ARTICLE

Use of knee height as a surrogate measure of height in older South Africans

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The study aimed to determine whether knee height would be a more appropriate surrogate measurement than armspan in determining height and body mass index (BMI) in a group of South African older people (≥ 60 years). A random sample of adults (older than 18 years) who attended selected clinics or who lived in selected old-age homes in the Western Cape volunteered to participate in the study. Subjects were divided into a study group of older people (≥ 60 years of age, N = 1 233) and a comparative group of younger adults (18 - 59 years, N = 1 038). Armspan, knee height, standing height and weight were measured using standardised techniques. The standing height measurements were significantly different between the two groups ($p = 0.0001$), with a mean for adults of 1.61 m (standard deviation (SD) 0.09) compared with that of older peole (1.57 m (SD 0.09)). Mean standing height decreased with age. Knee-height measurements were not significantly different between the two groups, but when used to calculate height, the adults were significantly taller ($p = 0.0001$), with a mean height of 1.67 m (SD 0.06) compared with that of the older people (1.59 m (SD 0.08)). Mean armspan also decreased with age, and derived standing height was significantly different ($p = 0.0001$) between the two groups, with adults being taller (1.67 m (SD 0.11)) than the older people (1.63 m (SD 0.11)). In this study group, the knee-height measurements were more closely related to the standing height than the armspan. The BMI calculated from armspan-derived height tended to classify the older people towards underweight. Knee-height measurement would appear to be a more accurate and appropriate method to determine height in older people in South Africa.

Changes in body composition are thought to reflect changes in nutritional status with age, and are also reported to be associated with increased morbidity and mortality.[1] Older people are recognised as a group at risk of malnutrition in the population as a whole.[2] In addition to being relatively simple, quick and inexpensive, anthropometry is the most reliable and specific indicator of malnutrition in the older adult population.[3] Most indices of nutritional status rely on accurate recording not only of body weight but also of height.[4,5]

Accurate methods are therefore needed to assess the nutritional status of older people.[6] At present, there are no guidelines on the degree of spinal curvature beyond which the measurement of height would be invalid, but there are obviously individuals whose height should not be measured using the usual methods. In such cases height has to be estimated, or preferably another measurement should be used as a surrogate.[2] Using standing height to calculate body mass index (BMI) in older people could be inappropriate because of the reported height loss with ageing resulting from the compression of vertebrae, kyphosis and osteoporosis.[4,7,8] A simple and reliable measure of height, especially in older people, is therefore necessary.[2,9] Since the length of long bones in the arms and legs does not reduce with age, armspan and knee height have been used as surrogate measures of height in older people.[10] Knee height would seem to be the preferred measurement, since it is not affected by height loss resulting from vertebral compression,[2,5-7,11] and various studies of adults and older people in non-South African populations[6,12-16] have found that it correlates well with height. Armspan has also been used, but may be less satisfactory than knee height because of joint stiffness in older people, which could reduce the accuracy of the measurement.[14,17] On average, in studies involving older people, height calculated from armspan measurement has been reported to be 5 - 7 cm greater than the measured standing height.[4,9]

Since the difference in such measurements may have a profound effect on the BMI calculations and lead to misclassification of malnutrition in older people, and given the paucity of such data on older South Africans, the aim of this study was to determine the most accurate and appropriate method to determine height in this population. It was hypothesised that knee height would be a more appropriate measurement than armspan in determining height and BMI in older South Africans.

Subjects

Of the 41 listed health facilities (clinics and day hospitals) and 49 old-age homes in 3 health districts in the Western Cape (Cape Metropole, Boland/Overberg and West Coast/Winelands), 40 health facilities and 47 old-age homes were included in the sample. These were all the facilities that met the single inclusion criterion of being in close proximity to the Health Sciences Faculty of Stellenbosch University (within 1 hour's travelling distance).

A convenience sample of adults (older than 18 years) attending the selected health facilities or living in the old-age homes on the day of the visit, were selected if they met the subject inclusion criteria and granted consent. Inclusion criteria for the subjects were being free from any physical constraint (for example being in a wheelchair, having a prosthesis) that could have affected the height measurement, and not being in frail care. The total sample size was 2 271. Subjects were divided into two groups for comparison, namely 1 233 older people (≥ 60 years), with 1 038 adults (18 - 59 years) as the comparative group.

Methods

Six groups of 3 BSc Dietetics 4th-year students collected the data under supervision of the investigators. Before data collection the students were trained as research assistants and were standardised in terms of the relevant anthropometric measuring techniques. During standardisation (inter-rater reliability), each research assistant/student was required to perform three measurements of weight, standing height, knee height and armspan on the same volunteer to ensure that error of measurement was within the required 0.1 kg for weight and 0.1 cm for height/length respectively.

Ethics approval for the study was obtained from Stellenbosch University's Human Research Committee. All subjects completed the mandatory consent forms before taking part in the study. Each group of students visited at least a clinic/day hospital and an old-age home daily (Monday - Thursday), for a 2-week period. Armspan, knee height, standing height and weight were measured for each subject.

Weight[18]

Subjects were weighed without shoes, in light clothing. The electronic platform scale (AND AD 6205) was placed on a flat, hard surface and calibrated regularly using a standard 1 kg weight (after every 20 measurements). The subject stood relaxed in the middle of the platform of the scale, without any support, looking straight ahead, with the head positioned in the Frankfort horizontal plane. Measurements were recorded to the nearest 0.1 kg.

Standing height[18]

Standing height was measured using a stadiometer. Subjects were measured wearing no shoes, hair coverings or hair bands, and with hair smoothed down. The subjects stood with arms at their sides looking straight ahead, breathing normally, feet flat, legs straight, with knees together and heels together. Shoulder blades, buttocks and heels touched the measuring board. Measurement was taken at maximum inspiration to the nearest millimetre with the head positioned in the Frankfort horizontal plane, and recorded to the nearest 0.1 cm.

Knee height[2]

Knee height was measured in a seated position, using a sliding broad-blade calliper. Measurements were taken on the left leg by positioning the knee and ankle at a 90° angle. The fixed blade of the calliper was placed under the heel, the shaft of the calliper was held parallel to the shaft of the tibia, and the moveable blade was positioned parallel to the fibula over the lateral malleolus and just posterior to the head of the fibula. Pressure was applied to the two blades to compress the soft tissues. Measurements were recorded to the nearest 0.1 cm.

The formulae for calculating height in adults were as follows:[19] Male stature (cm) = (2.02 x knee height (cm)) - (0.04 x age (yrs)) + 64.19; and female stature (cm) = (1.83 x knee height (cm)) - (0.24 x age (yrs)) + 84.88.

The formulae for calculating height in older people were as follows:[2] Male stature (cm) = (2.08 x knee-height) + 59.01; and female stature (cm) = (1.91 x knee height) - (0.17 x age) + 75.

Armspan[18]

Subjects stood without shoes, with their backs to the wall, arms stretched laterally and maximally (at a 90° angle to the body) at shoulder level, with palms facing outwards. Using a measuring tape, the distance between the tip of the middle finger on the left hand and the right-hand middle finger was measured, representing the armspan. Readings were taken to the nearest 0.1 cm.

BMI[18]

BMI was determined using the following formula: weight (kg)/height (m)^2.

BMI was calculated separately using the measured standing height, and that derived from the knee height and armspan.

Data analysis

The average of two measurements was used for data analysis for all the anthropometric measurements.

Subjects were divided into two groups for comparison, viz adults (18 - 59 years) and older people (≥ 60 years), with a further division into young adults (18 - 39 years) and old adults (40 - 59 years), and young-old (60 - 79 years) and old-old (≥ 80 years) for some of the socio-demographic correlations. Descriptive statistics were used for age, gender and ethnicity. The independent *t*-test was used to determine dependency between given variables and age groups (critical value of 0.05). The Bonferroni test, Kruskal-Wallis and chi-square tests were used to determine significant differences between the groups. The Pearson's correlation coefficient was used for association(s) between BMIs as determined by the three different height measurements.

Results

Sample

Fifty-four per cent of the total sample (N = 2 271) fell into the older people group (N = 1 233), with a mean age of 77 (standard deviation (SD) 9.0) years, and 46% in the adult group (N = 1 038) with a mean age of 39 (SD 12.3) years. Of the total sample, 49% (N = 1 123) were selected from clinics and 51% (N = 1 148) from old-age homes (Table I). Eighty-eight per cent of the adult group was selected from clinics/day hospitals, and 96% of the older people from the old-age homes. The sample comprised mostly women (74%) and coloured* people/Eur-African-Malay (59%) (Table I), which reflects the cultural distribution in the Western Cape.[21]

Anthropometry

Weight

The mean weights (70.09 kg (SD 17.82) and 66.01 kg (SD 15.13) respectively) for the adult and senior citizen groups were significantly different (p = 0.0001). The Bonferroni test indicated that old adults (40 - 59 years) were on average significantly heavier than the younger adults (18 - 39 years). The weight of the old-old (≥ 80 years) was significantly lower than that of the young-old (60 - 79 years). Women tended to be significantly heavier ($p < 0.01$) in the adult group than men, but significantly lighter ($p < 0.01$) in the older people group (Table II). There was a significant difference in weight ($p < 0.05$) between ethnic groups in the adult group, with coloureds weighing less than both blacks and whites.

*In South Africa the categories 'white', 'coloured' and 'black' based on population classification legislation were, and still are, often used as surrogates for social conditions.[20]

Height

Measured standing height was significantly different between the two groups (p = 0.0001), with the adult group being taller (1.61 m (SD 0.09)) than the older people group (1.57 m (SD 0.09)). Knee-height measurements were not significantly different between the two groups, but when knee height was used to calculate height, the adult group was again significantly taller (p = 0.0001) (1.67 m (SD 0.06)) than the older people group (1.59 m (SD 0.08)). Armspan measurements were significantly different between the two groups (p = 0.0001), with the adult group being taller (1.67 m (SD 0.11)) than the older people group (1.63 m (SD 0.11)).

When comparing the mean differences between height measurements obtained with the two different surrogate measurements, it was found that the height of adults determined by armspan and height calculated from knee height were on average 6 cm greater than the measured standing height. In the older people group, height determined on the basis of armspan measurements and height calculated from knee height were 6 cm and 2 cm greater than the measured standing height respectively. Overall, a significant negative correlation was found between age and all height measurements, that is measured standing height (r = –0.251; p = 0.0001), knee height (r = –0.050, $p < 0.05$) and armspan (r = –0.201, p = 0.0001).

In this study, height measurements were influenced by ethnicity, as indicated by blacks being significantly taller ($p < 0.01$), followed by coloureds and then whites, in the adult and older people groups. Height was also influenced by gender, with men being significantly taller than women for all height measurements (p <

Table I. Study sample characteristics by ethnic group, gender and location (N = 2 271)

Variable	Category	Total N (%)
Ethnic group	Black	168 (7.4)
	Coloured	1 344 (59.2)
	White	759 (33.4)
Gender	Male	582 (25.6)
	Female	1 689 (74.4)
Location	Clinic	1 123 (49.5)
	Old-age home	1 148 (50.6)

0.01) (Table II). When compared with women, men were 10 cm taller in the adult group and 20 cm taller in the older people group using standing height measurements, but when using height derived from knee height, the men were only 10 cm taller than the female older people group and there was no difference in standing height between males and females in the adult group. In both groups, the difference between measured standing height and height derived from knee height was significant between females at 10 cm ($p < 0.01$).

BMI

Using measured standing height the mean BMI was 27.06 (SD 6.99) for the adult group compared with 26.66 (SD 5.69) for the older people group, a statistically insignificant difference (Table III). The mean BMI derived from knee-height measurements was 25.03 (SD 6.16) for the adult group, which was significantly different from the mean BMI of 26.99 (SD 5.50) in the older people group ($p = 0.0001$). The difference in mean BMI between the adult and older people groups derived from armspan measurements was 25.20 (SD 6.63) and 24.89 (SD 5.68) respectively, a difference that did not reach statistical significance. Similarly, there was a mean difference of 1.9 and 1.8 between the BMI derived using armspan and the BMI derived from measured standing height. The difference in BMI obtained by knee height and armspan was not significant in either group, although it was higher in the older people group.

Similarly, there was a statistically significant positive correlation between age and BMI determined by knee height ($r = 0.130$, $p = 0.0001$), whereas the positive correlations were insignificant for measured standing height ($r = 0.007$) and derived armspan BMI ($r = 0.003$). Gender significantly influenced all three calculated BMI values, with women having a higher BMI than men ($p < 0.01$) (Table III), whereas ethnicity did not have a significant influence.

Discussion

Although not the main aim of the study, this study also provides information on the nutritional status of over 1 000 older South Africans. The sample may not be representative of all South Africans as the majority of subjects were women and coloured, but it nevertheless provides much-needed information. On average older South Africans, especially those over 80 years, tended to weigh significantly (4 kg) less than their younger counterparts. The imbalance in the proportion of women in the sample may be a limitation as the older women were found to be lighter than men, which

Table II. Means and standard deviations (SDs) of anthropometric measurements for males and females in adult (*N* = 1 038) and older people (*N* = 1 233) groups

	Adult group		Older people group	
	Male (*N* = 279)	Female (*N* = 759)	Male (*N* = 303)	Female (*N* = 930)
Weight (kg)*†	67.27 (16.83)	71.12 (18.06)	68.93 (15.16)	65.06 (15.01)
Measured standing height (m)*†	1.69 (0.07)	1.58 (0.07)	1.67 (0.08)	1.54 (0.07)
Measured knee height (cm)*†	53.05 (0.07)	49.44 (2.57)	52.70 (3.04)	49.39 (2.86)
Height derived from knee height (m)*†	1.70 (0.06)	1.66 (0.05)	1.69 (0.06)	1.56 (0.06)
Height derived from armspan (m)*†	1.77 (0.10)	1.64 (0.08)	1.74 (0.10)	1.60 (0.09)

* Significant difference between gender for the adult group, Kruskal-Wallis test, $p < 0.01$.
† Significant difference between gender for the older peoople group, Kruskal-Wallis test, $p < 0.01$.

Table III. Means and standard deviations (SDs) of BMI for adult (*N* = 1 038) and older people (*N* = 1 233) groups

	Age groups	
	18 - 59 years (%)	≥ 60 years (%)
BMI derived from measured standing height		
Mean	27.06	26.66
SD	(6.99)	(5.69)
BMI derived from armspan		
Mean	25.20	24.89
SD	(6.63)	(5.68)
BMI derived from knee height*		
Mean	25.03	25.99
SD	(6.16)	(5.50)

* Significant difference between the two groups (independent *t*-test), $p = 0.0001$.

concurs with findings in Chile.[22] Height was negatively correlated with age, with older South Africans being 4 - 8 cm shorter than adults depending on the height measurement used. Men were generally found to be taller. Regarding BMI, age was positively correlated with an increase in BMI, with women generally having a higher BMI. Ethnic differences should be interpreted with care as the imbalance between groups in the sample is a limitation of the study. Blacks were found to be taller, but only 7% of the total sample were black, and 90% of them were in the adult group, who are taller by default. Coloureds (59% of the sample) were found to be significantly shorter and lighter than the other two ethnic groups in both the adult and older people groups, but BMI values showed no significant differences between the ethnic groups.

In determining the most accurate and appropriate method of height measurement in older people, it was found that in adults both height derived from knee height and armspan measurements overestimated height by 6 cm. In older people, the difference between armspan measurement and standing height was also 6 cm. Previous studies[9] of older people also found armspan to be 5 - 7 cm greater than standing height and indicated that it may be an inappropriate proxy for height in certain populations. However in older people in this study the difference between height derived from knee-height measurement and standing height was only 2 cm. This indicates that spinal curvature in older people does result in height loss when measuring standing height, but knee-height measurements seemed to be less influenced. This, together with the negative correlation found between age and all three height measurements, indicates that height decreases with age, but the correlation is weaker with knee height. Other studies[22,23] have also found that height diminishes significantly with age, but according to Pini *et al.*[7] it is more pronounced in women. Santos *et al.*[22] found that knee height remained relatively constant across age groups in the elderly population of Chile, which corroborates well with this study's finding that knee-height measurements were not significantly different between the two groups. However once the measurement is used to derive height measurements, significant differences do occur. Use of formulae derived for specific population groups may be a limitation with regard to extrapolation of the data, but as there are no specific formulae available for the South African and specifically coloured population, the most appropriate formulae were selected.

Taking practical issues into consideration, the research assistants encountered fewer problems in measuring knee height in the older people group than in measuring either the standing height or armspan, a finding confirmed by other studies.[11,16] In a study by Murphy *et al.*[11] a single observer carried out knee-height measurements with minimal help from one assistant. Findings have also demonstrated the feasible, acceptable accuracy of estimating standing height from knee-height measurements in frail older people.[11] We therefore agree with the recommendation of Pini *et al.*[7] that measurements derived from knee height should be included routinely in anthropometric measurements, especially in older people.

The mean BMI using height derived from standing height and armspan was not significantly lower in the older people group than in the adult group, but was significantly higher when using height derived from knee-height measurements. The BMI in this study derived from armspan measurements tended to classify the subjects towards underweight compared with BMI calculated from standing height and knee-height measurements, indicating an overestimation of height resulting in a lower BMI, thus confirming similar findings in the literature.[1]

This study has shown that different height measurements can have a profound effect on BMI calculations, which could lead to misclassification of malnutrition in older people or to not identifying those at risk of malnutrition. The prediction that knee height would be a more appropriate measurement than armspan in determining height and BMI in older South Africans was found to be valid, although it is recommended that population-specific formulae for height derived from knee-height measurements be developed for the different South African ethnic groups.

Conclusions

The results of this study indicate that knee height is a better predictor of height than armspan in this sample of older people because the latter tended to overestimate height. As such knee height is probably a more appropriate surrogate measurement of height in a South African group of older people.

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ADSA association for dietetics in south africa

DIRECTIONS

News from ADSA

Dietetics is a uniquely diverse profession with practices in therapy, in the community and in food service management. It is because of the diversity of our training and the phenomenal change in the practice of dietetics that continued communication and learning are necessary. I would like to first congratulate all dietitians on being able to substantiate their participation in continued professional development to the HPCSA. The HPCSA CPD audit was undertaken in 2006. Of the 592 forms that were submitted to the HPCSA, 94% of dietitians were found to be compliant.

With a few years of experience dietitians combine their basic nutrition knowledge with many other areas of expertise such as public health, consultancy, marketing, personnel management, journalism, etc. Some dietitians are using their creativity in uniquely niche areas like recipe development for industry, and planning and adaptations to restaurant menus. This overwhelming demand for dietetic experts necessitates communication and planned education events. All dietitians know the detrimental effect of conflicting information. ADSA activities seek to minimise areas of conflict and archive consensus in nutrition knowledge and practice.

I am pleased to report that most dietitians have renewed their membership for 2007 and commendations go out to all regions for undertaking branch activities. With the move to the new ADSA office communication between ADSA has reached the best level since introduction of the website. There are still areas of improvement and dietitians continue to give support in this area. For dietitians who are still struggling with access, Adrie is the contact person to sort out problems.

On the website is a list of all CEU accreditors. There is also an option of sending the application directly to the CPD office for accreditation of the event. The simple process of archiving this can be accessed on the ADSA website. Abbott kindly sponsored valuable CPD files for all ADSA members which are being distributed through ADSA branches. These files allow for the dietitian to keep CPD records for the required three-year period.

Visit the ADSA website to learn what is happening in your area of expertise. There is a mail shot on job opportunities and any urgent announcement every Tuesday that is e-mailed to members. The ADSA newsletter, which discusses the issues and events within the executive and within branches, is emailed to all members on a monthly basis.

ADSA banking details have changed. I would like to encourage those who have not registered yet to communicate with Adrie da Silva at ADSA Secretariat (011 789-1384) or ie@vdw.co.za.

Bank: ABSA Bank
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