Original Research

Stature Estimation by Ulna Length in Living Adult Population of Kerala

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Abstract

Estimation of stature from a portion of a body plays an important role in identifying the deceased in forensic investigations. An attempt was made in this study to examine the correlation between left ulna length and stature using linear regression models for both genders. The study was conducted among 116 medical and dental students (62 males and 54 females), who are natives of Kerala and aged 18-25 years. Stature and left ulna length were measured from the study participants and linear regression equations were derived to estimate stature from the data collected using SPSS computer software. It was concluded in the study that there exists a positive correlation between left ulna length and stature with Pearson correlation coefficient (r) of 0.707 for males, 0.648 for females and 0.867 overall (males and females combined). Linear regression equations derived from left ulna length can be reliably used for the estimation of the stature in the native adult population of Kerala.

Key words: Identification, Left ulna length, Linear regression, Stature estimation

Introduction:

Establishing individuality is an important aspect in any investigating procedure. The individuality of a person can be established to great extent by determination of four parameters of biological profile such as stature, age, sex and race.[1] Estimation of stature forms an important criterion for establishing the individuality of the person and requires special attention in cases where dead bodies are found in mutilated state or when only comingled skeletal remains are discovered at the scene[2]. Stature has a definite and proportional biological relationship with every part of the body[3]. Anthropologists and forensic scientists estimate stature from the measurement of long bone lengths since long bone regressions produce most accurate stature estimations. Due to non-availability of complete body as in cases of mass disasters there is an increasing interest among forensic investigators to use mathematical methods to estimate stature from body segments or long bones[4]. These methods of stature estimation are reported to be both population and gender specific as studies on secular change and allometry have demonstrated differential limb proportions between genders and among populations[5].

Studies on north Indian population have established a correlation between stature and long bone dimensions[6-10]. Many studies have been conducted to investigate the correlation of stature with ulna length in many parts of the world as ulna length is considered to be the best parameter that correlates with stature in the upper

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extremity[11-22]. In this study, an attempt has been made to formulate regression equations for stature estimation using the percutaneous left ulna length specific to the adult population of Kerala.

Materials and methods:

The study was a cross sectional study conducted from March 2014 to August 2014 on 116 medical and dental students (62 males and 54 females) of K S Hegde Medical Academy and A B Shetty Memorial Institute of Dental Sciences, Nitte University, Mangalore who are natives of Kerala and aged between 18 and 25 years.

An approval to conduct study was obtained from Ethical Clearance Committee, Nitte University. The procedure and purpose of the study were explained to the study population and an informed consent was taken from all participants. Stature was taken from the vertex (the highest point on head in mid-sagittal plane) to the floor (the standing surface) maintaining the anatomic position and Frankfurt plane**.** The subjects were made to stand on bare foot while taking their stature measurement. Length of ulna was taken from the marked tip of olecranon process to the tip of styloid process of ulna. Percutaneous ulna length was taken from the left side, according to the procedure described by the International Biological Programme. The standard anthropometric instruments such as Herpenden stadiometer and sliding calipers were used for the taking measurements.

Both the measurements were recorded twice and their mean value was calculated for accuracy. The measurements were taken in a reasonably lit room before noon to avoid diurnal variation. The measurements were taken only by one person to avoid inter observer error in methodology. Non-natives of Kerala, subjects aged less than 18 years and more than 25 years, those with congenital deformities of spine, upper and lower limbs, with recent or old history of fracture long bones or spine and too short or too tall individuals were excluded from the study by detailed medical history taking and clinical examination.

Results:

A total of 116 participants (62 males and 54 females) were studied for the estimation of stature by left ulna length.

Table 1 depicts the descriptive statistics of the study population in terms of age, gender, religion and dietary habits. The mean age of the population studied is 20.16 years with the age range of 18-25 years. Among the population studied, Hindus comprised of 54.3%, Christians 35.4% and Muslims 12.3%.

Table 1: Descriptive statistics of study population

Variables		
Age (in years)	Mean(SD)	20.16(1.51)
	Median(Q1-Q3)	20(19-21)
	Range	18-25
Gender – N (%)	Male	62(53.4%)
	Female	54(46.6%)
Religion – N (%)	Christian	41(35.4%)
	Hindu	63(54.3%)
	Muslim	12(10.3%)
Dietary Habit – N (%)	Vegetarian	5(4.3%)
	Non-vegetarian	111(95.7%)

Table 2 depicts the descriptive statistics of stature in both the genders. Mean, standard deviation (SD) and range are given. Males exhibited higher mean values with wider range for both stature and left ulna length when compared to female subjects.

Table 3 depicts the mean, standard deviation and p-value of study parameters in age-wise distribution. It is observed that there was no statistically significant

Table 2: Mean, standard deviation (SD), median and range of study parameters

		Mean(SD)	Median(Q1-Q3)	Range
Male	**Stature**	173.27(6.05)	172.7(168.5-177.62)	161 - 189
	Ulna length	27.42(1.49)	27.63(26.13-28.59)	23.37-30.58
Female	**Stature**	157.89(5.7)	157.25(154.37-163.00)	148-172
	Ulna length	24.35(1.25)	24.43(23.66-25.39)	20.71-26.59

Table 3: Mean, standard deviation and p-value of study parameters in age-wise distribution

Parametres	Age groups	N	Mean(SD)	Mean difference(95%CI)	t#	p-value
Stature	<20 years	77	165.05(9.81)	-3.14(-6.89, 0.59)	-1.66	0.098
	20-25 years	39	168.20(9.21)			
Ulna length	<20 years	77	25.81(2.10)	-0.54(-1.34, 0.26)	1.33	0.183
	20-25 years	39	26.35(1.97)			

Student t- test p>0.05 - Non-significant, NS

Table 4: Comparison of stature and left ulna length between males and females

Parameters	Sex	Mean (SD)	Mean difference	95% CI of difference		t#	df	p-value
				Lower	Upper			
Stature	Male	173.27(6.05)	15.37	13.19	17.55	13.98	114	<0.001*
	Female	157.89(5.73)						
Left ulna length	Male	27.42(1.49)	3.07	2.55	3.58	11.84	114	<0.001*
	Female	24.35(1.25)						

*p<0.001 statistically significant

difference in the study parameters between the age groups <20 years and 20-25 years.

Table 4 gives the comparison of statute and left ulna length between males and females. It is observed that there is statistically significant difference in both stature and left ulna measurements among males and females with p-value <0.001.

Table 5 gives Pearson correlation coefficient (r) for males, females and overall study population against the study parameters. It is observed that left ulna length is more positively correlated to stature in males (r = 0.707) than females (r = 0.648). The correlation of stature with left ulna is highest in overall population (r = 0.867) than gender wise measurements.

Table 5: Pearson correlation co-efficient (r) and p-value for various parameters related to stature

Stature and Left ulna length	Pearson coefficient (r)	p-value
Male	0.707	<0.001*
Female	0.648	<0.001*
Overall	0.867	<0.001*

*p<0.001 statistically significant

Table 6: Model summary obtained by regression analysis:

Sex		Un-standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
Male	(Constant)	95.008	10.123		9.385	<0.001*
	ulna length	2.854	.369	.707	7.743	<0.001*
Female	(Constant)	86.044	11.738		7.330	<0.001*
	ulna length	2.950	.481	.648	6.129	<0.001*
Overall	(Constant)	60.60	5.69		10.64	<0.001*
	ulna length	4.05	0.21	0.867	18.59	<0.001*

Dependent Variable: stature, $R^2 = 0.50$ (male) , $R^2 = 0.41$(female), $R^2 = 0.750$(Overall)
*p<0.001 statistically significant

Table 7: The linear regression equations obtained in this study

Stature in male = 95.00 + 2.85 (ulna length) ± 4.363
Stature in female = 86.04 + 2.95 (ulna length) ± 4.006
Stature (overall) = 60.60 + 4.05 (ulna length) ± 4.84

Estimation of stature:

For estimation of stature linear regression was applied using SPSS software. Model summary of linear regression analysis is depicted in table 6. It is to be noted that, stature is being explained more significantly in overall study population (75% variation explained) as compared to males and females (54% and 41% variation explained respectively).

Table 7 lists the derived regression equations of stature from left ulna length in males, females and both sexes combined (overall). The regression equations have been computed separately for males, females and both combined. A computer analysis of the data enabled the calculation of regression coefficients 'a' and 'b', where 'a' is the regression coefficient of the dependent variable (stature) and 'b' is the regression coefficient of the independent variable (left ulna length). Hence stature = a + bx, where 'x' is the length of the bone measured (left ulna length). The table also gives standard error of estimate (SEE) along with linear regression equations for left ulna length. The utility of calculating SEE lies in its prediction of the deviations of estimated stature from the actual stature[23].

The positive linear correlation between the study parameters have been depicted by scatter plots for males, females and both genders combined in the figures 1, 2 and 3 respectively.

Discussion:

In this study an attempt was made to formulate regression equations for stature estimation using the left ulna length specific to the adult population of Kerala. The measurements of left ulna length and stature were taken in males and females separately. In the present study males showed statistically significant (p <0.001) higher mean values when compared with females in the parameters studied such as stature and left ulna length. In studies conducted by Thummar B, Patel ZK, Patel S and Rathod SP,[12] Ilayperuma I,

Figure 1: Scatter plot depicting linear correlation between stature and ulna length in males.

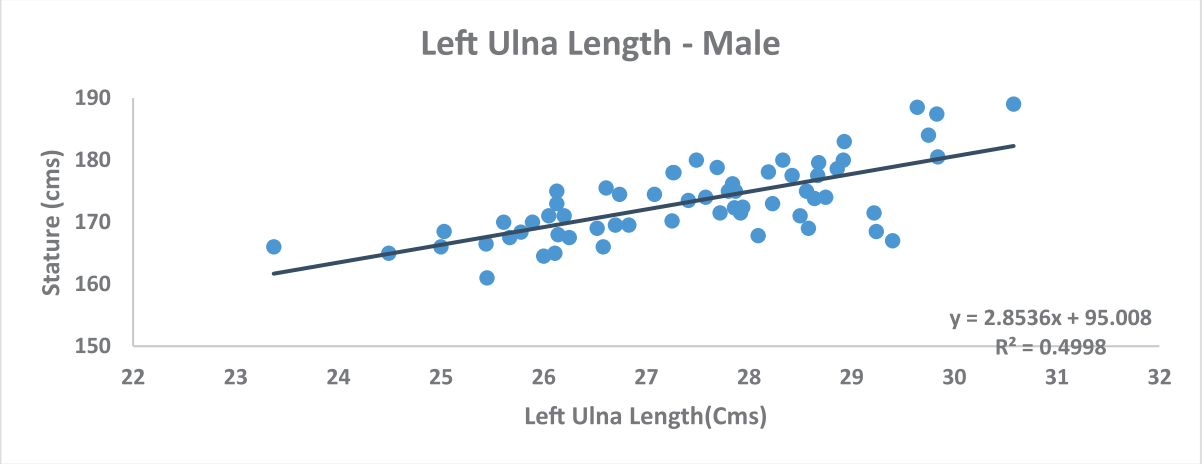


Figure 2: Scatter plot depicting linear correlation between stature and ulna length in females.

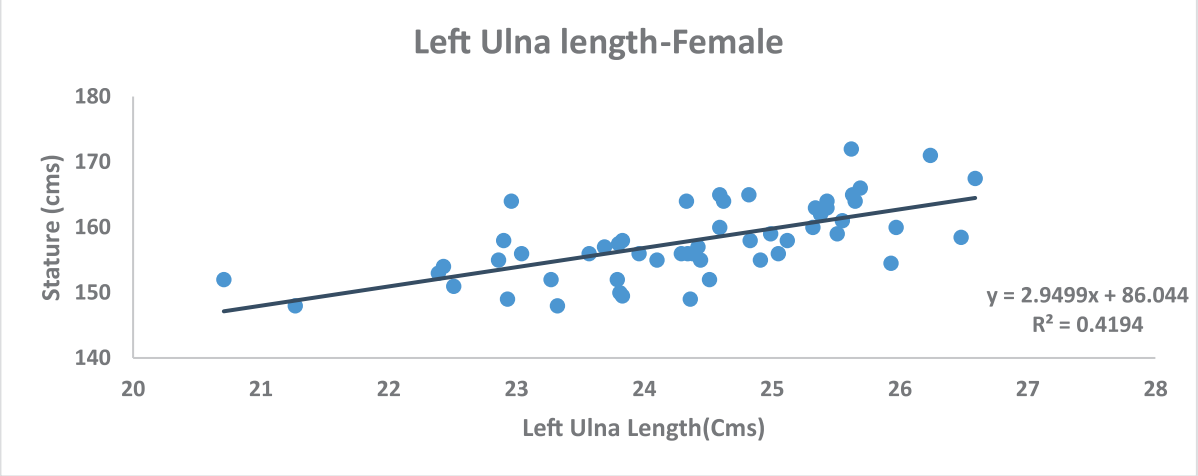
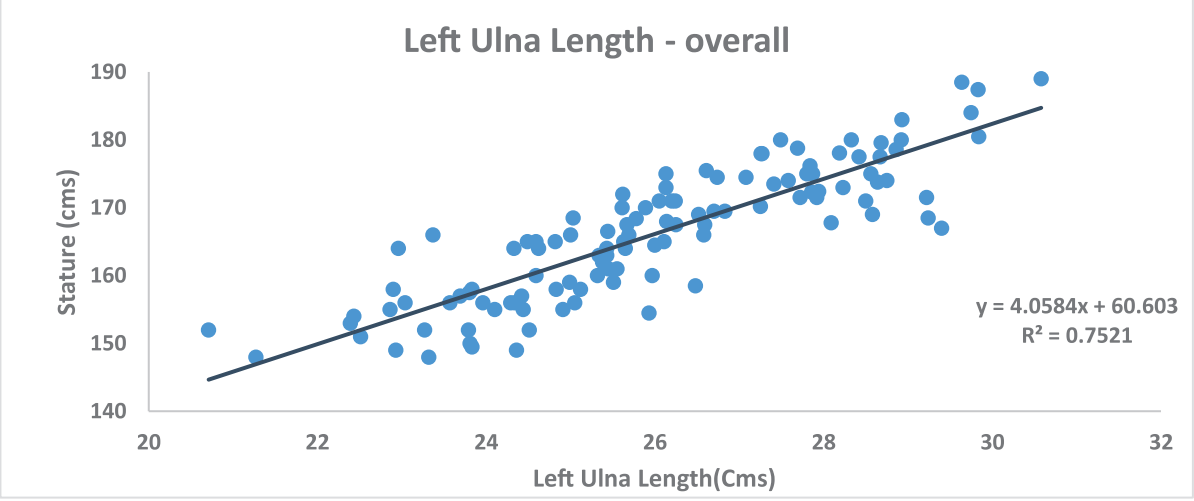


Figure 3: Scatter plot depicting linear correlation between stature and left ulna length in combined data.



Nanayakkara G and Palahepitiya N,[13] Ahmed A, Mohammad F and Farooque I,[14] Nath S and Badkur P,[15] Ozaslan A, Koc S, Ozaslan I and Tugcu H [18] and Chikhalkar BG, Mangaonkar AA, Nanandkar SD and Peddawad RG[19] similar statistically significant higher mean values for males are obtained. These statistically significant differences in mean values between males and females may be due to the early maturity of girls than boys and which necessitate generating separate regression equations for males and females.

Left ulna length showed statistically significant positive correlation with dependent variable (stature) in the present study with the Pearson correlation co-efficient ranging from 0.648- 0.867. The Pearson correlation co-efficient was highest (r = 0.867) for left ulna length for overall (males and females combined) and lowest for females (r = 0.648). In a study conducted by Ozaslan A, Koc S, Ozaslan I and Tugcu H [18] Pearson co-efficients of 0.73 and 0.66 for ulna length in males and females respectively were obtained which are higher compared to the correlation co-efficients of 0.707 and 0.648 for left ulna length for males and females obtained in the present study.

In a study conducted by Ahmed A, Mohammad F and Farooque I [14] on male and female population of Calicut, Kerala correlation co-efficient obtained for overall (males and females combined) was 0.771, and stature equation obtained was Stature=76.415 + 3.157 (ulna length) where as in the present study involving Kerala population the coefficient obtained is 0.867 and stature equation obtained is Stature= 60.60 + 4.05 (ulna length) ± 4.84. The correlation coefficient was higher in this study compared to the study in Calicut by Ahmed A, Mohammad F and Farooque I[14].

In the present study the standard error of estimates obtained for various regression equations obtained is in the range of 4.006 to 4.840. As the values of SEE are less, more narrow stature estimate can be given based on the regression equations derived in the present study. A study conducted by G Mall, M Hubig, A Buttner, J Kuznik, R Penning and M Graw [17] on German skeletal collection obtained SEE of >7 which is unsatisfactory. Ozaslan A, Koc S, Ozaslan I and Tugcu H [18] obtained SEE of 5.251 for males and 4.876 for females respectively while deriving regression equation using forearm length. Gadekar S, Vaishnani H, Vikani S, Gujaria IJ, Bondre KV and Shah GV [21] derived stature formulae for Gujarat population with SEE valves of 4.5 and 5.4 in males and females respectively. The values mentioned in these two studies are higher compared to the present study. However, the value of SEE is 2.998 for the regression equation obtained by a study conducted on Mumbai population by Chikhalkar BG, Mangaonkar AA, Nanandkar SD and Peddawad RG [19] which gives a more narrow stature estimate compared to the present study. The variations in the SEE in different studies can be explained by sample size taken. The SEE can be reduced by increasing the sample size.

Conflicts of interest:

The authors declare no conflicts of interest.

Conclusion:

The results of the present study indicate that the percutaneous length of ulna is highly reliable for the estimation of stature in forensic examinations as ulna length and stature are positively correlated (r = 0.707 for males, r = 0.648 for females and r = 0.867 for combined). The regression equations derived from this study can be applied reliably for estimation of stature on the adult population of Kerala. It is recommended to use the regression formula for combined data when the gender is not known and to use gender specific formula if gender is known. The only precaution to be taken into consideration is that these formulae are applicable to the population from which the data has been collected, due

to inherent population variation in these parameters as observed in this study.

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