

## Estimation of the Body Stature from Length of Ulna

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### Abstract

**Introduction:** Height is an important anthropometric parameter, it becomes difficult many times to record the height of an individual due to disability of lower limbs and axial skeleton, in forensic investigation and bedridden patients. Various studies tried to estimate the height of individual from the length of long bones like tibia and ulna. Length of ulna is an easily accessible anthropometric parameter. As the ulna is subcutaneous and easily accessible bone of the upper limb, we tried to analyze the relation between the length of ulna with height of individual. **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 conducted in the department of Anatomy, Prakash Institute of Medical Sciences & Research, Uran Islampur, in the state of Maharashtra in India. On 145 subjects who were students of first year MBBS. The age of the subjects ranged from 18 to 23 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 with a stadiometer, and for ulna length, the subject's elbow was flexed to 90° with fingers extended in the direction of the long axis of the forearm, and the distance between the most proximal point of the olecranon and the tip of the styloid process of the ulna was measured. Ulnar length of both the ulna was measured. The data were tabulated and analyzed statistically using SPSS software. **Results:** The mean height of male was 166.83±5.93 cm (range: 158 – 185 cm) and female was 157.96±5.96 cm (range: 145 – 168 cm). The difference between the mean heights of male and female was statistically highly significant ( $P < 0.001$ ). The mean length of right ulna bone in male was 27.95±1.34 cm (range: 24.50 – 29.95 cm) and in female was 25.56±1.27 cm (range: 22.10 – 28.10cm). 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 27.75±1.31 cm (range: 24.10 – 29.80 cm) and in female was 25.49±1.33 cm (range: 21.67 – 28.20 cm). The difference between the mean length of left ulna of male and female was statistically very highly significant ( $P < 0.001$ ). **Conclusion:** The length of 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.

**Keywords:** Height of Individual; Stature of Individual; Length of Ulna Bone; Ulna Bone; Estimation of Height.

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### Introduction

Stature is natural heights of a person in an upright position [1]. The height of an individual is one of the important parameters for establishing the identification [2]. Identification of an individual from mutilated, decomposed due to natural disasters is vital for medico legal and humanitarian grounds [3]. 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[3]. There is an established relationship between stature and dimensions of various body parts which allows forensic experts to estimate stature [4]. Sometimes, body fragments with soft tissue remain were found in the disasters and criminal cases. In this way, body fragments can be used for predicting the biological characteristics of individuals, especially height in forensic medicine. Mathematical methods and linear regression equations can predict the relation between height and body segments. In the previous studies, upper limb dimensions such as shoulder width, arm, forearm, hand, figures were considered for prediction of height [5]. 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.

## Material and Methods

The present study comprised of a total 145 Medical college students of Prakash Institute of Medical Sciences & Research, Uran Islampur, in the state of

Maharashtra during the period of October 2014 to October 2016. Their age ranged between 18 to 21 years. Institutional Ethics committee has approved the study protocol and an informed consent was obtained from the study participants. Students with significant systemic diseases, history of old fractures, orthopaedic malformation which could have affected the bony growth were excluded from study. Each subject's body height and forearm (ulna) length were measured using a Martin-type anthropometer. For height measurement, the subject stood in bare feet with his back to the anthropometer. The head was adjusted so that the Frankfurt plane was horizontal, and was then tilted slightly upwards by applying gentle force to the mastoid processes and zygomatic bones [6]. For ulna length, the subject's elbow was flexed to 90° with fingers extended in the direction of the long axis of the forearm, and the distance between the most proximal point of the olecranon and the tip of the styloid process of the ulna was measured [7]. All measurements were recorded to the nearest millimeter. The data was analyzed statistically using SPSS software version-20 for calculation of Mean, SD, Standard error, Correlation coefficient, Regression coefficient, value of constant and 't' test for correlation coefficient.

## Result

**Table 1:** Height, length of right ulna and length of left ulna in Mean±SD of male and female subjects.

Parameter	Measurements (Mean±SD)		Range (min – max )	
	Males (cm)	Females(cm)	Males (cm)	Females(cm)
Height	166.83±5.93	157.96±5.96	158 – 185	145 – 168
Length of Right ulna	27.95±1.34	25.56±1.27	24.50 – 29.95	22.10 – 28.10
Length of Left ulna	27.75±1.31	25.49±1.33	24.10 – 29.80	21.67 – 28.20

**Table 2:** Comparison of length of right and left ulna

Gender	Mean Length of Right	Mean Length of Left	p-value	t-value
	ulna (cm)	ulna (cm)		
Male	27.95	27.75	>0.05	0.56
Female	25.56	25.49	>0.05	0.62
p-value	<0.001	<0.001		
t-value	12.83	12.79		

**Table 3:** Correlation of height with length of ulna in male and female subjects

subjects	Correlation coefficient (r)		Coefficient of Determination (r <sup>2</sup> )		p-value
	Right	Left	Right	Left	
	Male	0.745	0.749	0.587	
Female	0.680	0.681	0.489	0.588	<0.0001

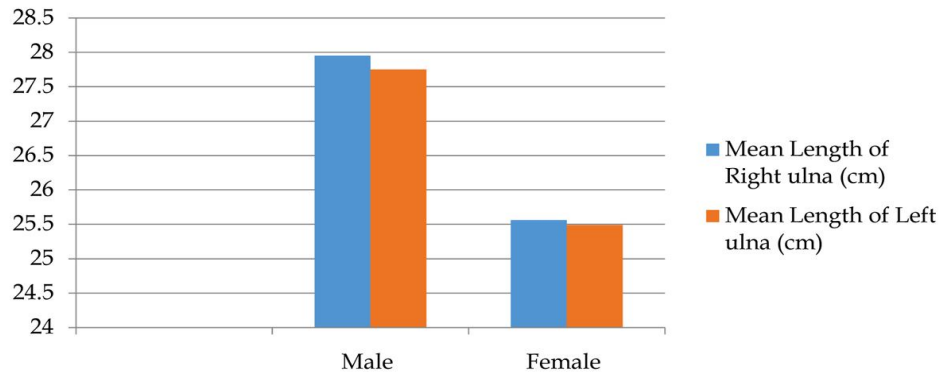


Fig. 1: Comparison of length of right and left ulna of male & female

Table 4: Percentage of Determination

Sex	Side	Correlation coefficient (r)	r <sup>2</sup>	% of determination	Regression equation (Y= a+bX)
Male	Right	0.745	0.587	55.75	Y=63.984+2.92X
	Left	0.749	0.698	56.5	Y=66.232+2.91X
Female	Right	0.680	0.489	48.7	Y=57.995+2.38X
	Left	0.681	0.588	50.2	Y=56.048+2.39X

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

The study subjects were analyzed according to their height and length of ulna as follows Table 1. The comparison between the height of the individual and length of ulna of male and female has been done in Table 1. The mean height of male was  $166.83 \pm 5.93$  cm (range: 158 – 185 cm) and female was  $157.96 \pm 5.96$  cm (range: 145 – 168 cm). The difference between the mean heights of male and female was statistically highly significant ( $P < 0.001$ ). The mean length of right ulna bone in male was  $27.95 \pm 1.34$  cm (range: 24.50 – 29.95 cm) and in female was  $25.56 \pm 1.27$  cm (range: 22.10 – 28.10 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  $27.75 \pm 1.31$  cm (range: 24.10 – 29.80 cm) and in female was  $25.49 \pm 1.33$  cm (range: 21.67 – 28.20 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  $27.95 \pm 1.34$  cm and left ulna was  $27.75 \pm 1.31$  cm in males. In females, the mean length of the right ulna was  $25.56 \pm 1.27$  cm, and left ulna was  $25.49 \pm 1.33$  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 0.745 (right ulna) and 0.749 (left ulna) in males; 0.680 (right ulna) and 0.681 (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. The % of determination which was derived from correlation coefficient (*r*) showed that the male right ulna determined the height of the individual by 55.75% (*r*<sup>2</sup>) and left ulna determined the height by 56.5% (*r*<sup>2</sup>). Similarly, the female right ulna determined the height of the individual by 48.7% (*r*<sup>2</sup>) and left ulna determined the height by 50.2% (*r*<sup>2</sup>) as shown in table.

## Discussion

This study was conducted to see if there is any relationship between length of ulna bone and height of an individual. A regression equation was derived with the acquired data, 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 Maharashtra population. The mean height of male was 166.83 cm and female was 157.96 cm in this study, which was also observed in other studies done in India population like Madhya Pradesh (males: 167.5 cm, females: 152.5 cm), Maharashtra population [1] (males: 171.9 cm, female: 165.4 cm), West Bengal population [8,9] (males: 164.3 cm, females: 153.8 cm), Gujarat population [2] (males: 169.8 cm, females: 155.2 cm), and Sri Lanka population [10] (males: 170.1 cm, females: 157.6 cm).

Ulna is a bone with prominent surface landmarks, its easily accessible and is subcutaneous bone. These qualities of ulna bone make it a perfect anatomical structure for taking anthropometric measurements in a large scale. The estimation of height from the length of the ulna was more accurate and reliable when compared to other bones. Ulna bone length can be advantageous, especially when there is a lower trunk and lower extremity deformity [11].

In this study, the coefficient correlation ( $r$ ) was 0.745 (right ulna) and 0.749 (left ulna) in males; 0.680 (right ulna) and 0.681 (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. Correlation was used to predict the significant relationship between the height and length of ulna of the subjects.

This was also similar to Prasad et al [1] who calculated the coefficient correlation ( $r$ ) as 0.65 in males and 0.68 in females. Mondal et al [8], 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. These findings are in agreement with the studies of Mondal et al and Prasad et al, confirming this study's observation that length of ulna bone can give a correct estimation of height as there is a very high significant relation between the length of ulna and height [1,8,9].

To ascertain the relation between the height of ulna and the height of individuals a regression equation was done. Researchers have stated that the regression coefficient 'b' is the determinant of the height.

Table 5 Shows the regression coefficient of different studies.

In the present study conducted in the state of Maharashtra, in India. The regression coefficient of male was 2.92 in right side and 2.91 in the left side. For females the regression coefficient was 2.38 and 2.39 on right and left side respectively. Our findings were very similar to the findings of other studies conducted in the India and Asian subcontinent. Thummar et al [2] conducted a similar study in the Gujarat state of India. The regression coefficient of male was 3.117 in right side and 3.667 in the left side. For females the regression coefficient was 5.314 and 5.335 on right and left side respectively. In a study conducted in Tamilnadu by Anupriya A et al [12], the regression coefficients were 3.631 and 3.551 on right and left side respectively for males and for females it was 3.745 and 3.839 on the right and left side respectively. Mondal et al [8] studied the relation between height of ulna and height of an individual in Bengali population they got a regression coefficient of 4.19 on right side and 3.26 on left side for male and 3.89 on right side and 4.39 on left side for females. There was difference in the regression coefficient as these studies were conducted in the different geographical locations in India.

Prasad et al [1] in their study conducted in Maharashtra got regression coefficient as 2.92 on right and left side for males. 2.37 on right and left side for females. While Illayaperumal et al [10] from Sri Lanka got a regression coefficient of 2.645 on right and left side for males and 3.536 on right and left side of females.

**Table 5:** Comparison of Coefficient of regression of present study with other studies

Study	Region	Male		Female	
		Right	Left	Right	Left
Present study	Maharashtra	2.92	2.91	2.38	2.39
Thummar <i>et al.</i> <sup>2</sup>	Gujarat	3.117	3.667	5.314	5.335
Anupriya A <i>et al.</i> <sup>12</sup>	Tamil Nadu	3.631	3.551	3.745	3.839
Mondal <i>et al.</i> <sup>8</sup>	West Bengal	4.19	3.26	3.89	4.39
Prasad <i>et al.</i> <sup>1</sup>	Maharashtra	2.92	2.92	2.37	2.37
Mehta <i>et al.</i> <sup>13</sup>	Madhya Pradesh	3.562	3.285	3.562	3.285
Illayaperumal <i>et al.</i> <sup>10</sup>	Sri Lanka	2.645	2.645	3.536	3.536
Allbrook D <sup>14</sup>	British	3.06	3.06	3.06	3.06

The observation from our study strengthens the relation between length of ulna and height of individual. The equation can be used for determining the height of individual in the cases of deformity of the axial skeleton or the lower limbs where a person cannot stand erect for height measurement [15]. Furthermore the equation can be used in the forensic investigations where only skeleton remains are found and approximate height of the individual needs to be determined to

ascertain the identity of the diseased person [16].

## Conclusion

Our study concludes that the length of ulna is a strong determinant of the height of the individual and if used by the clinicians, forensic experts, anthropologists and nutrition assessors it will help in determining the height of the individual.

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