Original Article

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Estimation of Personal Height From the Percutaneous Length of Ulna in Maharashtra Region (Regression Analysis)

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Abstract

Aims and objective: An effort was made to formulate a linear regression equation for prediction of personal height from the length of an ulna bone. *Material and Methods:* The present study was carried out on 326 (males 166 and females160) medical and paramedical students of PDVVPF's medical college, Ahmednagar, Maharashtra (age 18 to 25 years). The parameters measured are height and the length of right and left ulna. *Observations:* They were recorded in tabulated form and analysed statistically for mean, standard deviation, standard error, correlation coefficient (r), regression constant (a), regression coefficient (b) and standard error of estimation to formulate the linear regression formula. *Results:* The correlation coefficient (r) for male was 0.76 ($p < 0.01$) and 0.74 ($p<0.01$) for right and left ulna. The correlation coefficient (r) for female was 0.67 ($p<0.01$) and 0.66 ($p<0.01$) for right and left ulna. Considering both sex together it was 0.84 ($p<0.01$) for right and left ulna. The mean ulna length is higher in males than females. *Conclusion:* There is a definite correlation between length of ulna and height of an individual. The regression formula proposed in study will be useful for clinicians, anatomist, anthropologist and forensic experts.

Keywords: Linear Regression; Height; Ulna; Correlation Coefficient (r).

Introduction

The growth is a vital process measured by measuring the height of a person. The estimation of height by measurement of various long bones has been attempted by various authors. Pearson k.et al [1] introduced first time the correlation calculus for prediction of height from measuring various long bones. Height itself is a sum of certain long bones and an appendages of body parts.so they show certain relationship with total strature [2]. So the prediction of height from different parts of skeleton by anthropometric analysis is an area of interest to anatomist, anthropologist and forensic experts [3]. The main aim of taking help of anthropometric study in forensic science is to help the law enforcement agencies in achieving "personal identity" in case of an unknown human remains [4]. Also establishing identity of an individual from mutilated, decomposed and amputated body fragments has become important in present era due to natural or manmade disasters. It is important for both legal and humanitarian reasons .But the relationship between height and long bones differs according to race, age, sex and also influenced by environmental and genetic factors [4].

Pan N [5] worked on cadavers to derive relation between total height and length of ulna bone. Telekka et al. [6] also worked on the long bones of limbs and expressed his opinion that each racial group need a separate formula for estimation of stature. After that many workers worked on cadavers and living to give different formulae for prediction of height from length of long bones.

The ulna is a long bone which lies on medial side of forearm. It has easily identifiable surface landmarks which make the measurements more comfortably in compromised posture. Both ends are placed superficially. So ulna is often used long bone to estimate body height. Accordingly here also efforts are taken to derive linear regression formula to

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predict height from the length of ulna in males and females in Maharashtra region.

Materials and Methods

The present study was carried out on 326 healthy medical and paramedical students belonging to various regions of Maharashtra studying in PDVVPF'S Medical institute, Ahmednagar, Maharashtra over the period of two years. Out of total 326 subjects, male subjects were 166 and female subjects were 160 in number. Their ages ranged between 18 to 25 years. Subjects having old fractures, any significant disease, orthopaedic deformity, metabolic or developmental disorders which can affect general or bony growth were excluded from study. For every subject the height and length of right and left ulna were recorded. Measurements were always taken at a fixed time, between 3pm to 5pm to eliminate discrepancies of diurnal variation

Prior to the commencement of this study, the necessary permissions were taken from the institutional ethics committee. Informed consents were taken from each individual before including in the study.

The vertex to heel height was measured for each subject with them in standing erect posture with bare foot and head oriented in Frankfurt's plane with height measuring instruments.(Fig. 1) The height was recorded in centimetre. The length of ulna was measured with the help of anthropometric measuring tape from tip of olecranon process to tip of styloid process with elbow flexed (Fig. 2). Measurements of

Fig. 1: Figure showing measurement of height in erect posture

Fig. 2: Figure showing measurement of length of Ulna

length of right and left ulna were taken separately for calculation.

The obtained data were used to statistical analysis for calculation of mean, standard deviation, standard error, correlation coefficient (r), regression constant i.e. intercept (a), regression coefficient i.e. slope (b) and t test applied for correlation coefficient to test the statistical significance. The relationship between the changes of dependant variable (say, y) and an independent variable (say, x) was ascertained by simple linear regression, with the Regression coefficient (b), where the model of regression equation was $y = a + bX$(where a= y intercept, when $x = 0$). As in every equation a 95% confidence interval (which was equal to 1.96 standard deviation) was accepted and the standard error of regression (STE) was calculated. The final equation model was $y = a + b X \pm (1.96 \times STE)$

Results

The observations were recoded separately for Rt. and Lt. Ulna for each sex. Then they were tabulated and analysed separately with help of computer in Microsoft Windows XP Professional with Microsoft Excel 2010 using its standard statistical formulae.

Table 1 shows that mean height for male subject is 169.21 ±6.56 cm and mean of length of Right and Left ulna is 28.13 ± 1.61 and 27.81 ±1.60 cm respectively. It also shows that range for height for male is from 146 to 187cm, while range for length of Rt. and Lt. ulna is 23 to 32cm and 24 to 32cm respectively.

In the same way Table 2 shows values for Female subjects. The Mean height for female is 155.58 ± 6.01 cm. The Mean of length of Rt. and Lt. ulna is 25.68 ±1.36 cm and 25.25 ±1.26 cm respectively. While the range of height is 143 to 177 cm. The range for length of Rt. and Lt. ulna is 22 to 30cm and 22 to 29.5cm respectively.

While the Table 3 shows values when both sex are considered together. The Mean of height is 162.52 ± 9.27cm and it ranges from 143 to 187 cm. While the Mean of length of Rt. ulna and Lt. ulna is 26.93 ±1.93cm and 26.56 ±1.93 cm respectively. The range of length of Rt. and Lt. Ulna is from 22 to 32 cm.

Table 1: Male Subjects: n=166

Parameters	Mean	S.D.	Range
Height (cm)	169.21	6.56	146-187
Length of Rt. Ulna(cm)	28.13	1.61	23-32
Length of Lt. Ulna (cm)	27.81	1.60	24-32

Table 2: Female Subjects: n=160

Parameters	Mean	S.D.	Range
Height (cm)	155.58	6.01	143-177
Length of Rt. Ulna(cm)	25.68	1.36	22-30
Length of Lt. Ulna (cm)	25.25	1.26	22-29.5

Table 3: For both sex together: n=326

Parameters	Mean	S.D.	Range
Height (cm)	162.52	9.27	143-187
Length of Rt. Ulna(cm)	26.93	1.93	22-32
Length of Lt. Ulna (cm)	26.56	1.93	22-32

Table 4: Comparison of length of Rt. Ulna and Lt. Ulna:

Subjects	Length of Rt. Ulna(cm)	Length of Lt. Ulna(cm)	P value	t value
Male	28.13	27.81	0.936	1.012
Female	25.68	25.25	0.336	1.65

Table 5: Correlation of Height with length of ulna in Male and Female subject:

Subject	Correlation coefficient (r)		Coefficient of Determination (r^2)		P Value
	Rt.	Lt.	Rt.	Lt.	
Male	0.76	0.74	0.57	0.54	P < 0.01
Female	0.67	0.66	0.44	0.43	P < 0.01
Both sexes together	0.84	0.84	0.71	0.71	P < 0.01

Table 6: Regression equation for Height with length of ulna in Male and Female:

Subject	Side	Regression Equation
Male	Rt. Side	Y = 82 + 3.09 x Rt. ulna length (cm) ±8.29
	Lt. side	Y = 84.74 + 3.03 x Lt. ulna length(cm) ± 8.60
Female	Rt. Side	Y = 79.16 + 2.97x Rt. ulna length(cm) ± 8.70
	Lt. Side	Y = 75.26 + 3.17 x Lt. ulna length(cm) ± 8.70
Both sex together	Rt. Side	Y = 53.20 + 4.05 x Rt. ulna length(cm) ±9.60
	Lt. Side	Y = 54.31 + 4.07x Lt. ulna length(cm)±9.64

The Table 4 shows that comparison between the lengths of right and left ulna among male and female is statistically insignificant as p value is > 0.01. So we can say that there is no proper relation in between them.

The Table 5 shows that there is a positive correlation between the Height and the length of right and left ulna. The correlation coefficient (r) for male is 0.76 and 0.74 for Rt. and Lt. side respectively. The P value is < 0.01, which is statistically significant. Similarly 'r' value for Female is 0.67 and 0.66 for Rt. and Lt. side respectively, which is also statistically significant (P<0.01). It is also statistically significant when both sex are considered together.

While the Table 6 shows the regression equations for male and female subjects and for both sex considered together. It is based on $Y = a + b X \pm$ standard error of regression. Where 'a' is regression constant, 'b' is regression coefficient and 'X' is length of Ulna.

Discussion

The present study consists of finding correlation of Personal height with the length of right and Left ulna. The prediction of height of unknown individual from incomplete and decomposed skeletal remains is very important in point of forensic experts and anthropologists. It is also vital in determining the identity of an unknown individual.

Therefore formula which is based on length of ulna is an alternative to determine the height under such circumstances. The ulna has easily identifiable subcutaneous landmarks which make it comfortable to measure its length. If we know one parameter then with regression equation we can find out other factor that is height. Anjali Prasad et al [15] in their study report that average height of adult males within a population is significantly higher than that of adult female. The results obtained from our study are also in favour of the same statement.

Various workers like Allbrook D [8], Athwal M.C [9], Lal and Lala [10],Trotter M [12], Jadhav HR [13] and Saxena SK [14] have shown significant positive correlation between the stature and length of ulna bone as well as other long bones and different parts of body. The Correlation coefficient (r) obtained from our study matches very well with the previous studies done by Allbrook D [8], Mondal MK [3] and Anjali P. et al. [15] and Avantika B. et al. [16].

Allbrook D [8] formulated the regression equation for estimation of height from the length of ulna as

Stature = 88.94 + 3.06 x length of ulna ±4.4 (SE)

While, Athwale MC [9] after studying over 100 Maharashtrian adult males age range of 25 -30 derived regression formula like

stature = 56.97 +3.96 x length of ulna(cm) ±3.64

Thummar B. et al [11] derived regression equation for determination of height from length of right ulna and Left ulna in Gujarat population as follow for males

Y1 = 81.11 +3.11 x length of right ulna(cm)

Y2 = 65.76 + 3.66 x length of left ulna(cm)

Mondal MK et al [3] studied in west Bengal female population and derived regression equation as

Y = 45.89 + 4.39 x length of left ulna (cm) ±7.03

Y = 58.72 + 3.89 x length of right ulna(cm) ± 9.17

Ilayperuma I.et al [7] also studied in Srilankan population and proved positive correlation between height and length of ulna in them and derived regression equation for their population.

While Anjali P.et al [15] studied in Marathwada region of Maharashtra on 250 subjects and derived regression formula like

For male Y = 93.45 +2.92 x length of ulna (cm)

For female Y = 113.89 +2.37 x length of ulna (cm)

For both sex together Y = 132.43 +1.49 x length of ulna (cm)

The present study also shows positive correlation between height and length of ulna, which is statistically significant as p value is < 0.01. Table 6 shows the regression equations derived from present study for male, female and when both sex as together.

Conclusion

The Correlation coefficient between The height and length of ulna is statistically significant indicating a strong relationship between these two parameters. Hence we conclude that the length of ulna provides reliable platform for prediction of height of an unknown individual. The Regression equations derived from the present study can be applied successfully for estimation of personal height in Maharashtra region. This Fact will be of practical use in medico legal investigations as well as in anthropometry so more useful for Anthropologist and Forensic Medicine Experts.

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