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Stature estimation using the knee height measurement amongst Brazilian elderly

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Abstract

Introduction: **Stature is an important variable in several indices of nutritional status that are applicable to elderly persons. However, stature is difficult or impossible to measure in elderly because they are often unable to maintain the standing position. A alternative is the use of estimated height from measurements of knee height measure.**

Aims: **This study aimed to evaluate the accuracy of the formula proposed by Chumlea et al. (1985) based on the knee of a Caucasian population to estimate the height and its application in calculation of body mass index in community-dwelling older people residents in Viçosa, Minas Gerais, Brazil.**

Methods: **The sample included 621 elderly aged 60 years old and older, living in the community. Measures of weight, height and knee height (KH) were taken and Body Mass Index (BMI) was calculated with the measured weight and estimated. The Student`s t-test was used for comparison of measurements of height between the genders. For the comparison of estimated and measured values it was used paired t-test and also the methodology proposed by Bland and Altman to compare the difference between measurements. To evaluate the agreement between the classifications for BMI was used Cohen's Kappa.**

Results: **The average values obtained from KH were higher than those measured in the whole sample and women. There underestimation of BMI in females and also in the whole.**

Conclusions: **The present results suggest that the equation Chumlea was not adequate to estimate the height of the sample in question, especially for women.**

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Key words: *Aging. Anthropometry. Height. Knee height.*

ESTIMACIÓN DE LA ESTATURA UTILIZANDO LA MEDICIÓN DE LA ALTURA DE LA RODILLA ENTRE ANCIANOS BRASILEÑOS

Resumen

Introducción: **La estatura es una variable importante en varios índices del estado nutricional que son aplicables a las personas mayores. Sin embargo, la estatura es difícil o imposible de medir en la edad avanzada, ya que a menudo son incapaces de mantener la posición de pie. Una alternativa es el uso de altura estimada a partir de mediciones de medida de altura de la rodilla.**

Objetivos: **Este estudio tuvo como objetivo evaluar la exactitud de la fórmula propuesta por Chumlea et al. (1985), basado en la altura de la rodilla de una población caucásica para estimar la altura y su aplicación en el cálculo del índice de masa corporal en las personas mayores residentes en la comunidad de Viçosa, Minas Gerais, Brasil.**

Métodos: **La muestra incluyó a 621 adultos mayores de 60 anõs y más, que viven en la comunidad. Se tomaron medidas de peso, talla y altura de la rodilla (AR) y el Índice de Masa Corporal (IMC) se calculó con el peso medido y estimado. Se utilize la prueba T del estudiante para la comparación de las mediciones de altura entre los géneros. Para la comparación de los valores estimados y medidos se utilizó la prueba T pareada y también la metodología propuesta por Bland y Altman para comparar la diferencia entre las mediciones. Para evaluar el acuerdo entre las clasificaciones para el IMC se utilizó el Kappa de Cohen.**

Resultados: **Los valores medios obtenidos a partir de AR fueron más altos que los medidos en la muestra completa y mujeres. Hay subestimación de IMC en mujeres y también en el conjunto.**

Conclusiones: **Los resultados sugieren que la ecuación Chumlea no era adecuado para estimar la altura de la muestra en cuestión, especialmente para las mujeres.**

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Palabras clave: *Envejecimiento. Antropometría. Altura. Altura de la rodilla.*

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Introduction

Screening of elderly people in order to identify nutritional risk plays an important role in the identification and prevention of complications related to malnutrition in patients in hospitals and the community[1]. There are a large number of screening tools that facilitate this process, and most of them use a combination of variables, including clinical, biochemical, nutritional and anthropometric measures[2,3]. These are easy to use and inexpensive and have good reliability[4].

Body mass index (BMI) is commonly used in nutritional screening, including the Mini Nutritional Assessment (MNA) and Malnutrition Universal Screening Tool (MUST)[5,6]. It requires a measure of height that might be difficult to obtain in older individuals because they are often unable to maintain the standing position[7,8].

An alternative is the use of estimated height from measurements of different segments of skeleton[9]. Several international studies show that stature estimation formulas through knee`s height measure are easily conducted among individuals aged 60 or older[1,10–13]. Chumlea et al.[10] pioneered the studies to obtain high predictive formulas through the knee`s height measurement. Currently, these are the formulas used in most hospitals and care clinics in Brazil.

However, evidences suggest reduced accuracy of equations when it is used to estimate height in populations in which the equation was not derived, ie, It is well known that anthropometric measurements are ethnic-specific[11,13–17]. Large differences in these measures can result in damage to the health of the elderly, once erroneously classified according to their nutritional status.

Studies comparing the height estimated with real stature showed that there is an overestimation of the measure both in adults and in the elderly, regardless of gender[18–20]. It should be considered that these equations are of limited use because they did not include all the groups of the population and were not developed with data from nationally representative sample.

Therefore, the aim of this study was to evaluate the accuracy of the formula proposed by Chumlea et al. (1985) based on the knee of a Caucasian population to estimate the height and its application in calculation of body mass index in community-dwelling older people residents in Viçosa, Minas Gerais, Brazil.

The context of Viçosa

Viçosa is a small town in Brazil located in the area called Zona da Mata of Minas Gerais with a population of 70,404 inhabitants. According to the Brazilian population census conducted in 2007, 10% of the population of Viçosa is 60 years and older. In regard the age group distribution, 53.7% of elderly are between 60 and 69 years old and 31.5% between 70 and 79 years old[17,21].

According to the Brazilian census of 2010, the majority of the population declared themselves as white (46%), followed by mulattos (38%) and black (15%). The other races or colors totaled the remaining 2%[22].

Materials and methods

Study Design

This was a descriptive correlational study with a cross-sectional design, conducted in Viçosa, Minas Gerais (MG), Brazil, from June to December 2009 with elderly aged 60 and older. The Department of Nutrition and Health, at Universidade Federal de Viçosa conducted this research.

Target Population and Sample

The target population consisted of elderly people aged 60 years and older living in urban and rural Viçosa (MG). This group was surveyed during ‘‘The National Campaign for Elderly Vaccination’’ from April to May 2008. With the aim of identifying non-participants in the vaccination campaign to complement the database, the campaign's database was merged with other municipalities databases (Viçosa's, Federal University employees, active and retired, the registers of the municipality's health services, such as Elderly Health Program (PSF), Physiotherapy service, the Center of Women's Health, Psychosocial Services, Care Unit, HiperDia and the Polyclinic). This merged data aimed to identify older people who had not participated in the 2008 vaccination campaign to complement the database. After combination of these lists, 7980 people aged 60 and over were identified and this number formed the basis for obtaining the sample. The institutionalized elderly were excluded from the sample.

The sample size calculation was performed considering the reference population of 7980 elderly, confidence level of 95% and estimated prevalence of 50% and 4.0% of error. From these parameters, the minimum final sample would be 558 elderly people, to which was added 20% to cover potential losses, totaling 670 elderly people being studied. The selection of participants was made from the formed basis by simple random sampling. Some information was lost due to subject refusal to participate and unavoidable reasons that interviews could not be conducted (Losses were considered inevitable in situations where randomly selected individuals had died; had an address that could not be located; or had moved to other locations which were either difficult to find or in other municipalities). So, 621 elderly were actually assessed. For the current analysis, 74 individuals

(11.9%) were excluded because they were wheelchair, bedridden or have suffered amputation of lower limbs, making it impossible to obtain their anthropometric measurements. The sample distribution by gender and age group was similar to the observed for the elderly population in the municipality of Viçosa.

Data Collection

The interviews were conducted at each elderly's home using a semi-structured questionnaire applied directly to the elderly. However, when medical reasons prevented the interview, like deafness or cognitive disabilities, interviews were conducted in the presence of relatives or caregivers, who also provided information (except in self-evaluation). Were taken measures for anthropometric assessment. Weight was measured in portable balance (digital electronics) with a capacity of 199.95 kg and 50 grams. Height was measured with a portable stadiometer, with a length of 2.13 meters, divided into centimeters and subdivided in millimeters. Measurements were performed according to the procedures recommended by Jelliffe[23].

The knee`s height was measured in the left leg at an angle of 90° with the knee and ankle and with the elderly in sitting or lying position. Was used an anthropometer with fixed ruler with a sensitivity of 0.1 cm, consisting of a fixed part, which has been positioned in the plantar surface of the foot (heel) and a movable part, which was positioned over the patella. The measure was taken in the precise centimeter. The height estimated from the knee`s height (KH) was calculated through the Chumlea et al.[10] formulas:

Women: height (cm) = 84.88 + [1.83 x KH (cm)] - [0.24 x age (years)]

Men: height (cm) = 64.19 + [2.02 x KH (cm)] - [0.04 x age (years)]

The Body Mass Index (BMI) was calculated through the formula: BMI = weight (kg)/ height (m^2) both with the measured height, as with measures estimated by Chumlea et al.[10]. The cutoff points adopted for the evaluation were proposed by Lipschitz (underweight <22 kg/m^2, normal 22-27 kg/m^2 and overweight > 27 kg/m^2)[23].

Data Analysis

The normality of variables distribution was evaluated using the Kolmogorov-Smirnov test. The analysis was stratified by gender. The Student`s t-test was used for comparison of measurements of height between the genders. For the comparison of estimated and measured values it was used paired t-test and also the methodology proposed by Bland and Altman to compare the difference between measurements[24]. To evaluate the agreement between the classifications for BMI was used Cohen's Kappa, using the evaluation criteria of Landis and Koch[25].

For data storage was used Epi Info software, version 6.04; and data analysis was conducted in the Stata software, version 7.0, (Stata Corp., College Station, United States). For all comparisons, the significance level adopted was 0.05.

The study was approved by the Ethics Committee on Human Research of Universidade Federal de Viçosa (process 027/2008). Participants received a term of informed consent, in writing, where the agreement was recorded by signature or fingerprint.

Results

Among the 547 study participants, 274 (50.1%) were female. Participants had a mean age of 69.72 years (SD = 7.34), ranging between 60 and 94 years old, with more than half (n =302 to 55.2%) aged 60-69 years old and 57 (10.4%) aged 80 years old or more. The average age of women (mean, SD = 69.83, 7.35 years) and men (mean, SD = 69.60; 7.34) did not differ statistically.

Men had significantly higher mean values for weight, height and knee`s height. Women had an average BMI significantly higher than men (Table I).

The mean estimated height from the knee`s height was higher than that measured in all the sample, specially with the women. For men, the average difference was not statistically significant. There was underestimation of BMI in women and also in all the sample when estimated height was used for obtaining it. Among men, estimated BMI did not differ significantly from measured BMI (Table II).

Table I
Anthropometric Parameters of the elderly, according to gender. Viçosa, MG, Brazil, 2009

	Woman		*Men*		
	Mean	SD	Mean	SD	p-value*
Height (cm)	152.4	5.8	165.5	6.6	<0.001
Weight (Kg)	65.5	13.7	70.9	14.6	<0.001
KH (cm)	47.3	2.5	51.6	2.7	<0.001
BMI (Kg/m²)	28.2	5.5	25.8	4.5	<0.001

SD: Standard deviation; KH: Knee Height; BMI: Body Mass Index; *Student's t-test

Measured and estimated height showed good agreement for men, but not for women. According to the regression line, the error is associated with magnitude in both genders. For women there was a higher estimated height calculated from the Chumlea et al.[10] equation (Figure 1A and 1B).

In men, the mean difference between estimated and measured BMI was almost zero, indicating good agreement between the measures and not related to the magnitude. For women, BMI measurements were less consistent in relation to men's, and the difference tends to increase with increasing values of BMI (Figures 1C and 1D).

Proceeding BMI classification, by gender, according to Lipschitz[24] there was an increase in the prevalence of underweight in both genders when considering estimated BMI in relation to measured BMI (Table III).

For women, the Kappa was 0.89 with a confidence interval of 95%, from 0.80 to 0.99 (p <0.001) and for men the agreement was still higher, 0.97 with a confidence interval of 95% from 0.88 to 1.0 (p <0.001) being both classified as almost perfect agreement.

Despite the high Kappa, 29 men (10.6%) and 37 women (13.5%) had changes in their body composition when using the estimated measure of height for the BMI calculation.

Discussion

This study evaluated 547 elderly in order to check the reliability of the equation proposed by Chumlea et al.[10] in this age group in Brazil. Those equations were chosen both because of their wide use in clinical and epidemiological studies in this country.

It was observed that the Chumlea et al.[10] equation led to errors when applied to the Brazilian elderly. These equations overestimate women`s height in 2.22 cm (p <0.0001), but not for men. When the differences between measurements of height were significant, the indices calculated from it also differ in terms of absolute value. As women had their height overestimated, consequently BMI underestimation was found for this group.

Confirming the specific character of the formula for different populations can observer that stud-

Table II
Comparison between measured and estimated anthropometric measures for the elderly, according to gender. Viçosa (MG), Brazil, 2009

	Mean	*SD*	*Median*	*Min-Max*	*MD*	*P value**
All						
Measured height (cm)	158.9	9.1	158.3	136.8-188.2		
Estimated height (cm) (n= 547)	160.1	7.6	159.6	131.8-183.0	-1.2	<0.001
Measured BMI (Kg/m²)	27.0	5.2	26.4	15.2-46.8		
Estimated BMI (Kg/m²) (n=547)	26.5	4.9	26.1	14.23-44.6	0.5	<0.001
Men						
Measured height (cm)	165.5	6.6	165.2	147.9-188.2		
Estimated height (cm) (n= 273)	165.6	5.5	165.4	149.5-183.0	-0.1	0.617
Measured BMI (Kg/m²)	25.8	4.5	25.5	15.7-41.8		
Estimated BMI (Kg/m²) (n= 273)	25.8	4.5	25.4	15.0-42.4	0	0.634
Women						
Measured height (cm)	152.4	5.9	152.2	136.8-170.1		
Estimated height (cm) (n= 274)	154.6	4.9	155.0	131.8-168.7	-2.2	<0.001
Measured BMI (Kg/m²)	28.2	5.5	27.4	15.2-46.8		
Estimated BMI (Kg/m²) (n= 274)	27.3	5.1	27.1	14.3-44.6	0.9	<0.001

SD: Standard deviation; Min: Minimum; Max: Maximum; MD: mean difference; BMI: Body Mass Index; *Paired t-test

Table III
Body composition of the elderly, from measured and estimated BMI according to gender. Viçosa (MG), Brazil, 2009

	Men (n=273)				Woman (n=274)			
	Measured BMI		Estimated BMI		Measured BMI		Estimated BMI	
	n	%	n	%	n	%	n	%
Underweight	50	18,3	53	19,4	25	9,1	33	12,0
Normal	126	46,2	125	45,8	100	36,5	100	36,5
High weight	97	35,5	95	34,8	149	54,4	141	51,5

BMI: Body Mass Index.

ies with populations from which the formula did not originate reported similar results to ours. Li et al.[25] found differences between the Estimated and Measured height for the same equations in Chinese elderly. These authors also found differences between the estimated and measured height for women only (1.7 cm $p<0.025$) overestimating the stature of Chinese elderly. In Japanese Americans the equations of Chumlea et al.[10] besides overestimate females height in 1.5 cm ($p <0.001$), underestimated the men`s height in 2.37 cm ($p <0.001$)[13]. In hospitalized elderly Swedes, equation overestimated the height in 2 cm ($p <0.001$) in men and 1 cm in women ($p <0.001$), but there was a high correlation with the measured height[17].

When the measured and estimated BMI was classified according Lipschitz[24], it was observed that a significant portion of the sample had changes in the body composition, especially the low weight had increased prevalence when calculated with the estimated height. However, according to Kappa, agreement was considered almost perfect for both men and women. It should be considered that Kappa has limitations because it does not consider changes in classification individually, but only the total score of the two methods assessed[26].

The misclassification of approximately 10% of the sample may not show effects in population studies, since considering the high value of Kappa. But, this error can be very harmful in the screening and assessment of individual elderly.

According to the strategy of Bland Altman has been an important systematic error of Chumlea et al.[10] equations. These tend to underestimate the height of the lowest individuals and overestimate the height of the highest individuals. This trend is also reflected in the value and classification of BMI.

The participants studied in this research were recruited from a predominantly healthy population. As a result, the numerical data of the present study should not be extrapolated and used to correct the height values obtained by equation evaluated in a elderly hospitalized population.

There is a need to consider alternative methods of estimating height and evaluate the clinical implications of using an inaccurate value in nutritional screening. If a value for the height can not be obtained by measurement or calculation using a prediction equation, the self reported or estimated height can be used, but their use in the elderly should be careful because the physical changes that occur with age, causing a reduction in the height of the years.

Conclusions

Accordingly, it could be concluded that the Chumlea et al.[10] equation was not adequate to estimate the height of the sample in question, especially for women. Their use should be made with caution in studies of nutritional assessment, since there may be varying degrees of impact in determining the clinical and nutritional behaviors with higher risk of adopting misconduct, directly interfering with the individual's health.

The results presented raise some concerns about the use of these equations in some population groups and therefore there is a need to develop ethnic specific equations that provide more accurate values. While the use of Chumlea et al.[10] equations is already done, care must be taken when evaluating the stature of elderly individuals. The ideal is to use complementary methods to obtain the correct nutritional diagnosis.

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