Original Article

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Estimating the Height of an Individual from the Length of Ulna in Tamil Nadu Population and its Clinical Significance

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Abstract

Introduction: The height of an individual is a very important parameter for establishing the identification. The height can be indirectly estimated from different parts of the skeleton. Such estimations are of great use in anthropometry, forensic science, and anatomy. Ulna bone has been chosen because it is subcutaneous and can be used for measurements.

Objective: The objective of this study is to estimate the height of an individual from the length of ulna using a derived equation and to compare the results with other studies done in different populations.

Materials and Methods: The study was done on 300 subjects who were patients and the attenders visiting the out patient Department of Sri Muthukumaran Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India. The age of the subjects ranged from 20 to 50 years and was healthy without any skeletal deformity. The Institutional Ethics Committee clearance was obtained. After getting written consent from the subject, the height of the individual was measured from vertex to heel, and the length of both right and left ulna bones was measured from olecranon process to styloid process. The data were tabulated and analyzed statistically.

Results: In this study, the mean height of male was 164.4 cm and female was 153.7 cm. The mean length of the right ulna was 27.7 cm (males) and 25.6 cm (females). The mean length of the left ulna was 27.6 cm (males) and 25.4 cm (females). Pearson's correlation interpreted a very high significant ($P < 0.001$) relation between the length of the ulna and the height. The regression equation was derived to estimate the height of an individual from the length of the ulna in males and females.

Conclusion: The ulna bone length is a reliable and accurate parameter which is used in estimating the height of an individual. The regression equation, which was derived in this study, can be of great help to anatomists, clinicians, anthropologists, and forensic scientists.

Key words: Estimation of height, Height of individual, Length of ulna bone, Stature of individual, Ulna bone

INTRODUCTION

The height of an individual is one of the important parameters for establishing the identification. In bedridden, old or individuals with skeletal deformity the height can be indirectly estimated from different parts of skeleton.[1] Such estimations are of great use in anthropometry, forensic science, and anatomy.[1,2] Previous studies in this regard have been done on cadavers. The measurements taken on a cadaver may not be accurate because of the positioning of cadaver, age factor or due to debilitating diseases.[3] Hence, measurement on live subjects gives an accurate data for deriving the regression equation to correlate the height of an individual with length of the ulna.

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This study used ulna bone as it is subcutaneous and hence surface landmarks such as olecranon and styloid process are easily identifiable and can be used for measurements.[4] Ossification of ulna starts at the 8th week of fetal life and the proximal epiphysis fuses with the shaft at the 14th year in females and 15th year in males. The distal epiphysis fuses at the 17th year in females and 18th year in males. After

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50 years, there will be some degenerative changes in joints and cartilages and also spinal cord shrinkage affecting the height of an individual.[4] Hence, the age group considered for the study ranged from 20 and 50 years.

Factors, such as race, gender, and nutrition, determine the height of an individual. Hence, a population and gender specific formula are necessary for estimating the height of an individual. The objective of this study is to estimate the height of an individual from the length of ulna using a derived equation for Tamil Nadu population and to compare the results of our study with other studies done in different populations.

MATERIALS AND METHODS

This study was done on 300 subjects (119 males and 181 females) who were the patients and the attenders visiting the Outpatient Department of General Medicine of Sri Muthukumaran Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India. The Institutional Ethics Committee clearance was obtained. Subject information sheet was given to the patients and written informed consent was obtained from them. Following are the inclusion criteria for the study: (1) The age of the subjects ranged from 20 to 50 years and (2) The subjects were healthy without any skeletal deformity. The exclusion criteria for the study were: (1) Bedridden patients and (2) Patients who did not know their age.

The subjects were made to stand erect in anatomical position. The height of the individual subject was measured from vertex to heel in centimeters using a standard height measuring scale. The subjects were asked to fully flex the elbow with palms spread over opposite shoulder. The length of both right and left ulna bone was measured in centimeters from tip of olecranon process to tip of styloid process using a measuring tape. The data thus obtained were tabulated separately for male and female and were analyzed statistically.

Statistical Analysis

IBM SPSS Statistics Version 20 was used. Mean, standard deviation, and range were calculated for height of the subjects and length of the ulna bone (on both sides separately). The above statistics were interpreted by Student's *t*-test.

Pearson's correlation was used for comparing the relationship between the height of the individual and length of the ulna bone of the study subjects. Simple regression equation was derived for both sides in male and female separately. *P* values ($P \leq 0.05$) were treated as statistically significant.

RESULTS

The study subjects were analyzed according to their height and length of ulna as follows Table 1.

In Table 1, the comparison between the height of the individual and length of ulna of male and female has been done. The mean height of male was 164.4 ± 6.4 cm (range: 147.4-179 cm) and female was 153.7 ± 7.0 cm (range: 138.7-173 cm). The difference between the mean heights of male and female was statistically very highly significant ($P < 0.001$). The mean length of right ulna bone in male was 27.7 ± 1.3 cm (range: 24.4-31 cm) and in female was 25.6 ± 1.3 cm (range: 23-29.5 cm). The difference between the mean length of the right ulna of male and female was statistically very highly significant ($P < 0.001$). The mean length of left ulna bone in male was 27.6 ± 1.4 cm (range: 24-31 cm) and in female was 25.4 ± 1.3 cm (range: 22.9-29.4 cm). The difference between the mean length of left ulna of male and female was statistically very highly significant ($P < 0.001$).

The mean length of the right ulna was 27.7 ± 1.3 cm and left ulna was 27.6 ± 1.3 cm in males. In females, the mean length of the right ulna was 25.6 ± 1.3 cm, and left ulna was 25.4 ± 1.3 cm. The difference between the mean length of right and left ulna was not statistically significant in both male and female as per Student's *t*-test interpretation ($P > 0.05$) as shown in Table 2.

Pearson's correlation was used to interpret the relationship between the length of ulna and height of the individual. In this study, the coefficient correlation (*r*) was 0.754 (right ulna) and 0.745 (left ulna) in males; 0.691 (right ulna) and 0.701 (left ulna)

Table 1: Comparison of height of the individual and ulna bone length between the male and female

Variable	Mean±SD		Difference between the mean	*t*	d.f	Significance
	Male *n*=119	Female *n*=181				
Height (cm)	164.4±6.4	153.7±7.0	10.7	13.293	298	*P*<0.001
Right ulna (cm)	27.7±1.3	25.6±1.3	2.1	13.525	298	*P*<0.001
Left ulna (cm)	27.6±1.4	25.4±1.3	2.2	14.243	298	*P*<0.001

SD: Standard deviation

in females. This value of *r* shows a positive correlation. This indicates a very high significant ($P < 0.001$) relation between the length of the ulna and the height. The % of determination which was derived from correlation coefficient (*r*) showed that the male right ulna determined the height of the individual by 56.85% (r^2) and left ulna determined the height by 55.5% (r^2). Similarly, the female right ulna determined the height of the individual by 47.7% (r^2) and left ulna determined the height by 49.1% (r^2) as shown in Table 3.

The above respective regression equation may be used for estimation of the individual height. The estimated height of male using either right or left side length of ulna may be equal. Similarly, in female estimated height may be equal using either right or left side length of the ulna.

DISCUSSION

This study was done to observe the relationship of length of ulna bone with the height of the individual. With the acquired data, a regression equation was derived to estimate the height of an individual from the length of the ulna.

Height depends on age, gender, and race hence varies in various populations. This study is a population-specific study, which was done in Tamil Nadu population. The mean height of males were higher than females (males: 164.3 cm, female: 153.7 cm) in this study, which was also observed in other studies done in Eastern India population[5] (males: 167.5 cm, females: 152.5 cm), Gujarat population[2] (males: 169.8 cm, females: 155.2 cm), Maharashtra population[1] (males: 171.9 cm, female: 165.4 cm), West Bengal population[3,6] (males: 164.3 cm, females: 153.8 cm), and Sri Lanka population[7] (males: 170.1 cm, females: 157.6 cm).

The age group for this study was 20-50 years. Ossification of ulna begins at the 8th week of fetal life. The proximal epiphysis fuses with shaft at 16th year and distal epiphysis fuses at the 18th year in females and 20th year in males. After 50 years, some degenerative changes in joints and cartilage will affect the height.[4]

Ulna bone was used in this study because it is subcutaneous and the surface landmarks were easily measurable. The estimation of height from the length of the ulna was more accurate and reliable when compared to other studies done using foot,[8] tibia,[9] skull,[10] and radius[11] length. Ulna bone length can be advantageous, especially when there is a lower trunk and lower extremity deformity.[12]

Pearson's correlation was used to predict the significant relationship between the height and length of ulna of the subjects. In this study, the coefficient correlation (*r*) was 0.754 (right ulna) and 0.745 (left ulna) in males; 0.691 (right ulna) and 0.701 (left ulna) in females. This value of *r* shows a positive correlation. This indicates a very high significant ($P < 0.001$) relation between the length of the ulna and the height.

This was also similar to Mondal *et al.*,[3,6] who also observed that coefficient correlation (*r*) was 0.786 (right ulna) and 0.687 (left ulna) in males; 0.67 (right ulna) and 0.82 (left ulna) in females. Prasad *et al.*[1] calculated the coefficient correlation (*r*) as 0.65 in males and 0.68 in females. Hence, confirming this study's observation that length of ulna bone can give a correct estimation of height because of a very high significant relation between the length of ulna and height.

The simple regression analysis was done to know the strength of the relation between length of ulna and height. According to Lal and Lala,[13] regression coefficient (b) is a better guide for calculation of height of an individual

Table 2: Comparison of ulna length between right and left in male and female

Sex	Mean±SD		Difference between the mean	*t*	d.f	Significance
	Right ulna length (cm)	Left ulna length (cm)				
Male	27.7±1.3	27.6±1.4	0.1	0.068	236	*P*>0.05
Female	25.6±1.3	25.4±1.3	0.2	0.866	360	*P*>0.05

SD: Standard deviation

Table 3: Estimation of height of male and female from length of ulna

Sex	Side	Correlation coefficient (*r*)	r^2	% of determination	Regression equation (Y=a+bX)
Male	Right	0.754	0.5685	56.85	Y=63.984+3.631X
	Left	0.745	0.555	55.5	Y=66.232+3.551X
Female	Right	0.691	0.477	47.7	Y=57.995+3.745X
	Left	0.701	0.491	49.1	Y=56.048+3.839X

Y: Height of an individual, a: Constant, b: Regression coefficient of X, X: Length of ulna

Table 4: Regression coefficient in different populations

Study	Region	Male		Female	
		Right	Left	Right	Left
Present study	Tamil Nadu	3.631	3.551	3.745	3.839
Thummar *et al.*[2]	Gujarat	3.117	3.667	5.314	5.335
Prasad *et al.*[1]	Maharashtra	2.92	2.92	2.37	2.37
Mondal *et al.*[3,6]	West Bengal	4.19	3.26	3.89	4.39
Mehta *et al.*[14]	Madhya Pradesh	3.562	3.285	3.562	3.285
Allbrook[15]	British	3.06	3.06	3.06	3.06
Illayaperumal *et al.*[7]	Sri Lanka	2.645	2.645	3.536	3.536

when the identity of the individual is not known. In this study, it was 3.631 (right ulna) and 3.551 (left ulna) in males; 3.745 (right ulna) and 3.839 (left ulna) in females. Following is the comparison of regression coefficient of our study with other studies in different populations, as given in Table 4.

In this study, the regression equations derived for Tamil Nadu population will help in estimating the height of an individual from the length of ulna bone. This equation will serve as an alternative for prediction of height, which can be used for nutritional assessment in bedridden patients, old patients, or patients with skeletal deformity.[16] It can be used in forensic science to predict the stature from incomplete or decomposed skeletal remains which help to establish the identity of an unknown individual.[1,2,17] Anthropometry uses various scientific methods and the techniques for estimating the various measurements on the living as well as the skeleton of man.[2] For biological anthropologists, it is important to update their researches on diverse population groups residing in different geographic zones.[8] Hence, this study will help the anthropologists in their further researches.

CONCLUSION

The length of the ulna bone is a reliable and accurate parameter, which is used in estimating the height of an individual. The regression equation, which was derived in this study, can be of great help to anatomists, clinicians, anthropologists, and forensic scientists.

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