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SHORT COMMUNICATION

Estimation of Stature in Iranian Adults Using Knee Height

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ABSTRACT

Introduction: This study aimed to establish an equation for stature prediction using knee height in the Iranian population. **Methods**: Anthropometric measurements of 320 (193 women and 127 men) healthy dormitory students of a medical sciences university were taken by a trained dietitian to minimise errors. Linear regression analysis was used to estimate stature with height as the dependent variable and knee height and age as independent variables. A control group (63 women and 67 men) was used for validation of prediction equations. **Results:** The developed regression equations for height estimation by using knee height in Iranian men and women were 62.913 + (2.077 × Knee height) and 76.362 + (1.76 × Knee height) respectively. There was no significant difference between estimated mean height derived from the present study equation and actual mean height in the control group. **Conclusions:** New stature prediction equations for both sexes using knee height are presented for the Iranian adult population, which may be different from those for other populations.

Key words: Iranian adults, knee height, stature prediction

INTRODUCTION

Height as a component of anthropometric measurements is essential for nutritional assessment, calculating energy/nutrient delivery and drug prescription. However, in bedridden patients and critically ill persons, it is difficult to obtain height measurements. There are equations to estimate height from body lengths in which knee height measurement is highly correlated with upright height. This is useful for those who are unable to stand upright and who have covertures of the spine.

Knee height is measured using a sliding broad-blade caliper. A device designed for this purpose is commercially available. The patient's height is then estimated using a standard formula (Chumlea equation) (Chumlea, Roche & Steinbaugh, 1985). The Chumlea equation, which is used in Iranian populations for measuring height from knee height, was established on Caucasian subjects. Formulas which estimate height from body lengths are ethnic specific (Edmund *et al.,* 2000). Owing to variations in body segment proportions between populations, the accuracy of such formulas is reduced when applied to other populations (Myers, Takiguichi & Yu, 1994; Frid *et al.,* 2013). There are various population-specific formulas designed for

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both sexes. These include Non-Hispanic white, Non-Hispanic black, Mexican-American, Taiwanese, elderly Italians, French, Mexicans, Filipinos, adults and elderly Malaysians (Chumlea *et al*., 1998; Cheng, See & Sheih, 2006; Donini *et al.,* 2000; Guo *et al.,* 1998; Mendoza-Nunez *et al.,* 2002; Tanchoco, Duante & Lopez, 2001; Shahar & Pooy, 2003). Hence, we conducted a cross-sectional study to establish an equation for stature prediction using knee height in an Iranian population.

METHODS

In this cross-sectional study, a total of 320 healthy dormitory students of a medical sciences university was assessed. The study was conducted over 3 months in 2015. The study protocol was approved by the university ethics committee and written informed consent was obtained from all subjects. Anyone with splints, casts, prostheses, disorders of bone, muscle or joints and edema in the lower extremities were excluded from the study.

Anthropometric measurements were taken by a single trained dietitian to minimise errors in measurement. Height was measured in a standing position, without shoes, using a tape meter fixed to the wall, while the shoulders were in a normal alignment. Knee height was measured using a knee caliper while the subjects bend the knee and ankle of left leg at a 90 degree angle lying supine. The fixed blade was placed under the heel of the foot in line with the ankle bone and the sliding blade of the caliper on the anterior surface of the thigh about 3.0 cm above the patella. The shaft of the caliper was held parallel to the long axis of the lower leg and pressure was applied to compress the tissues (Mahan & Raymond, 2017). Each measurement was recorded to the nearest 0.1 cm and repeated twice. If the difference between the two measurements was within 0.5 cm of one another, the average was calculated; if however, the difference exceeded 0.5 cm, the two measurements were repeated. For generating equations to estimate height in both genders, linear regression analysis was used with adult height as the dependant variable and knee height and age as independent variables. The calculated equations were compared with the height derived from equations developed in other countries (Table 1). For validation of the derived Iranian equations, we used a second group including 63 women and 67 men as control.

Statistical methods

Subject demographics are reported as mean ± SD. Linear regression analysis was used to estimate stature. The estimated mean heights was compared with the estimated mean heights derived from other formulas and the control group with the Student`s *t*-test. P values less than 0.05 were considered significant, and all statistical analyses were performed using SPSS version 21.

RESULTS

A total of 320 (193 women and 127 men) subjects ranging in age between 20 and 43 years were included in the study. The baseline characteristics of the patients are shown in Table 2.

In Iranian men, stature can be predicted by knee height (t= 21.65, P<0.001) in a linear regression model with adjusted r^2 of 0.788 (P<0.001). The developed regression equation for height estimation by using knee height in men is 62.913 + (2.077 × knee height). In women, knee height (t= 16.731, P<0.001) was found to predict stature with an adjusted r^2 of 0.592(P<0.001). The developed regression equation for height estimation by using knee height in women is 76.362 + (1.76 × knee height). There was no increment in r^2 value in both sexes, when age was included as an independent variable. Table 3 shows a comparison between the study's estimated height and other formulas. The formulas

Table 1. Population-specific knee height formula

Variable	*Men (n = 127)*	*Women (n = 193)*
Non-Hispanic white[1]	78.31 + (1.94 × knee height) - (0.14 × age), (R2=0.68)	82.21 + (1.85 × knee height) - (0.21 × age) , (R2=0.63)
Non-Hispanic black[1]	79.69 + (1.85 × knee height) - (0.14 × age), (R2=0.69)	89.58 + (1.61 × knee height) - (0.17 × age), (R2=0.57)
Mexican-American[1]	82.77 + (1.83 × knee height) - (0.16 × age), (R2=0.65)	84.25 + (1.82 × knee height) - (0.26 × age), (R2=0.73)
Taiwanese[2]	85.10 + (1.73 × knee height) - (0.11 × age), (R2=0.61)	91.45 + (1.53 × knee height) - (0.16 × age), (R2=0.58)
French[3]	74.7 + (2.07 × knee height) - (-0.21 × age), (R2=0.65)	67.00 + (2.2 × knee height) - (0.25 × age), (R2=0.64)
Mexicans[4]	52.6 + (2.17 × knee height), (R2=0.83)	96.50 + (1.38 × knee height) - (0.08 × age), (R2=0.86)
Filipino[5]	96.50 + (1.38 × knee height) - (0.08 × age), (R2=0.68)	89.63 + (1.53 × knee height) - (0.17× age), (R2=0.66)
Malaysian[6]	69.38 + (1.924 × knee height), (R2=0.66)	50.25 + (2.225 × knee height), (R2=0.7)

[1]Chumlea *et al.*(1998); [2]Cheng *et al.*, 2001; [3]Guo *et al.*,1994;
[4]Mendoza-Nunez *et al.* (2002); [5]Tanchoco *et al.* (2001); [6]Shahar & Pooy (2003)

Table 2. Mean ± sd of subjects' characteristics

Variable	*Men (n = 127)*	*Women (n = 193)*
Age (y)	22.51±6.57	21.26±7.87
Min-Max	20- 38	20- 43
Height (cm)	176.12±6.01	161.73±4.75
Min-Max	164- 190	150.5-176
Knee height (cm)	54.51±2.57	48.50±2.12
Min-Max	48.1- 60.5	44.10- 54.3

Table 3. A comparison between study's estimated height and other formulas

	Men (n = 127)	*Women (n = 193)*
Non-Hispanic white	180.93 ± 4.98*	167.47 ± 4.03*
Non-Hispanic black	177.40 ± 4.74*	164.05 ± 3.49*
Mexican-American	178.94 ± 4.69*	166.99 ± 4.03*
Taiwanese	176.94 ± 4.44*	162.26 ± 3.31*
French	192.28 ± 5.36*	168.39 ± 4.79*
Mexican	170.91 ± 5.58*	161.73 ± 2.92
Filipino	169.94 ± 3.54*	160.22 ± 3.33*
Malaysian	174.27 ± 4.95*	155.76 ± 4.81*
Present study	176.11 ± 5.34	161.73 ± 3.66

*P< 0.005, significance

Table 4. Cornparison of estimated mean height derived from equations with actual mean height in the control group * (Mean ± sd)

	Actual height	*Estimated height*	*Difference*	*P-value*
Men (n=67)	176.12 ± 6.01	176 ± 5.6	0.12 ± 0.59	0.7
Women (n=63)	161.16 ± 6.44	160.36 ± 4.92	0.8 ± 1.52	0.3

* Independent t-test

for Non-Hispanic white and black, French, Taiwanese and Mexican-American men overestimate the height of Iranians and the formulas for Mexicans, Filipinos and Malaysians underestimate the height of Iranians. There was no significant difference between mean height of women with Mexican-American formula and the formula of the present study..

Table 4 shows that there is no significant difference between estimated mean height derived from the present study equation and actual mean height in the control group. The mean difference was 0.12 cm in men and 0.8 cm in women.

DISCUSSION

Our study showed that the developed equations for some countries over-estimate and for others under-estimate the stature of Iranians except for the Mexican equation for women. Stature estimation should involve a complex analysis because populations differ on a number of issues, and its application should be made with caution. Estimations using a reference sample that is not similar on many accounts to the sample in question will likely result in a poor estimation of stature. Body segment proportions vary between populations. The long bone lengths of one population do not necessarily correlate with the same stature in another population. This is most likely due in small part to the genetics of the population, and in large part to environmental factors like nutrition, climate, and migration (Genoves, 1967). Our results and the need for population-specific regression equations can be seen by the application of these studies. In a study on Brazilian elderly, it was observed that the Chumlea equation led to errors when applied to the Brazilian elderly (Fogal *et al.,* 2015). In the study by Ozer *et al*. (2007), a specific equation was developed for the Turkish population because of poor estimation of stature with other formulas. Similar results have been shown in the Taiwanese (Cheng *et al*., 2001), French (Guo *et al*., 1994), Mexicans (Mendoza-Nunez *et al.,* 2002), Filipinos (Tanchoco *et al.,* 2001), and Malaysians (Shahar & Pooy, 2003) populations with the generation of specific equations. In our study the r^2 value in women was not as strong as the r^2 value in men (0.788 versus 0.592). As the age range was narrow, there was no increment in r^2 value in both sexes when age was included as an independent variable. We found no significant difference between the calculated mean heights by the equation in the control group of women, with the actual height (0.8±1.52) which can validate our results based on low r^2 in women. The lowest r^2 value in women compared to men was also reported in Taiwanese, non-Hispanic blacks and non-Hispanic whites (0.58, 0.57, 0.63 sequentially).

CONCLUSION

The relationship between stature and long bone length may differ among populations and, as a consequence, population-specific regression equations should be used for individuals from different populations. This study represents a useful contribution to estimate body height based on knee height of Iranian adults by sex-specific equations.

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Conflict of interest

Authors declare that there is no conflict of interest.

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