial: 0.61 to 0.80; c) moderate: 0.41 to 0.60; d) fair: 0.21 to 0.40; e) slight: 0.00 to 0.20 and f) poor: less than 0.00 [21].

Additionally, the graphic approach proposed by Bland and Altman (1995) [22] was used. This graphical analysis was complemented by an analysis of the linear regression of the mean of the measures onto the difference, when it is possible to evaluate the existence of fixed bias and/or proportional bias [22,23]. In the latter case, it means that the difference between the two measures of height is proportional to the size of the measure.

All analyses considered the significance level alpha = 0.05. The software applications used to analyze the data were free software R, version 3.1.2 (R Development Core Team, Vienna, Austria), and MedCalc version 15.8.

3. Results

A total of 675 subjects were evaluated, with 50.8% (n = 343) of males. The age of the participants ranged from 62 to 96 years, with mean of 71.64 years (sd = 7.26 years) for men and 71.89 years (sd = 7.21 years) for women. The majority of the older adults completed the initial grades of elementary school (64.2%). Regarding race/color, 70.3% of them were white (Table 1).

The simple linear regression analysis showed that only the association between race/color and height measured did not show $p \leq 0.20$ and was not included in the multiple model. Multiple regression analysis revealed the presence of interaction between the variables knee height and age. Thus, two equations of height estimation were proposed, one for the age group 60–74 years and another for age group ≥75 years, each composed by the variables gender, knee height, and schooling (Table 2).

Both models proposed for the height estimation equation had high coefficient of determination (R^2): 87.0% for the model proposed for the group 60–74 years and 84.0% for the group ≥ 75 years (Table 2). The height measured ranged from 136.8 cm to 188.2 cm.

Table 1
Sample distribution according to social and demographic variables (n = 675).

Variable	N	%
Sex		
Male	343	50.8
Female	332	49.2
Age group		
60–74 years	457	67.7
75 years and more	218	32.3
Schooling[a]		
Never studied	96	14.3
Up to 4 years of study	433	64.2
5 years of study and more	145	21.5
Race/color[b]		
White	461	70.3
Black	117	17.8
Pardo	78	11.9

Note.
[a] Data missing for 1 individual.
[b] Data missing for 19 individuals.

The concordance between the height measured and height estimated by the proposed equation, for both age groups, was almost perfect (Table 3).

The graphical analysis showed that the mean of height estimated by the proposed equation was not significantly different from the height measured for both age groups: mean difference of 2.49 × 10-16 cm and p value = 0.99 for the older adults with 60–74 years; mean difference of −2.77 × 10-9 cm and p value = 0.99 for the older adults with 75 years or older. Interestingly, the proportional bias was observed in the two age groups, with overestimation of height among the taller older adults and underestimation of the same among the shorter older adults (Fig. 1).

The concordance analysis between the indicators of body adiposity calculated from the measured and estimated heights indicated, from the ICC, and Cohen's Kappa and Weighted Kappa Indexes, an almost perfect concordance level for all indicators in both age groups (Tables 3 and 4).

4. Discussion

In the present study, we develop an equation of height estimation from a small set of easily measurable variables with high predictive power, which reinforces the usefulness of recumbent measures in the evaluation of anthropometric indicators in older persons. Few studies proposed equations for estimating height in older population, using these measures. Given the scenario of population aging and the physiological and physical changes with advancing age, the use of accurate and precise height estimates[7] is of great importance, especially because it is a component of relevant nutritional status indicators [16,24].

In our study, the proposed equations were stratified by age group. This stratification was necessary due to the presence of significant interaction between knee height and age, suggesting that the prediction of height measured is different according to the participant's age. The criterion of stratification in the age groups 60–74 years and ≥75 years differentiated more properly the physiological characteristics of the older adults such as body composition, health conditions, disease profile, and functional capacity [25].

The equations proposed here showed a high predictive capacity, with determination coefficients of 87% for the age group 60–74 years and 84% for the age group ≥75 years. These coefficients of determination were higher than those of the equations proposed by Chumlea et al. (1985) [10] (R^2 = 0.67 for men and 0.65 for women), Chumlea and Guo (1992) [26] (R^2 = 0.59 for white women, 0.70 for black women, 0.68 for white men and 0.51 black men), Chumlea et al. (1998) [27] (R^2 = 0.69, 0.70, and 0.66 for white, black, and Mexican men, respectively, and 0.64, 0.63, and 0.65 for white, black, and Mexican women, respectively), Lera et al. (2005) [13] (R^2 = 0.69 for men and 0.58 for women), and Najas (1995) [11] (R^2 = 0.79 for men and 0.69 for women).

Although the coefficient of determination was slightly higher in the model for younger group, we found that the coefficient of regression for knee height was higher in the model for the group with the older individuals. This suggests that this measure has an important influence on the determination of height in older persons, especially in the older group, probably because of the greater difficulty in measuring height in this age group due to the physiological and physical changes occurring with aging [8].

Similar to the present study, other authors used the variables schooling, sex, age, and knee height in their equations of height estimation [10,11,13,14,26,27]. Schooling was used as an indicator of socioeconomic status, since there is consistent evidence about the association between lower socioeconomic position, worst opportunities for health care and impairments in height growth [28–30], which was also confirmed in our study. Since we do not have data

Table 2
Regression coefficients for the variables composing the equation of height estimation (n = 674).

	Intercept	Knee height	Age	Sex female	Schooling[a]		Race/color[b]	
					Up to 5 years of study	5 years of study and more	Black	Pardo
Simple Linear Regression								
B	158.90	2.46	−0.17	−12.87	2.92	7.32	−0.88	0.34
p value	0.000	0.000	0.001	0.000	0.003	0.000	0.347	0.755
R^2	0.00	0.81	0.02	0.51	0.06		0.00	
Multiple Linear Regression								
B	68.56	1.97	−0.08	−4.59	0.68	2.77	–	–
p value	0.000	0.000	0.000	0.000	0.073	0.000	–	–
R^2	0.86						–	–
p value for interaction with knee height	–	–	0.036	0.269	0.307		–	–
Multiple Linear Regression (Age group 60 to 74 years)								
B	65.41	1.93	–	−4.63	0.54	2.77	–	–
p value	0.000	0.000	–	0.000	0.268	0.000	–	–
R^2			0.87				–	–
Multiple Linear Regression (75 years or older)								
B	55.03	2.11	–	−4.55	0.92	2.68	–	–
p value	0.000	0.000	–	0.000	0.137	0.002	–	–
R^2			0.84				–	–

Note: R^2, Coefficient of determination. Reference category.
[a] Never studied.
[b] White.

Table 3
Concordance between height and body adiposity indicators measured and estimated by the equation of height estimation in older adults, according to age group (n = 674).

Variable	60–74 years			75 years or older		
	Mean (SD)	ICC	CI95%	Mean (SD)	ICC	CI95%
Height measured (cm)	159.46 (9.08)	0.932	0.919–0.943	157.71 (8.79)	0.915	0.891–0.934
Height estimated (cm)	159.46 (8.48)			157.71 (8.08)		
BMI with height measured (kg/m^2)	27.31 (5.06)	0.973	0.968–0.978	26.12 (4.80)	0.965	0.955–0.973
BMI with height estimated (kg/m^2)	27.28 (4.97)			26.09 (4.60)		
WHR with height measured	0.60 (0.08)	0.988	0.985–0.990	0.60 (0.08)	0.983	0.978–0.987
WHR with height estimated	0.60 (0.08)			0.60 (0.07)		
BAI with height measured	30.05 (6.59)	0.970	0.964–0.975	32.07 (6.79)	0.965	0.954–0.973
BAI with height estimated	31.97 (6.33)			32.00 (6.29)		
CI with height measured	1.34 (0.08)	0.982	0.978–0.985	1.36 (0.07)	0.975	0.968–0.981
CI with height estimated	1.34 (0.08)			1.36 (0.08)		

Note: SD, Standard deviation. ICC, Intraclass correlation coefficient. CI95%, 95% confidence interval. BMI: missing data for 2 older adults people aged 60–74 years and 3 for older adults aged 75 years or older; WHR: missing data for 4 older adults people aged 60–74 years and 1 for older adults aged 75 years or older; BAI: missing data for 3 older adults people aged 60–74 years and 1 for older adults people aged 75 years or older; CI: missing data for 6 older adults people aged 60–74 years and 4 for older adults people aged 75 years or older.

about the socioeconomic conditions in childhood of the older adults studied, we used the participant's current level of schooling as a proxy for the previous socioeconomic position.

Regarding sex, the need to consider it in the proposition of predictive equations of height is justified by physiological, physical, and hormonal differences between men and women, which influence height of individuals [6]. Differently from other studies that proposed specific equations by gender and schooling, in our study there was no interaction between these variables and knee height [10,11,13,14,26,27].

The variable race/color did not remain in the final model of the proposed height estimation equation, unlike other studies with

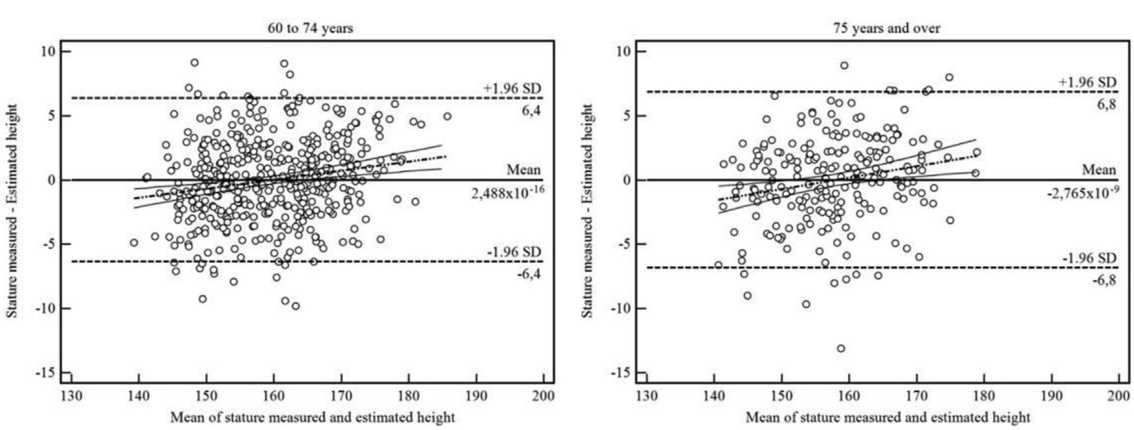

Fig. 1. Limits of concordance between height measured and height estimated by the equation of height estimation (n = 674).

Table 4
Cohen's Kappa and Weighted Kappa Indexes for concordance between indicators of body adiposity obtained by height measured and height estimated in the older adults (n = 674).

Variable	60–74 years			75 years or older		
	Height measured	Height estimated	Kappa	Height measured	Height estimated	Kappa
	n (%)	n (%)		n (%)	n (%)	
BMI						
Low weight	82 (18.0)	79 (17.4)	0.84	54 (25.2)	54 (25.2)	0.84
Eutrophy	200 (44.0)	194 (42.6)		93 (43.5)	91 (42.5)	
Preobesity	60 (13.2)	70 (15.4)		33 (15.4)	33 (15.4)	
Obesity	113 (24.8)	112 (24.6)		34 (15.9)	36 (16.8)	
WHC						
Without cardiometabolic risk	37 (8.1)	36 (7.9)	0.96	17 (7.9)	18 (8.3)	0.95
With cardiometabolic risk	416 (91.8)	417 (92.1)		199 (92.1)	198 (91.7)	
BAI						
1st tertile	154 (33.9)	157 (34.6)	0.85	69 (31.9)	66 (30.6)	0.83
2nd tertile	147 (32.4)	144 (31.7)		77 (35.6)	80 (37.0)	
3rd tertile	153 (33.7)	153 (33.7)		70 (32.4)	70 (32.4)	
CI						
1st tertile	159 (35.3)	165 (36.6)	0.89	62 (29.1)	56 (26.3)	0.81
2nd tertile	154 (34.1)	147 (32.6)		66 (31.0)	75 (35.2)	
3rd tertile	138 (30.6)	139 (30.8)		85 (39.9)	82 (38.5)	

Note: BMI: missing data for 2 older adults people aged 60–74 years and 3 older adults people aged 75 years or older; WHR: missing data for 4 older adults people aged 60–74 years and 1 older adults aged 75 years or older; BAI: missing data for 3 older adults people aged 60–74 years and 1 older adults aged 75 years or older; CI: missing data for 6 older adults people aged 60–74 years and 4 older adults people aged 75 years or older.

populations of the United States of America and Latin American countries [14,26,27]. It is possible that this result is due in part to the high frequency of white older adults in the sample (70.4%), in addition to the substantial miscegenation of the Brazilian population [12].

The mean height calculated with the equation proposed in our study was not significantly different from the height measured. However, when assessing the participants individually, it is possible to find considerable differences between the heights measured and estimated. Thus, it is clear the suitability of the use of the equation at the population level. For individual evaluation, it requires caution, given the possibility of under or overestimation of height, especially in the extreme values of this measure, for the presence of proportional bias. Thus, special attention should be given to underestimation of underweight and overweight in individuals with short and tall heights, respectively, and these conditions are associated with higher morbidity and mortality in this age group [5].

Despite the existence of proportional bias, there was almost perfect concordance between the body adiposity indicators obtained from the measured and estimated heights. It is important to emphasize that these indicators are among the most important ones for assessing the nutritional status of older persons.

One limitation of our study is that the older adults population is resident of a specific Brazilian municipality. However, since it has a demographic profile similar to that of other municipalities, in relation to the distribution by sex and age group [31]. We suggest that the equation proposed may be useful for assessing height in other populations of Brazilian older adults. Nonetheless, future studies on equations of height estimation for the Brazilian population as a whole are required.

In conclusion, all of our results point to the good performance of the estimation of height using knee height in the composition of indicators of body adiposity, being a viable alternative in cases of difficulty in determining height. These results stand out considering the great importance that the nutritional evaluation plays in monitoring the health conditions of the older adults population.

Declaration of competing interest

The authors declare no conflict of interest.

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References

[1] United Nations. Department of economic and social affairs. UN: Population Division; 2017. World Population Ageing 2017 - Highlights (ST/ESA/SER.A/397).
[2] Instituto Brasileiro de Geografia e Estatística. Síntese de Indicadores Sociais. Uma análise das condições de vida da população brasileira. In: Estudos e Pesquisas. Informação Demográfica e Socioeconômica. Rio de Janeiro: IBGE; 2016. no. 36.
[3] Massa KHC, Duarte YAO, Filho ADPC. Análise da prevalência de doenças cardiovasculares e fatores associados em idosos, 2000-2010. Ciência Saúde Coletiva 2019;24(1):105–14. https://doi.org/10.1590/1413-81232018241.02072017.
[4] Vigitel Brasil 2017: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico: estimativas sobre frequência e distribuição sociodemográfica de fatores de risco e proteção para doenças crônicas nas capitais dos 26 estados brasileiros e no Distrito Federal em 2017. Ministério da Saúde, Secretaria de Vigilância em Saúde, Departamento de Vigilância de Doenças e Agravos não Transmissíveis e Promoção da Saúde. Brasília: Ministério da Saúde; 2018. p. 130p.
[5] Pereira IFS, Spyrides MHC, Andrade LMB. Estado nutricional de ancianos em Brasil: um enfoque multinível. Cad Saúde Pública 2016;32(5):1–12. https://doi.org/10.1590/0102-311X00178814.
[6] França AP, Pivi GAK. Alterações orgânicas, fisiológicas e metabólicas do processo de envelhecimento e seus reflexos na nutrição do idoso. In: Tratado de Nutrição em gerontologia, [MLN silva, MFN marucci, MA roediger, editores São Paulo: Manole; 2016. p. 49–61.
[7] Souza ECG, Duarte MSL. Epidemiologia e Processo Biológico do Envelhecimento. In: Abordagem nutricional no envelhecimento, [MSL duarte, FAC rezende, ECG souza, editores Rio de Janeiro: Rúbio; 2016. p. 1–10.
[8] Roediger MA, Silva MLN, Marucci MFN. Avaliação nutricional de idosos. In: Tratado de Nutrição em gerontologia, [MLN silva, MFN marucci, MA roediger, editores São Paulo: Manole; 2016. p. 62–91.
[9] Frid H, Adolfsson ET, Rosenblad A, Nydahl M. Agreement between different methods of measuring height in elderly patients. J Hum Nutr Diet 2013;26:504–11. https://doi.org/10.1111/jhn.12031.
[10] Chumlea WC, Roche AF, Steinbaugh ML. Estimating stature from knee height for persons 60 to 90 Years of age. J Am Geriatr Soc 1985;33(2):116–20. https://doi.org/10.1111/j.1532-5415.1985.tb02276.x.

[11] Najas MS. Avaliação do estado nutricional de idosos a partir da utilização da medida do comprimento da perna -"knee height"- Como método preditor da estatura. Tese de Mestrado, Universidade Federal de São Paulo – Escola Paulista de Medicina; 1995.
[12] Behrendt C, Zaluski A, Albuquerque RP, Sousa EB, Cavanellas N. Avaliação comparativa de métodos da altura patelar na população brasileira. Rev Bras Ortop 2016;51(1):53–7. https://doi.org/10.1016/j.rbo.2015.02.004.
[13] Lera L, Luis Santos J, García C, Arroyo P, Albala C. Predictive equations for stature in the elderly: a study in three Latin American cities. Ann Hum Biol 2005;32(6):773–81. https://doi.org/10.1080/03014460500421304.
[14] Palloni A, Guend A. Stature prediction equations for elderly hispanics in Latin American countries by sex and ethnic background. J Gerontol A Biol Sci Med Sci 2005;60A(6):804–10. https://doi.org/10.1590/0102-311X00178814.
[15] Jelliffe DB. Evaluacion del estado de nutrición de la comunidade com especial referencia a las encuestas em las regiones in desarrollo. 1968.
[16] World Health Organization. Physical status: the use and interpretation of anthropometry. WHO technical report series. Genebra: WHO; 1995.
[17] Instituto Brasileiro de Geografia e Estatística. Características Étnico-raciais da População. Classificações e Identidades. Estudos e Análises. Informação Demográfica e Socioeconômica, no. 2. Rio de Janeiro: IBGE; 2013.
[18] Organização Pan-Americana da Saúde. XXXVI Reunión del Comitê Asesor de Investigaciones en Salud – encuestra Multicêntrica – salud Bienestar y Envejecimiento (SABE) en América Latina e el Caribe – informe preliminar. Washington, D.C. XXXVI Reunión del Comité Asesor de Investigaciones en Salud. Jamaica: Kingston. OPAS; 2001.
[19] Hsieh SD, Yoshinaga H. Is there any difference in coronary heart disease risk factors and prevalence of fatty liver in subjects with normal body mass index having different physiques? Tohoku J Exp Med 1995;177(3):223–31.
[20] Martínez González MA, Sánchez-Villegas A, Toledo Atucha EA, Faulin J. Bioestadística amigable. 3 ed Barcelona. Elsevier; 2014. p. 596.
[21] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33(1):159–74. https://doi.org/10.2307/2529310.
[22] Bland JM, Altman DG. Comparing two methods of clinical measurement: a personal history. Int J Epidemiol 1995;24(3):S7–14. https://doi.org/10.1093/ije/24.supplement_1.s7.
[23] Luiz RR. Métodos estatísticos em estudos de concordância. In: Medronho RA, editor. Epidemiologia. 2nd ed. Atheneu; 2009. p. 343–69.
[24] Fogal AS, franceschinni SCC, Priore SE, Cotta RM, Ribeiro AQ. Stature estimation using the knee height measurement amongst Brazilian elderly. Nutr Hosp 2015;31(2):829–34. https://doi.org/10.3305/nh.2015.31.2.7618.
[25] Menezes TN, Brito MT, Araújo TBP, Silva CCM, Nolasco RRN, Fischer MATS. Perfil antropométrico dos idosos residente em Campina Grande – PB. Rev Bras Geriatr e Gerontol 2013;16(1):19–27. https://doi.org/10.1590/S1809-98232013000100003.
[26] Chumlea WC, Guo SS. Equations for predicting stature in white and black elderly individuals. J Am Geriatr Soc 1992;47(6):197–203. https://doi.org/10.1093/geronj/47.6.M197.
[27] Chumlea WC, Guo SS, Wholihan K, Cockram D, Kuczmarski RJ, Johnson CL. Stature prediction equations for elderly non-Hispanic white, non-Hispanic black, and Mexican-American persons developed from NHANES III data. J Am Diet Assoc 1998;98(2):137–42. https://doi.org/10.1016/S0002-8223(98)00036-4.
[28] Brigola AG, Alexandre TS, Inouye K, Yassuda MS, Pavarini SCL, Mioshi E. Limited formal education is strongly associated with lower cognitive status, functional disability and frailty status in older adults. Dement. Neuropsychol 2019;13(2):216–24. https://doi.org/10.1590/1980-57642018dn13-020011.
[29] Drachler ML, Andersson MCS, Leite JCC, Marshall T, Aerts DRGC, Freitas PF, et al. Social inequalities and other determinants of height in children: a multilevel analysis. Cad Saúde Pública 2003;19(6):1815–25. https://doi.org/10.1590/S0102-311X2003000600025.
[30] Curi AZ, Menezes-Filho NA. The relationship between height, school, occupation and wages in Brazil. Pesqui Planej Econ 2008;38(3):413–58.
[31] Instituto Brasileiro de Geografia e Estatística. Censo Demográfico 2010. Características da População e dos Domicílios – resultados do Universo. Ministério do Planejamento, Orçamento e Gestão. Rio de Janeiro: IBGE; 2011.