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Estimation Of Stature Using Ulnar Measurements In Adult Males of Ethiopian Population

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Abstarct
Stature estimation of an individual from body parts & skeleton is very much important in anatomy, anthropology & forensic medicine. Identification of individuals from mutilated, partially or completely decomposed or amputated body parts, as a consequence of natural & artificial disasters or of the individuals who are victims of crime is significant for medico legal purpose.The forearm medial bone of humans known as ulna has a complete subcutaneous border which extends. This study was intended to define the ulnar measurements for the precise prediction of height, and to develop regression equations for stature for Ethiopian population from the anthropometric measurement.
Methods: Cross sectional study was carried out in the Department of Anatomy, Faculty of Medicine & Health Sciences, Hawassa University, Hawassa, Ethiopia on a total of 100 subjects. The subjects taken for study were students and staff members of age between 21-50 years from Hawassa University, Hawassa, Ethiopia. Stature and length of left and right was measured using standard protocol. The tabulated data were subjected to statistical analysis.
Results: In this study the correlation between stature with length of right ulna and left ulna was analyzed using Pearson product moment correlation andSpearman's Rank Order correlation and was found to be positively correlated.The calculated multiple linear regression equation for stature from the length of right ulna was YR= 77.738 + (3.3329 x Right ulnar length cm) ± 3.959 and for left ulna was YL = 80.946 + (3.239 x left ulnar length in cm) ± 4.199. The derived formulae can be used for forensic and anthropometric skeletal analysis of Ethiopian population.
Keywords: skeleton, Ulna, Anthropometric, Stature, Forensic, correlation

Introduction

Stature estimation of an individualfrom body parts & skeleton is very much important in anatomy, anthropology & forensic medicine. Establishing systematic quantitative measurements& dimensions of different parts of human body, organs and skeletons is the main purpose of anthropometry which in turn is main area of interests for anatomist & forensic medicine specialists(1).Stature of an individual is an important characteristic for personal identification. Indirect stature estimation of individual by correlating height with other body measurements is important clinically when direct assessment of height is impossible or not accurate, especially in old, seriously ill & bedridden, or patients with vertebral column & limb deformity.Identification of individuals from mutilated, partially or completely decomposed or amputated body parts, as a consequence of natural & artificial disasters (earthquakes, tsunamis, cyclones, floods, terror attacks, bomb blasts, wars, and planecrashes) or of the individuals who are victims of crime is significant for medico legal purpose. The accurate height and weight of an individual is also very much important to access the nutritional status andpharmacokinetic parameters. Moreover in vertebral column deformity stature measurements are not accurate by using stadiometer.
The living stature estimation from long bones is established up on the principle that most of the long bones in our body have a positively correlation with the stature. During identification of skeletal remainders, general demographic characteristics like age, race, &sex of an individual are determined first. To narrow the possibilities further and thus to increases the possibilities of identification of an individual, factors of individualization like stature are determined(2).
Krogman and Iscan reported that same prisoners while questioning declare different statures in different circumstances(3). So, the assessment of heightby means of long bones ofupper limbusing regression formula may give accurate results than personaldeclarations of stature on several occasions.Pearson K first presented the methodfor calculation of statureutilizing long bone measurements with the help of correlational calculus(4).The forearm medial bone of humans known as ulna has a complete subcutaneous border which extends the whole length of the bone from tip of olecranon process to the styloidprocess(5). For the same reason, length of ulna can be used effectively for the estimation of height of an individual. Telekka et al. studied on the long bones of the extremities and concluded that it is necessary to havediscrete formula for the assessment of stature for different racial group(6).

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So far few studies were conducted in this regard on Ethiopian population. More over African people have relatively long limb bones, and the formula calculated for non-African population is not appropriate forapplication on the African population(7). This study was intendedto definethe ulnar measurements forthe precise prediction of height, and to develop regression equations for stature for Ethiopian population from the anthropometric measurement.

MATERIALS AND METHODS

The present cross sectional study was carried out in the Department of Anatomy, Faculty of Medicine & Health Sciences, Hawassa University, Hawassa, Ethiopia on a total of 100 subjects. The subjects taken for study were students and staff members from Hawassa University, Hawassa, Ethiopia. The age groups of 21-50 years were selected and their height and length of right and left ulna were recorded. Stature is taken from vertex to the floor, retaining the anatomical position and Frankfurt horizontal plane. Length of ulna was measured usingVernier calipers from tip of the olecranon process to the tip of the styloid process with elbow flexed and palm spread over opposite shoulder. For calculations length of both right and left ulna were taken separately. Ethical approval was obtained from the concerned authority prior to the start of research. After collection of data, they were subjected to statistical analysis which includes Spearman's Rank Order Correlation, Pearson Product Moment Correlation and Mann-Whitney Rank Sum Test, which has given some important information regarding the following parameters such as mean, median, standard deviation, correlation coefficient, regression coefficient, standard error of estimate etc. All the statistical analysis was done using the statistical software Sigma Stat Version 4 (Sigma- ALDRICH Company, USA).

RESULTS

The mean height of the subjects was 171.32 ± 0.642 cm. The mean length of right ulna was 28.115 ± 0.152cm whereas the mean length of the left ulna was 27.90 ± 0.151cm.

TABLE – I

Descriptive Statistics of Variables

Variables	No. of samples	Mean	Median	Standard Deviation	Standard Error
Height	100	171.320	170.500	6.423	0.642
Right ulnar	100	28.115	28.500	1.524	0.152
Left Ulna	100	27.900	28.00	1.506	0.151

Table I shows the descriptive statistics of the extracted data that include mean, median, standard deviation and standard error.

Table II

The Correlation Data between Height ofthe Person with Length of Right Ulna And Left Ulna Using Different Methods

Group	No. of samples	Correlation Coefficient	'P' Value	Correlation
Pearson Product Moment Correlation				
HeightVsRight Ulna	100	0.790	0.022	+ve
HeightVsLeft Ulna	100	0.759	0.020	+ve
Spearman Rank Order Correlation				
HeightVsRight Ulna	100	0.750	0.000	+ve
HeightVsLeft Ulna	100	0.752	0.000	+ve

The pair (s) of variables with positive correlation coefficients and 'P' values below 0.050 tends to increase together.

Table II shows the correlation between stature of the person with length of right ulna and left ulna using Pearson product moment correlation. The correlation coefficient (r) of height and length of right ulna is 0.790 (p value .022) and of left ulna is 0.759 (p value 0.020). Since the p values of height v/s right ulna and height v/s left ulna are 0.22 and 0.020 respectively, they show positive correlation. The correlation between stature of the person with length of right and left ulna using Spearman's Rank Order correlation was depicted in table II. Since the correlation coefficient of height and length of right ulna using Spearman's Rank Order correlation is 0.000 and of left ulna is 0.000 respectively, they also showspositive correlation.

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As both the correlation analysis (Table II) shows positive correlation between stature and right ulna and left ulna, it is clear that stature increases with the increasing length of right ulna and left ulna.

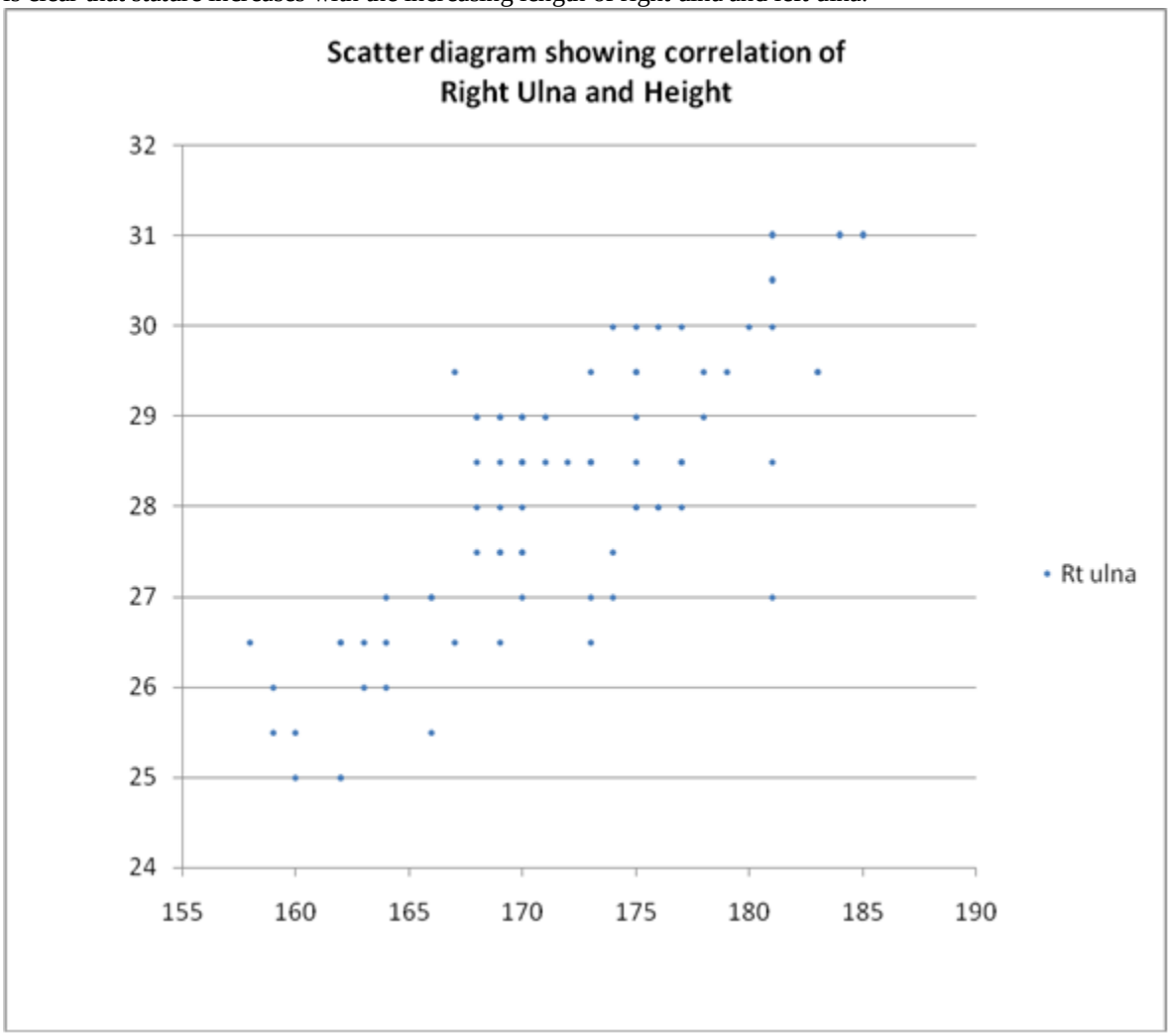

FIGURE I: Scatter diagram showing correlation of right ulna and height

Figure I depict the graphical representation, where length of right ulna (X) is plotted on the y-axis and height (Y) is plotted on the x-axis. The scatter diagram clearly shows that linear relationship exists between x and y that is between stature and right ulnar length. Thus there is positive relationship between height and ulnar length.

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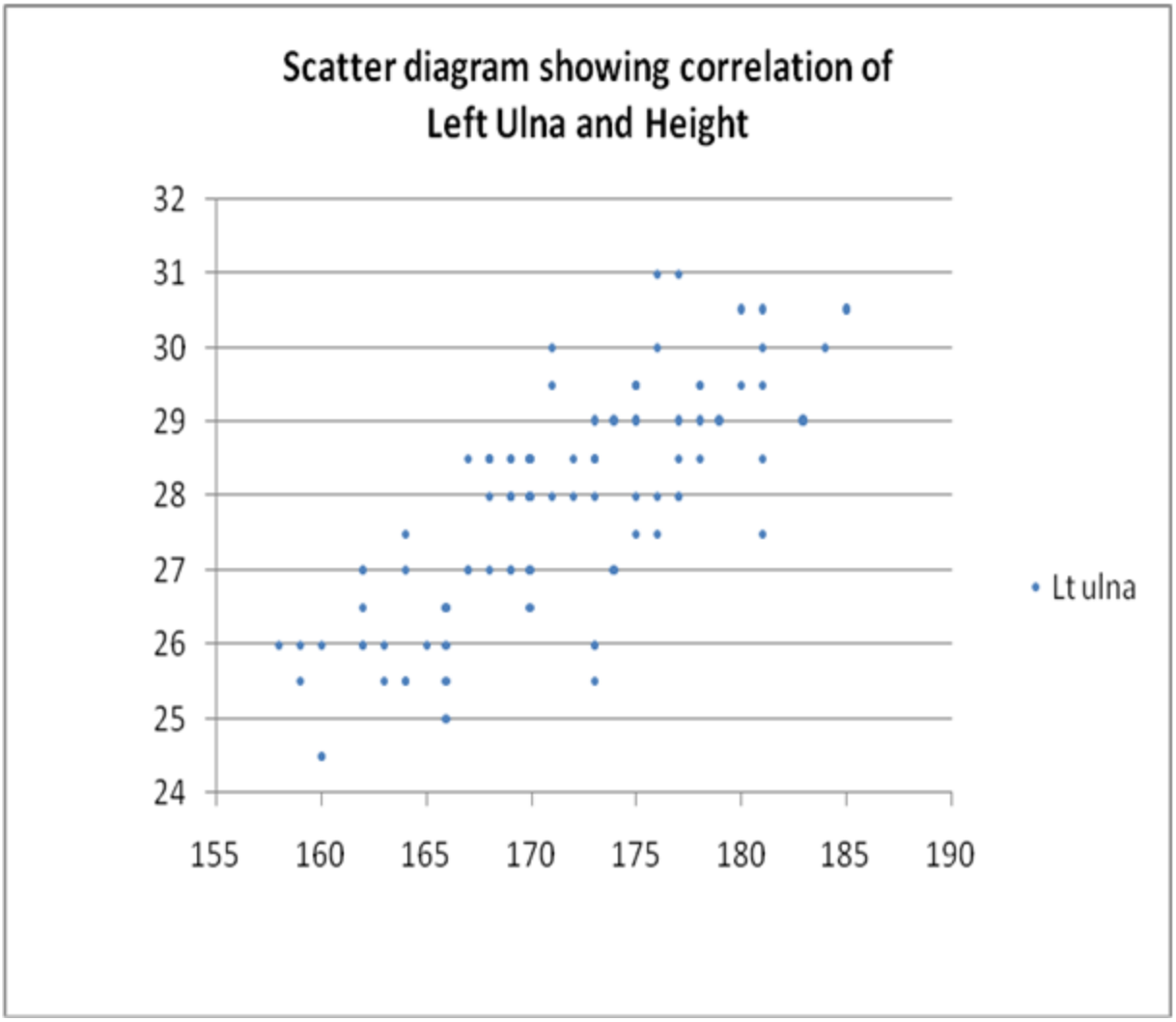

Figure II: Scatter diagram showing correlation of left ulna and height

Figure II depict the graphical representation, where length of left ulna is plotted on the y-axis and height (Y) is plotted on the x-axis. The scatter diagram clearly shows that linear relationship exists between length of left ulna and stature. Thus there is positive relationship between height and ulnar length.

TABLE – III
Shows the correlation between Right and Left Ulna using Mann-Whitney Rank Sum Test

Group	No. Of samples	Median	T	P
Right Ulna	100	28.500		
Left Ulna	100	28.000	9594.00	0.263

Normality Test : Failed

Table III shows comparison between right and left ulna using Mann-Whitney Rank Sum test. As the P value is 0.263, it is clear that there is no statistically significant difference between them. The apparent difference between the medium values of right and left ulna is not statistically significant but it can be due to random sampling variability.

The Standard Error of Estimate for right ulna was 3.959. The dependent variable height can be predicted from a linear combination of the independent variables length of right ulna (P = <0.001). Passed Normality test (P = 0.178) and constant variance test(P=0.271). Power of performed test with alpha is 0.050: 1.000.

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The Standard error of estimate for left ulna was 4.199. The dependent variable height can be predicted from a linear combination of the independent variable left ulna (P<0.001). Passed the normality Test (P=0.081) and Constant variance Test(P=0.622). Power of performed test with alpha is 0.050: 1.00

TABLE – IV
Multiple Linear Regression Analysis for Right and Left Ulna

Group	Coefficient	Standard Error	't'	'p'
For Right Ulna				
Constant	77.738	7.352	10.574	<0.001
Right Ulna	3.329	0.261	12.747	<0.001
For Left Ulna				
Constant	80.946	7.831	10.337	<0.001
Left Ulna	3.239	0.280	11.557	<0.001

Multiple linear regression analysis for right ulna represented in Table IV demonstrates that a linear combination of the independent variable, right ulnar length (cm) is predictive of the dependent variable height. The value of t is 12.747 and p value is <0.001 so the value of t is found to be statistically significant. It isalso evident that the estimated stature from right ulna was YR= 77.738 + (3.3329 x Right ulnar length cm).The standard error of estimate works out to be 3.959. Thus at 95% confidence level (power of performed test with alpha = 0.050: 1.00) the estimated stature of male was,YR= 77.738 + (3.3329 x Right ulnar length cm) ± 3.959 (SEE).This is the multiple linear regression equation for stature from the length of right ulna.

From the multiple linear regression analysis for left ulna presented in Table IV, it is apparent that the dependent variable height can be predicted from a linear combination of the independent variable left ulna. The value of t is 11.557 for ulna, p value is < 0.001 and it is statistically significant. So the estimated stature from right ulna wasY_L = 80.946 + (3.239 x Left ulnar length in cm). The standard error of estimate works out to be 4.199. Thus at 95% confidence level (power of performed test with alpha = 0.050: 1.00), the estimated stature of male was Y_L = 80.946 + (3.239 x left ulnar length in cm) ± 4.199.This is the multiple linear regression equation to estimate stature from the length of left ulna

DISCUSSIONS

Even though various methods are used to establish the identity of unknown human remains, the reliability of each method varies. Stature estimation in personal identification process is greatly important in physical anthropology. But unfortunately the main pitfall of these methods is the limited availability of fragmentary remains especially if the body has been mutilated such as the limbs or head amputated from the trunk. In these situations, an estimate must be made based on the known relationship of remains to stature. The introduction of regression formula developed in the modern populations has improved the recovery of stature estimation.

Trotter M et al., estimated the statureof American whites and negroes from the ulna with linear regression equations(8).LundyJK et al. estimated the stature from the long limb bones in the South African population and discussed effectiveness of the regression equation and the mathematical and theanatomical method of stature estimation(9). Agnihotri AK et al. and Barbaosa VM et al. studied on Mauritius and Portuguese populations respectively and found that linear regression model is best model to estimate an individual's stature from the percutaneous ulnar length(10, 11).

In South India, linear regression equations have been derived for stature estimation from measurements of different segments of the vertebral column, hand dimensions and by using odontometry and skull osteometry(12).Mondal et al. formulated a linear regression equation for estimation of stature from the length of ulna for both males & females in Burdwan district and adjacent areas of West Bengal(13, 14).Allbrook D derived regression formula for estimation of stature from the length of ulna as stature =88.94 +3.06 (ulnar length) ± 4.4 9 standard error)(15). Athwale studied one hundred Maharashtrian males of age ranging from 25 to 30 years with the help of various graphs; he showed that there is definite correlation between stature of an individual with length of forearm bones and also with upper limb(16). The regression formula derived for estimation of stature form length of long bones for Maharashtrian population was stature = 59.2923cm + 4.1042 x average length of right and left radius (cm) ± 3.64cm. Stature = 56.9709cm + 3.9613 x average length of right and left ulna(cm) ± 3.64cm.

Many workers around the world estimated stature from different parts of the body in different ways(17-23). Various other workers have shown significant correlation between height and different parts of the body. Singh and Sohal, Jit

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and Singh have shown a significant correlation between height and length of clavicle(24, 25). Lal andlalaworked in the estimation of height by surface anatomy of long bones like tibia and ulna. The ulnar mean multiplication factor was comparable in all series and claimed that ulnar multiplication factor is better guide for calculation of height, when it is not definitely known to which part of the country the individual belongs(26). Devi et.al, studiedthe upper arm length of living population of Maring tribes of Manipurand calculatedthe correlation coefficient (r= 0.619 for male and 0.584 for female) and regression equation formula for estimation of stature(27). Digssie,A et al,developed an equation for estimatingbody height from linear bodymeasurements of Ethiopian adults usingthe three linear body measurements such as arm span, half arm span & Knee height(28).Patel Joshi and Dongre have derived regression equation between tibia and total height of persons in Gujarati population(29).

In the present study, the correlation coefficient (r) of height and length of right ulna is 0.790 (p value +0.022) and the correlation coefficient of height and length of left ulna is 0.759 (p value +0.020) (By using person product moment correlation). When Spearmans Rank Order correlation is used, the correlation coefficient of height and length of right ulna is 0.750 (p value 0.000) and of left ulna is 0.752 (p value 0.000). The value of r implies that there is positive correlation.

The p values from the table II shows that the height of an individual is related to length of ulna. That is the height is more if the length of ulna is more. This holds true for the sample size taken. Body dimensions which correlate highly with stature would provide more accurate estimate of stature as compared to the one that has a relatively low correlation with stature.

The usefulness of regression equation is generally assessed on the basis of their standard error of estimate. In this study standard error of estimate was 4.199, while using left ulna and was 3.959, while using right ulna. Thus, two separate formulae (one for right ulna and one for left ulna) were derived for Ethiopian population by using multiple linear regression equation for male.

FOR RIGHT ULNA

Stature= 77.738 + (3.329 x right ulnar length in cm) ± 3.959

FOR LEFT ULNA

Stature = 80 .946 + (3.239 x left ulnar length in cm) ± 4.199

This multiple linear regression equation derived can be used for estimation of stature in Ethiopian population.

CONCLUSION

This study was carried out to investigate the possibility of estimating the height of a person from ulnar length by the application of regression analysis. The study indicates that stature can be predicted from the length of ulna by multiple linear regression analysis. The equation presented in this study can be used in forensic cases for human identification when only right or left ulna is available, since regression equation in known to be population and sex specific.

Similar studies applied to the Ethiopian female population are proposed. Additional research on a large sample needs to be conducted in this region to further confirm the relationship between stature and ulnar length. Hence, it is clear that if either of the measurement of either right ulna or left ulna is known, the stature of the person can be estimated. Moreover, this may be of practical use in medico legal investigation and also in anthropometry.

Conflict Of Interest:

No conflict of interest.

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Not applicable.

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