Original Article

Indian Journal of Forensic Medicine and Pathology
Volume 10 Number 2, April - June 2017
DOI: http://dx.doi.org/10.21088/ijfmp.0974.3383.10217.10

Estimation of Stature by Per-Cutaneous Measurements of Distal Half of the Upper Limb

Karukuri Rajesham*, Nishat Ahmed Sheikh**

Abstract

Background: Stature of a person is one of the vital parts of identification. Assessment of height from different parts of the body by anthropometric study of skeleton is an area of interest to anatomist, anthropologist and forensic experts. *Objective:* This study aims to find the relationship between stature and forearm lengths and set regression equations for estimation of stature from radius and ulna length for Telangana population. *Study Design:* Descriptive cross sectional study. *Material and Method:* In the present study, stature and per cutaneous Forearm length measurements of 164 college students of ages 19- 27 years were done. The data for the present work was collected from the various senior secondary schools and colleges of Karimnagar area of Karimnagar District of Telangana State of India. *Observation and Discussion:* In the present study, regression equations have been formulated with the standard error of estimate (SEE) ranging from ±5.1892 cm to ± 5.5292 cm. For females the standard error of the estimation is observed in Left Ulna length (SEE = ± 5.1311 cm) and the Left radial length (SEE = ± 5.1092cm). For Males the standard error of the estimation is observed in Left Ulna Length (SEE = ± 5.5292 cm) and the Right radial length (SEE = ± 5.4395 cm). *Conclusion:* The Multiple regression equations provide slightly better results than the linear regression equations. The results in the present study indicate that the length of forearm can be efficiently used for stature estimation.

Keywords: Per-Cutaneous Forearm Length; Forensic Anthropology; Stature; Multiple Regression Analysis.

Introduction

Anthropometry is often viewed as a traditional and perhaps the basic tool of biological anthropology, but it has a long tradition of use in forensic sciences and it is finding increased use in medical sciences especially in the discipline of Anatomy & Forensic Medicine.

Pearson K, et al. (1898) [1] fist introduced the co-relational calculus into the field of work for the prediction of the stature from the measurement of the 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. Telekka et al. (1950) [2] worked on the bones of the limbs and expressed the opinion that each racial group needs a separate formula for the estimation of stature. Many of the previous workers worked on cadavers or on skeletal remains [3, 4]. But cadavers cannot be the representatives of the population; because the cadavers are largely of persons who are aged, and they may have suffered from chronic debilitating diseases. It may be likely that they had been lying in an abnormal posture and it may not have been possible to straighten the body to get the accurate stature measurement. Again, according to Trotter M et al. (1952) [5], there is an increase in the height of 2.5 cm after death, when the measurement is taken in the recumbent posture. Lundy JK (1985) [6] discussed the regression equation and the mathematical and the anatomical method of estimating the living stature from the long limb bones. The hand lengths can be used as a basis for estimating age- related loss in stature and as an alternative measure to stature when stature cannot

Authors Affiliation: *Assistant Professor of Forensic Medicine, Chalmeda Anandrao Institute of Medical Sciences, Bommakal, Karimnagar-505001, Telangana, India. **Professor & Head of Forensic Medicine, Jaipur National University, Institute for Medical Sciences and Research Center, Jaipur-302017, Rajasthan, India.

Reprints Requests: Nishat Ahmed Sheikh, Professor and Head, Department of Forensic Medicine, Jaipur National University, Institute for Medical Sciences and Research Center, Jaipur-302017, Rajasthan, India.
E-mail: drnishatsheikh@gmail.com

Received on 23.05.2017, **Accepted on** 13.06.2017

be measured directly due to deformity like kyphosis, lordosis and scoliosis, contracture or missing legs.

Objectives

This study aims to find the relationship between stature and forearm lengths and set regression equations for estimation of stature from radius and ulna length for Telangana population.

Material and Method

In the present study, stature and per cutaneous Forearm length measurements of 164 college students (74 male & 90 female) of ages 19- 27 years were done. The data for the present work was collected from the various senior secondary schools and colleges of Karimnagar area of Karimnagar District of Telangana State of India. The study was a predominantly descriptive cross sectional study with analytical and comparative components. Sufficient permissions and consents are procured before the measurements of the students are taken and clearance from the Institutional Ethical committee is obtained in advance. Stature; using the stadio-meter, the subject was made to stand barefoot in the standard standing position on its baseboard. Both feet are in close contact with each other and head oriented in Frankfurt's plane. The height was then recorded in centimeter from the standing surface to the vertex in the weight bearing position of foot.

The forearm measurements were taken using a sliding caliper. The ulna length was measured as the distance from the distal tip of Olecrenon process to the tip of ulna styloid process (the elbow to the wrist of forearm) and the radial length was measured as the distance from the distal tip of ulna head to the tip of radial styloid process. The subject's elbow was flexed at 90° to 110° with fingers extended in the direction of the long axis of the forearm. All measurements were recorded to the nearest millimeter.

Exclusion Criterion

Students morphologically showing the congenital malformations, Dwarfism / Achondroplasia, features of nutritional deficiencies and injuries to extremities, using medication thought to alter growth, neuromuscular weakness or abnormal tone or with any other major medical illnesses or growth disturbance were excluded from the study.

Data Analysis

In vernier caliper, Length = reading of the main scale + vernier coincidence x vernier constant + mechanical error. (Here vernier constant = 0.01 and mechanical error = 0) Calculation of stature using regression equation: Stature = value of constant + regression coefficient x Per-cutaneous Radial ulnar Length. Value of the constant and regression coefficient was calculated using SPSS Version 19 program. Descriptive statistics of stature and forearm (ulna and radial) measurements were calculated for both males and females. T-test was utilized to examine statistical significance in bilateral asymmetry in forearm measurements of males and females. Statistical significance was considered at P-value < 0.05. The Pearson's correlation coefficient was calculated. Simple linear and multiple regression analyses were performed to derive regression equations for estimation of stature from forearm measurements for males and females.

Observation

Descriptive statistics, the descriptive statistics for stature and forearm measurements in males and females (the minimum values, maximum values, means, and standard deviations) are shown in Table 1.

Bilateral asymmetry

Table 2 presents the results of paired samples t-tests; the statistical significance of bilaterally asymmetry in forearm lengths of both sexes is represented by t and p values.

It is observed that bilateral asymmetry in the right

Table 1: Descriptive Statistics for stature and forearm measurements in male and female (n = 164)

Measurement	Side	Male (n= 74)				female (n= 90)			
		Min	Max	Mean	S.D.	Min	Max	Mean	S.D.
Age		19	27	22	1.7	19	26	21	1.1
Height		151	181	169.054	7.1393	148	179	162.789	7.2134
Ulna length	Left	23	29	26.476	1.3692	23	28	25.192	1.9567
	Right	23	29	26.405	1.4064	23	28.5	25.079	1.2664
Radial Length	Left	23	29	26.453	1.3284	22.5	28.2	25.427	1.2837
	Right	23	29	26.434	1.3254	22.5	28	25.397	1.3011

Table 2: Bilateral differences in forearm measurements in male and female (n= 164)

Measurement	Male (n= 74)				female (n= 90)			
	Mean diff. (left-Right)	S.D.	t-value	P- value	Mean diff. (left-Right)	S.D.	t-value	P- value
Ulna length	0.07027	0.20777	2.88962	0.00508	0.11333	0.30594	3.49474	0.00074
Radius length	0.01892	0.16413	0.98484	0.32796	0.03176	0.17285	1.63735	0.10509

and left ulna length of both sexes is not statistically significant. Similarly, the bilateral asymmetry in radial length of females is not statistically significant. On the other hand, bilateral asymmetry in radial length of males is statistically significant.

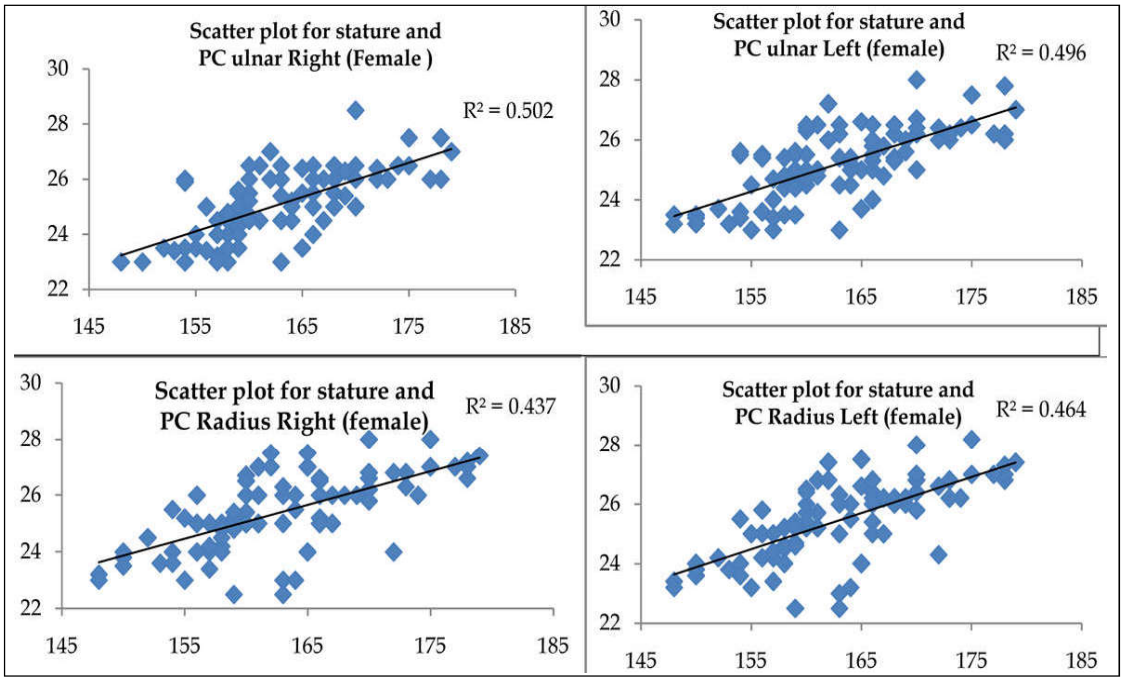

Fig. 1: Scatter plot for stature, Radius and Ulna for Female

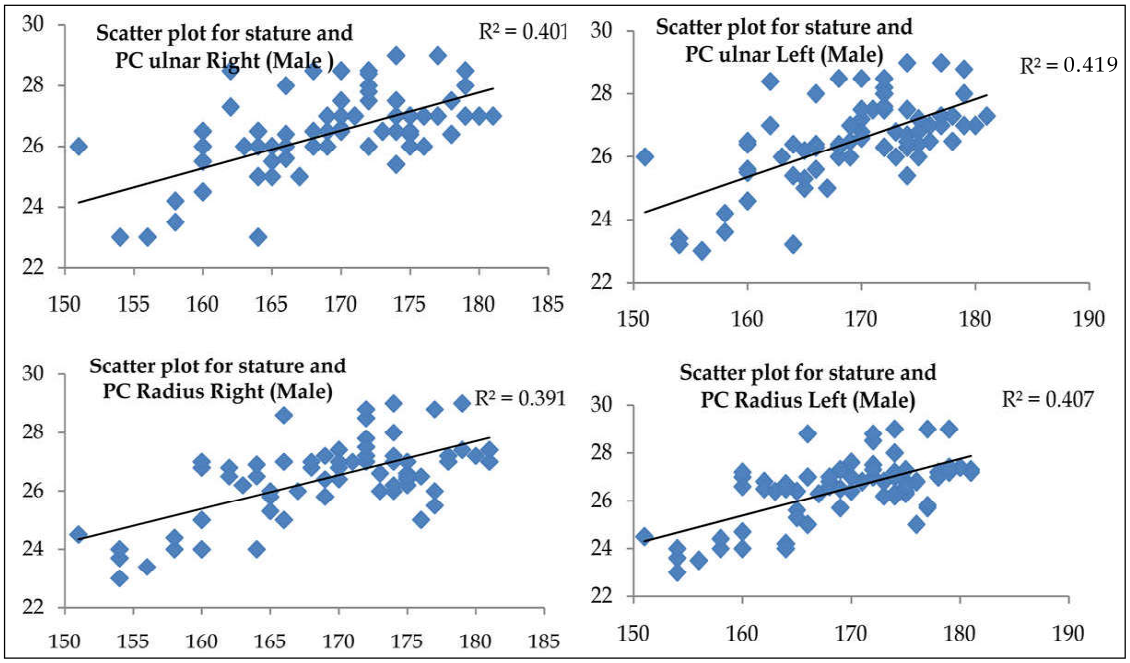

Fig. 2: Scatter plot for stature, Radius and Ulna for Male

Pearson's Correlation Coefficients

The results of the correlation coefficients between stature and forearm measurements are shown in Table 3. All forearm measurements exhibit statistically significant correlation coefficients with stature (p-value < 0.001). The correlation coefficient between stature and forearm length (ulna and radial) was higher in the female group. For females, the highest correlation is exhibited by the right ulna length (r = 0.7085, SEE = ±5.1311), and the lowest by both sides of radial length (r = 0.6253, SEE = ±5.1092 cm for left side and SEE = ±5.1311 for right side). For males, the highest correlation is exhibited by the Left Ulna length (r = 0.6473, SEE = ±5.4395), and the lowest by both sides of right radial length (r = 0.6253, SEE = ±5.5292 cm for right side and SEE = ±5.4395 for left side).

Table 3: Pearson's correlation coefficient between stature and forearm length

Measurement	Side	Male (n = 74)		Female (n = 90)	
		R	P	R	P
Ulna Length	Left	0.6473	0.0000	0.7043	0.0000
	Right	0.6332	0.0000	0.7085	0.0000
Radius Length	Left	0.6380	0.0000	0.6812	0.0000
	Right	0.6253	0.0000	0.6611	0.0000

The results of linear regression equations of different parameters were obtained as follows:

Male :	Stature (cm) = 79.6 + (3.38 x PC Ulnar Left)	(cm)
	Stature (cm) = 84.1 + (3.22 x PC Ulnar Right)	(cm)
	Stature (cm) = 78.3 + (3.43 x PC Radius Left)	(cm)
	Stature (cm) = 80.0 + (3.37 x PC Radius Right)	(cm)
Female :	Stature (cm) = 55.7 + (4.25 x PC Ulnar Left)	(cm)
	Stature (cm) = 61.5 + (4.04 x PC Ulnar Right)	(cm)
	Stature (cm) = 65.5 + (3.83 x PC Radius Left)	(cm)
	Stature (cm) = 69.6 + (3.67 x PC Radius Right)	(cm)

In the present study, regression equations have been formulated with the standard error of estimate (SEE) ranging from ± 5.1892 cm to ±5.5292 cm. For Females the standard error of the estimation is observed in Left Ulna length (SEE = ±5.1311 cm) and the Left radial length (SEE = ±5.1092cm). For Males the standard error of the estimation is observed in Left Ulna Length (SEE = ±5.5292 cm) and the Right radial length (SEE = ± 5.4395 cm)

Multiple Regression Equations

The multiple regression equations for estimation of stature from different combinations of forearm measurements for males and females are presented in Table 4.

Table 4: Multiple regression equations for stature estimation from forearm measurements in cm

(n = 164)

Sex	Side	Equations	r	R^2	SEE
Male	Left	S=72.7 + (1.98 x LUL) + (1.66 x LRL)	0.6656	0.4430	5.4395
	Right	S=76.2 + (a1.87 x RUL) + (1.65 x RRL)	0.6512	0.4240	5.5292
Female	Left	S=52.8 + (2.79 x LUL) + (1.56 x LRL)	0.7176	0.5150	5.1092
	Right	S=58.5 + (3.12 x RUL) + (1.02 x RRL)	0.7148	0.5110	5.1311

It is observed that the correlation coefficients, the coefficients of determination, and standard errors of the estimate of the multiple regression equations are better than those of the linear regression equations. For males, the Left side of forearm measurements shows the highest correlation coefficient with stature (r = 0.6656) and the lowest standard error of the estimate (SEE = ± 5.4395 cm). For females, the Left side of forearm measurements exhibits the highest correlation coefficient with stature (r = 0.7176) and the lowest standard error of the estimate (SEE = ± 5.1092 cm).

Discussion

In our study, stature and forearm lengths were measured from a total of 164 (74 males and 90 females) students in Karimnagar region of Telangana state.

The results show that the mean stature and all forearm lengths of females are higher than those of males. Similar findings were observed in previous studies [7]. Nishat Ahmed Sheikh *et al.* (2014) estimated stature from forearm length, the ratio fall between 3.49 and 3.88 for boys with a mean of 3.67 and SD + 0.090; and between 3.45 and 3.88 for girls with a mean of 3.68 and SD 0.093 [8]. The results of paired samples t- tests show no significant bilateral asymmetry in ulna length in both sexes (mean difference = 0.07027, p-value = 0.00508 for males and mean difference = 0.11333 , p-value = 0.00074 for females). Similarly, no significant bilateral asymmetry in radial length is observed in females (mean difference = 0.03176, p-value = 0.10509). This result is supported by the study of Arun Kumar Agnihotri (2009) [9] that showed no significant bilateral asymmetry in forearm bones of Indo Mauritian populations.

Nishat A Sheikh [10 & 11] et. al studied Regression equation for estimation of stature from foot length for both sex Y= 82.934+ 3.404 x Foot length, for individual male sex Y= 138.59 + 1.35 x Foot length and for Female sex Y= 119.50 + 1.604 x Foot length. The correlation coefficient between height & foot length is + 0.688 in Male & +0.587 in female which is highly significant. Therefore, we can use either side of ulna for both sexes and either side of radius for females in constructing models. This is supported by another study on limb bilateral asymmetry (Freedman, Edwards, Willems, & Meals, 1998). On the other hand, bilateral asymmetry in radial length of males was significant (mean difference = 0.01892, p-value = 0.32796), which may be due to the regularly use of both left and right side of forearms. Growth usually indicates physical changes in height, weight and other limbs of the body. It means the increase and enlargement of the body or different parts of the body making it heavier and larger. Seema S Sutay & Nishat A Sheikh [12, 13] et.al. Studied regression equation for estimation of stature from Per-cutaneous ulnar length for both sex Y= 64.36+ 3.82 x PC ulnar Length, for individual male sex Y= 130.10 + 1.57 x PC ulnar Length and for Female sex Y= 75.94 + 3.21 x PC ulnar Length. Variety of factors such as age, race, gender and nutritional status affect human development and growth. Therefore, different equations may be required for different populations.

Conclusion

The Multiple regression equations provide slightly better results than the linear regression equations. The results in the present study indicate that the length of forearm can be efficiently used for stature estimation. This reasonable exercise may be useful in all medico-legal examinations and anthropometry procedures. We conclude that the multiple regression equations presented here can be used to estimate ante-mortem stature, with reasonable accuracy, of unknown human forearm remains from per-cutaneous lengths of radius and Ulna in medico-legal cases, particularly from Telangana state of South India.

Acknowledgement

Authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript.

Conflict of Interest

No conflict.

Ethical Clearance

The articles do not violate any ethical, moral or legal guidelines pertaining to original scientific work.

References

1. Pearson K. A mathematical contribution to the theory of evolution. On the reconstruction of the stature of the prehistoric races. Philos Trans R Soc. London; Series A 1898; 192: 169-244.
2. Telekka A. The prediction of the human stature from the long bones. Acta Anatomica 1950; (9):103-11.
3. Mall G, Hubig M, Büttner A, Kuznik J, Penning R, Graw M. Sex determination and estimation of stature from the long bones of the arm. Forensic Sci Int. 2001 Mar 1; 117(1-2):23-30. (Available in http/: www.pubmed.gov. accessed on 23 June 2012).
4. Celbis O, Agritmis H. Estimation of the stature and the determination of sex from the radial and the ulnar bone lengths in a Turkish corpse sample. Forensic Sci Int. 2006 May 10; 158(2-3):135-9. Epub 2005 Jun 28. (Available in http//:www.pubmed. gov. accessed on 23 June 2012).
5. Trotter M, Glesser GC. Estimation of stature from the long bones of American whites and negroes. Am J Phy Anthropol 1952; (10):463-514.
6. Lundy JK. The mathematical versus anatomical methods of stature estimation from the long bones. Am J Forensic Med Pathol 1985; 6(1):73-76.

7. Ilayperuma, I., & Nanayakkara, G. A model for the Estimation of Personal Stature from the Length of Forearm. Int. J. Morphol, 2010; 28(4):1081-1086.
8. Nishat Ahmed Sheikh et al. Stature estimation from forearm length. Indian Journal of Forensic Medicine and Pathology, 2014 April – June; 7(2):59–64.
9. Agnihotri, A.K., Kachhwaha, S., Jowaheer, V., & Singh, A.P. Estimating stature from percutaneous length of tibia and ulna in Indo-Mauritian population Forensic Science International, 209; 187(109), e1-109e103.
10. Seema S Sutay, Nishat A Sheikh et. al. Comparative Analysis of Equations to Estimate Stature with Foot Length. Indian Journal of Forensic Medicine and Toxicology. 2015 July-December; 9(2):67-71.
11. Perugu Vanishri & Nishat A Sheikh. Stature Estimation from Foot Length of School Age Group Children. Indian Journal of Forensic Medicine and Pathology. 2017 January – March; 10(1):11-16.
12. Nishat Ahmed Sheikh et al. Estimation of Stature from Foot Length of school age group children in Telangana state. International Journal of Current Research 2015 Jan; 7(1):11659-11663.
13. Seema S Sutay & Nishat A Sheikh. Study of Stature by Per-cutaneous ulnar Length In Madhya Pradesh Population of India. International Journal of Medico-legal Update, 2016 Jan-April, 16(1):173-177.