Estimation of male stature by ulnar length in Madhya Pradesh region by using linear regression analysis

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Abstract

Introduction: Establishment of reliable formula for stature estimation from fragments of bones especially in forensic examination is important for individual identification. Sexual differences in height and of long bones exist so there is need for studies emphasizing quantitative standards of sexual dimorphism in different populations. Limited availability of gender specific studies of stature estimation by using individual bones provide data for forensic identification that led me to study ulna bone to establish a linear regression equation for stature estimation in living adult males of age group 18-26 yrs in Madhya Pradesh region. **Material & Methods:** Cross sectional study was conducted in Department of Anatomy, Gandhi Medical College, Bhopal (M.P.) on 238 males by using anthropometer and spreading caliper and statistically analyzed. Ulna length were measured independently on right and left sides of each subject with the help of spreading caliper from the tip of olecranon process to the tip of styloid process and vertex to heel height was measured in the standing erect posture with subject looking forward straight to the horizon. **Results:** Value of correlation coefficient(r) of right ulna with stature was found to be 0.995 and left ulna with stature was 0.997. Regression equations and graphs interpret the height from the ulnar length in males. **Conclusion:** The regression formula derived will be useful for anatomists, clinician, anthropologists and forensic experts for estimation of the individual stature in Madhya Pradesh region for establishing identity.

Keywords: Male Stature, Olecranon, Ulnar length.
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Introduction

Anthropometry is defined as systematized techniques for measuring and taking observations on man, his skeleton, the skull, the limbs, and trunk etc., as well as the organs, by the most reliable means and scientific methods. Anthropometric characteristics have a direct relationship with age, sex, shape, and form of an individual. These factors are intimately linked with each other and manifestation of the internal structure and tissue components which in turn are influenced by environmental and genetic factors [1]. As infants grow, they change their body proportions gradually towards adult shapes; these proportions diverge towards one sex at puberty. Assessment of stature from the different

parts of the body by the anthropometric study of the skeleton is an area of interest to anatomist, anthropologists and to forensic experts [2,3].

Estimation of stature from the measurement of limb bones has long been formulated and the accuracy of such estimations improved over time. Most forensic and anthropological studies use stature estimation developed by an eminent scientist [4]. Pearson K first introduced the correlational calculus into the field of work for prediction of stature from the measurement of long bones. Height is one of the factors in the description of impressiveness of an individual and it varies with race, age, sex, heredity, climate and nutritional status [5]. Telkka A. et al, worked on bones of Finns expressed the opinion that each racial group needs a separate formula

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for estimation of stature. He measured six long bones such as humerus, radius, ulna, femur, tibia and fibula to obtain stature of the corpse [6].

Establishment of reliable formula for stature estimation from fragments of bones is especially important for individual identification. Sexual differences in height and long bones exist, so there is a need for studies to emphasize the need for standards of sexual dimorphism in a different population. Lundy JK discussed the regression equation, mathematical and anatomical method for estimating living stature from long limb bones [7,8]. In ancient observation in India (Charaka and Vagbhat) that the height of an individual is nearly three and a half times the length of his "cubit" (point of the elbow to the tip of middle finger), hence the radius and ulna were considered the most suitable bones for deriving a relationship with height [9].

Cadavers cannot represent the population and might have suffered from the chronic debilitating disease, likely to have been lying in an abnormal posture and it may be not possible to straighten the body to get accurate stature measurement.

All these problems led me to study in the living males. In the present study, the ulna is selected to establish a relationship between stature of individual and length of ulna as a tool for forensic identification and anthropometric studies, because ulna is subcutaneous throughout its length.

Hence it is easily approachable for the measurement. The purpose of present study was to find out the height of all subjects by measuring maximum ulna length and correlation of height with the length of ulna by the regression equation.

Material and Methods

The present study was conducted in Department of Anatomy, Gandhi Medical College, Bhopal (M.P.) on a total 238 male subjects by using anthropometer and spreading caliper after due permissions and informed consent from the subjects. Subjects who have any kind of ailments or upper limb deformity and those who did not give consent for participation in the study were excluded.

Ulna length was measured independently on right and left sides of each subject with the help of spreading caliper from the tip of olecranon process to the tip of the styloid process with elbow flexed and palm spread over opposite shoulder[Figure-1]. Vertex to heel height was measured in the standing erect posture with the subject looking forward straight to the horizon so that Frankfurt's plane remains horizontal. Height was measured from floor level to the highest point over the head marked by the tangentially placed ruler [Figure-2]. All measurements were taken between 2:00 PM to 3:00 PM because of diurnal variation in height.
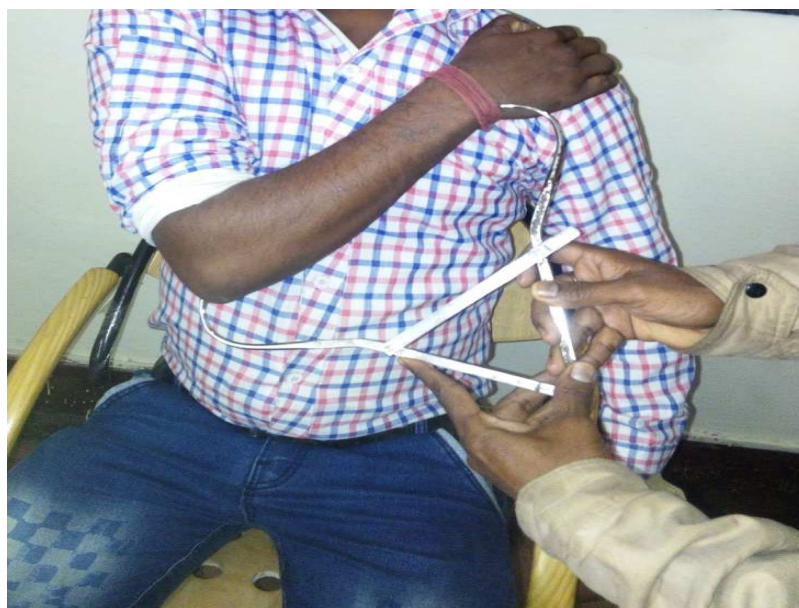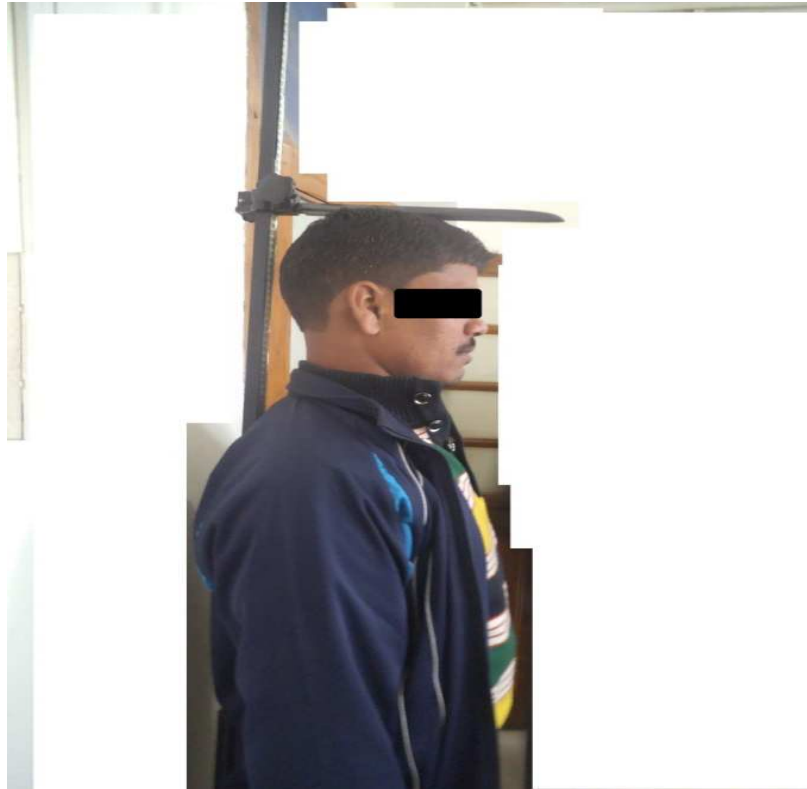

Figure-1: Showing ulna measurement

Figure-2: Showing Stature measurement

The correlation coefficient measures the relationship or association between two quantitatively measures or continuous variables. The extent or degree of relationship between two sets of figures is measured in terms of another parameter called correlation coefficient. It is denoted by letter 'r'. It is calculated by following formula:-

$$r = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2 \sum (y - \bar{y})^2}}$$

Like correlation, regression is also used to describe the relationship between two variables. Linear regression helps in predicting the values of the dependent variable, given that we know the values of the independent variable. At least two observations on a data pair (i.e. variable x and y), is needed to derive a linear equation.
The general form of the equation is Y=a + bx

The obtained values were used for the statistical analysis which was done by using the SPSS-14.0 software for the required analysis. As in our study, a 95% confidence interval (which was equivalent to 1.96 standard deviations) was accepted and the standard error of regression (STE) was calculated. Therefore the final equation in our study is **Y = (a + bx) $\pm$ (1.96 $\times$ STE). Y** denotes height, **a** value of constant, **b** regression coefficient and **x** length of ulna.

Results

All the male subjects under study were in the range of 18- 26 yrs with the highest frequency in 21-22 yrs (31.9%) of age group followed by 22-23 years 19.3%) and 20-21 years (18.9%) age group [Table-1]. Height of the subjects were range from 154.4 cms to 188.4 cms. Mean stature height was 168.19 cms [Table-2 & 3]. In the present study, ulnar length was range from 24.5 to 32,9 cms, with mean ulnar length 27.77 cms [Table-3]. The mean length of the right ulna was 27.88 cms and left ulna was 27.67 cms [Table-2].

Table 1: Age distribution of all subjects.

Age group (in years)	Total numbers and percentage (%)
18-19	07 (0.08%)
19-20	22 (9.24%)
20-21	45 (18.9%)
21-22	76 (31.9%)
22-23	46 (19.3%)
23-24	28 (11.7%)
24-25	05 (2.1%)
25-26	09 (3.8%)
Total	**238**

Table 2: Mean and standard deviation of stature and length of ulna of all subjects

Age in years	Height mean ± SD	length of Rt. ulna mean ± SD	length of Lt. ulna mean ± SD
18-26	168.19 ± 5.62	27.88 ± 1.55	27.67 ± 1.53

Table 3: Selected parameters for all subjects.

Parameter	Values and Ranges
• Total No. of subjects	238
• Mean age	21.18 ± 1.50
• Height Range (cm)	154.4 - 188.4
• Mean Height	168.19± 5.62
• Ulna length Range (cm)	24.50 - 32.90
• Mean ulna length	27.77 ± 1.25
• Correlation coefficient	0.995(Height – Right Ulna) 0.997(Height – Left Ulna)
• Regression coefficient (b)	3.60 & 3.64 (Right & Left Ulna)
• Value of constant (a)	67.60 & 67.30 (Right & Left Ulna)

Table 4: Correlation coefficient between height and ulna length.

Parameter	Coefficient Value	Probability	Result
Height – Right Ulna	.995	<0.01	Significant
Height – Left Ulna	.997	<0.01	Significant

In this study, stature height of the males were significantly correlated with the right ulnar length ($r = 0.995$, $p < 0.01$) and left ulnar length ($r = 0.997$, $p < 0.01$) [Table-4]. The regression equation for stature estimation in the present study was derived by formula **Y = (a + bx) $\pm$ (1.96 × standard error of regression).** For height, **Y**=**67.60+3.60** (**Right ulna length) $\pm$ (1.078**) and **67.30+3.64(Left ulna length) $\pm$ (0.784**).

Discussion

The stature of an individual is an inherent characteristic. The estimation of which is considered to be an important assessment in the identification of unknown human remains. Height-estimation formulae based on length of ulna show similar levels of accuracy to calculations based on the length of other long bones of upper limbs [4]. Various methodologies have been proposed to estimate the stature from long bones of limbs, but regression analysis proved to be the easiest and the reliable method [2,10,11].

Ilayperuma I et.al conducted a study, in the age group of 20-23 years on medical students for estimation of stature from the length of forearm [2]. Similar to above studies, in our study, age group of 18 to 26 years is selected because up to the age of 18th years in male ossification of ulna bone is completed [3].

Thummar B et al, conducted a study in the age group of 20-40 years, for estimation of height from the ulnar length in Gujrat, and found mean height of the male was 169.87 cm, whereas mean right ulnar and left ulnar length in male were 28.48 cm and 28.39 cm respectively [10]. Mondal MK et al, reported that mean height of the male was 164.32 cm, whereas mean right ulnar length and left ulnar length were 27.13 cm and 27.01 cm respectively [12]. Similar to above studies, in the present study, the mean height of subjects was 168.19 cm and mean length of the right ulna and left ulna was 27.88 cm and 27.67 cm respectively.

Various studies had shown significant correlation between height and ulna bone length, other long bones and different parts of the body [13-15]. In our study there is linear relationship showing positive correlation between height and length of the ulna[Graph 1&2].
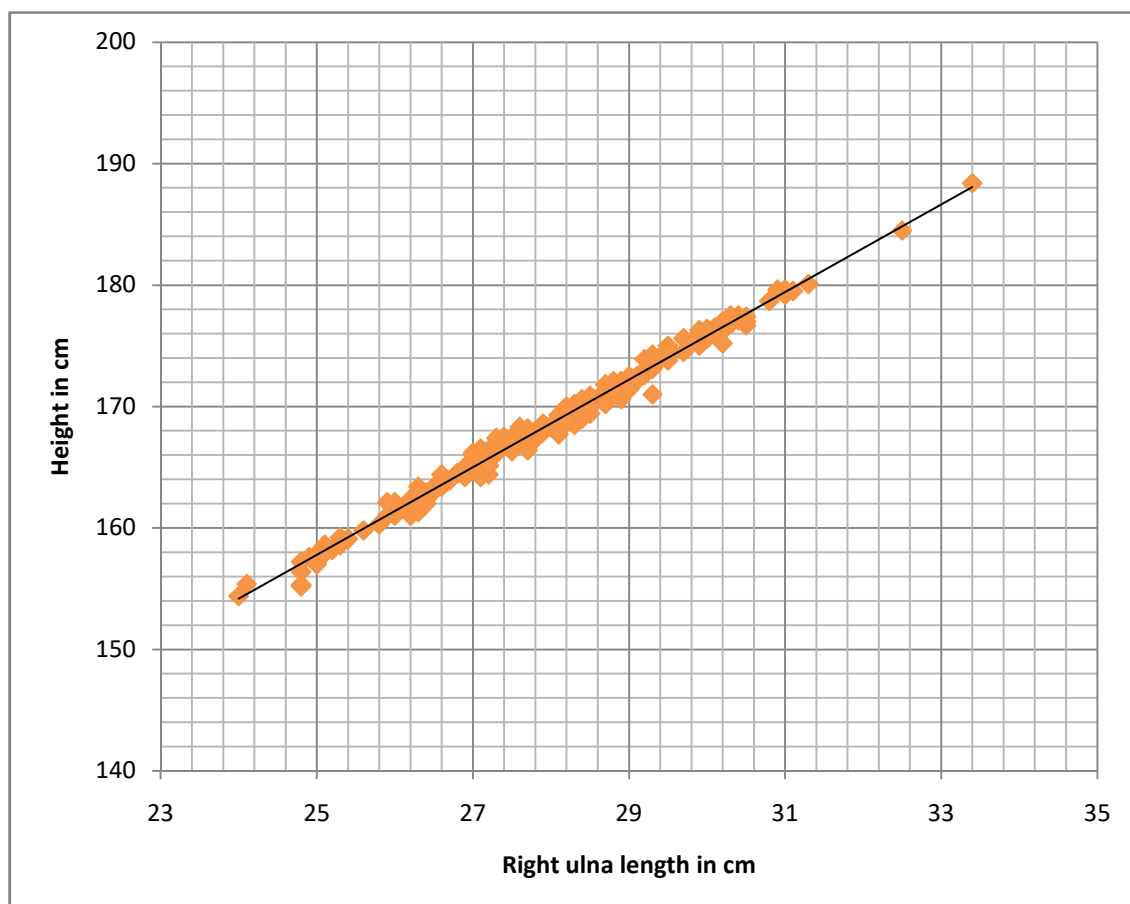
Graph-1: Linear regression line showing positive relationship between stature and right ulna length of all subjects

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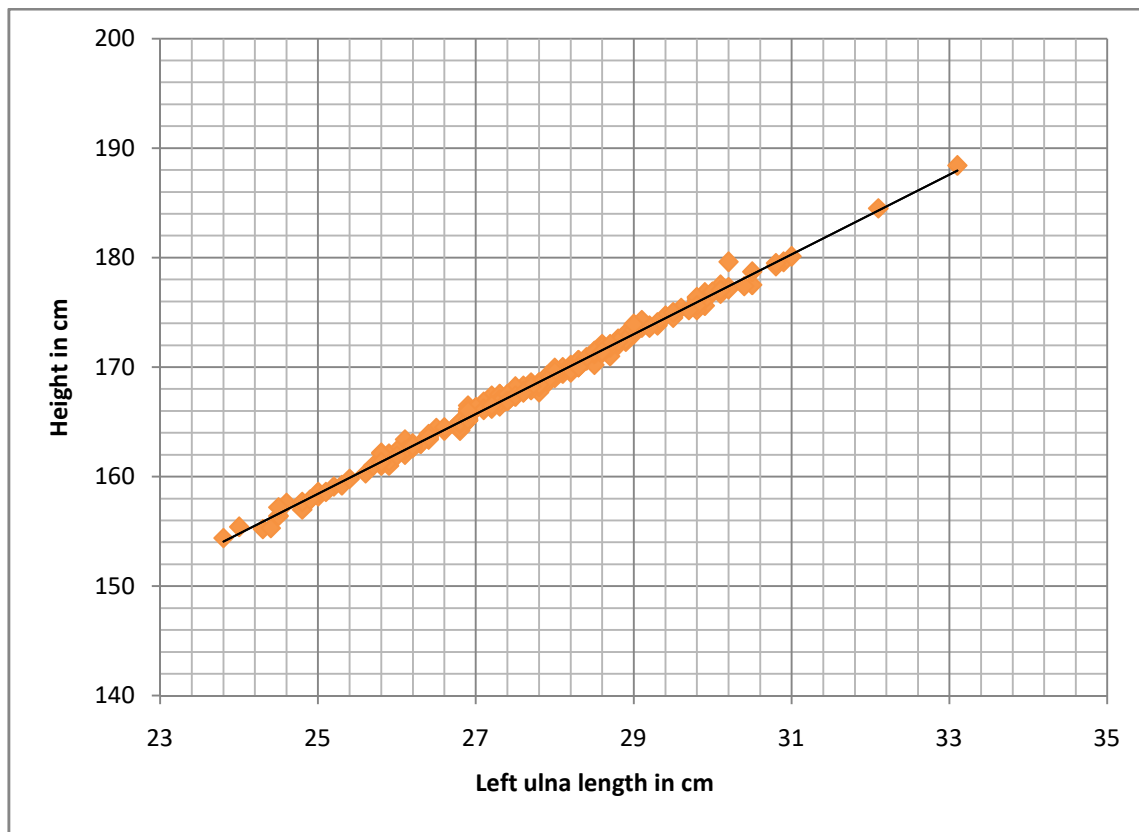
Graph-2: Linear regression line showing positive relationship between stature and left ulna length of all subjects

Trotter M et al, reported that different regression equations were required among different races, for establish the relationship between lengths of the long bones and stature. It is important to note that every race of particular age group and sex should have its own equations for estimation of height using various parameters [4].

In the present study, two separate formulae were derived for males of age group 18 to 26 years for estimation of stature from the measurement of ulna length in Madhya Pradesh region.

a.   Estimation of height from right ulna: $Y_1 = 67.60 + 3.60$ (Rt. ulna length) $\pm$ (1.078)

b.   Estimation of height from left ulna: $Y_2 = 67.30 + 3.64$ (Lt. ulna length) $\pm$ (0.784)

Conclusion

The correlation coefficient between the total height of male and their ulna length was found to be statistically significant. Regression models for stature prediction were formulated using lengths of the ulna and checked for their accuracy by comparing the estimated stature and the actual stature. Our results further confirmed that ulna length provides an accurate and reliable means in stature prediction. The regression models proposed will be of immense practical use in clinical practice, medico-legal and anthropometric studies where total height of a subject can be calculated if the ulna length is known.

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