GMR
The Original

EVALUATION OF PERCUTANEOUS FOREARM LONG BONES LENGTH AS A PREDICTOR OF STATURE IN NORTH INDIANS

[1]Nisha Goyal, [2]Prachi S Aneja, [3]Susmita Saha

[1] Ph.D. Scholar, Department of Anatomy, SGT Medical College and Research Institute, Budhera, Gurgaon, Haryana, India
[2]Professor & Head, Department of Anatomy, SGT Medical College and Research Institute, Budhera, Gurgaon, Haryana, India
[3]Professor, Department of Anatomy, SGT Medical College and Research Institute, Budhera, Gurgaon, Haryana, India
Correspondence Author: Nisha Goyal, Email ID: anilnishagarg@gmail.com

ABSTRACT

Background: Stature is one of the principal determinants that help in the identification of a person even after death. It plays a crucial role in forensic identification, when it becomes complicated to identify unknown bodies, especially when only skeletal remains are present due to decomposition, mutilation, petrification, or accidents. Statistical analyses across different populations have revealed significant positive correlations between radial and ulnar lengths and stature in both sexes, although sex-specific regression equations are often required to improve predictive accuracy. The regression models based on both bones give more reliable results, enhancing reliability, particularly in cases involving incomplete skeletal remains.

Methodology: The present prospective cross-sectional study involving 1 000 subjects (500 male and 500 female) aged between 18 to 30 years, from the North Indian population at SGT Medical College, Gurgaon. Statures of the subjects were measured with the help of a stadiometer and the percutaneous length of the long bones (ulna and radius) by measuring tape.

Results: The mean Radius length was 24.71 cm, and the mean Ulna length was 26.41 cm, indicating that the Ulna is generally longer than the Radius in the study sample. A strong positive correlation was observed between Radius length and Ulna length ($r=0.649$, $P<0.001$).

Conclusion: This indicates that individuals with greater Radius length tend to have greater Ulna length. The regression model was statistically significant ($F = 360.9$, $p < 0.001$) and explained 42.1 % of the variation in Ulna length ($R^2 = 0.421$).

KEYWORDS: Stature; Length; Identification; Skeleton.

INTRODUCTION:

Bones of the skeleton change in size, shape, and structure, beginning during foetal life, progressing through childhood and puberty, and completing as young adults. Establishing the biological identification of a person is one of the most important aspects of forensic investigations. It is a challenging task to identify an unknown human body from dismembered parts, especially in cases involving mass disasters, accidents, decomposition, and criminal investigations. It becomes more difficult when the unknown bodies have to be identified from a mixed population and when incomplete or badly damaged skeleton remains are present [1.] Personal identification means the determination of the individuality of a person based on available evidence. Out of the biological determinants used in forensic identification, sex, age, ancestry, and stature are considered as primary characteristics for establishing the identity of a person [2.] Human stature is a prime biological parameter that can significantly narrow the pool of potential matches during identification. Stature is influenced by many factors such as nutritional, genetic, and environmental factors, which can significantly affect a person's height. Stature also possesses diurnal variations, i.e., more in the morning and gradually decreases during the afternoon and evening due to the decreased elasticity of the vertebral column and compression of intervertebral discs due to gravitational forces and routine activities [(1)]. According to Trotter M et al., body stature also changed immediately after death, an increase in length of about 2.5 cm due to loss of muscle tone, relaxation of muscles, and major joints[3.] Long bones of the upper and lower limbs show a strong positive correlation with a person’s stature, therefore commonly used for stature estimation. The radius and Ulna are the long bones of the forearm. Studies have demonstrated that the simultaneous assessment of both the radius and ulna improves the accuracy and offers more precise and reliable stature estimates compared to using either bone independently. A consistent positive linear relationship exists between the length of the radius and ulna, forearm bone length and overall stature, indicating that taller individuals generally have longer radius and ulna. In both sexes, radius and ulna lengths were significantly and positively correlated with actual body stature. Forensic anthropologists utilize regression-based approaches to estimate these biological parameters by comparing observed bone measurements with established population-specific standards. Regression equations and formulae derived for stature estimation for a specific population of one region may yield inappropriate results when applied to a different population due to the diversity of the population in India[4.] Therefore, continuous research on different populations is necessary to make forensic standards and enhance the effectiveness of person identification in medico-legal cases. Regression equations derived from measurements of long bones of the body are generally regarded as more accurate and provide more precise

estimation than those derived from other bones, such as skull bones, foot bones, hand bones, and vertebrae. [5-10]. The regression models based on both bones give more reliable results, enhancing reliability, particularly in cases involving incomplete skeletal remains. Radius and ulna bone lengths were measured externally using standard anthropometric tools. The precision of stature estimation is influenced by several factors, such as sample size, measurement technique, observer accuracy and both bones are available are intact. Since the radius and ulna are relatively resistant to post-mortem damage and can often be recovered intact, they are valuable tools in anthropometric and forensic investigations.
The percutaneous length means the measurement of the length of the radius and ulna from skin surface landmarks — offers a non-invasive, cost-effective, less time-consuming, reproducible method to collect reliable data for improving the accuracy of the results.

MATERIALS AND METHODS

Study Design: The present study was designed as a prospective, cross-sectional study involving 1 000 subjects (500 male and 500 female) aged between 18 and 30 years, from the North Indian population at SGT Medical College, Gurugram, during the period from December 2024 to December 2025. Only apparently healthy individuals were included in the study after obtaining informed consent from all the participants. The study was approved by the institutional ethics committee vide letter No. IEC/FMHS/PhD/2024-5.
Anthropometric Measurement: Anthropometric measurements were taken from the above-mentioned normal healthy volunteers by a single observer to avoid inter-observer error from the department of Anatomy of the institute.
Stature--The stature was measured from vertex to heel using a standard stadiometer with the participants standing straight with their bare feet in approximation and maintaining the head in a Frankfort horizontal plane. The movable part of the stadiometer was brought into contact with the vertex of the subject.
The percutaneous length of the forearm bones, i.e., radius and ulna were measured from the specific and predetermined anatomical landmarks by using a standard measuring tape. For measuring the length, subjects were made to sit and measured from both sides. From the following landmarks length of the bones was measured:

1. Length of Ulna: Olecranon process to the maximum prominent point of the styloid process of the ulna. This was done with an extended elbow in the supinated forearm.
2. Length of Radius: Head of radius to the maximum prominent point of the styloid process of the radius. This was done with an extended elbow in the supinated forearm.

RESULTS

Table 1: Statistical Analysis of the Relationship between Radius and Ulna Lengths.

Variable	N	Mean	SD	MIN	Q1	Median	Q3	Max
Rad-L	499	24.71	1 .07	20.52	24.1 3	24.65	25.52	27.48
Uln-L	499	26.41	1 .02	20.42	25.80	26.47	27.1 1	28.81

Summary statistics of Radius and Ulna lengths.
Interpretation: The mean Radius length was 24.71 cm, and the mean Ulna length was 26.41 cm, indicating that the Ulna is generally longer than the Radius in the study sample.

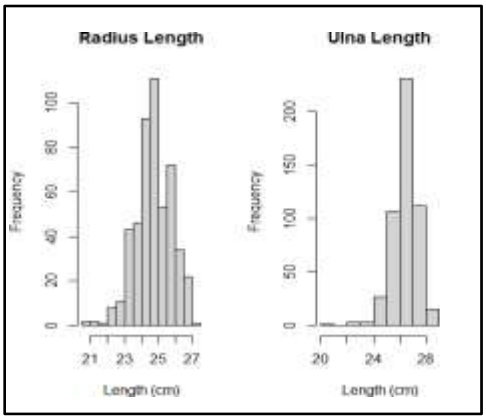

Figure:1

Histogram of Radius and Ulna Lengths
Interpretation: Figure 01 shows that the radius and Ulna lengths are approximately normally distributed, with most observations clustered around the mean values.

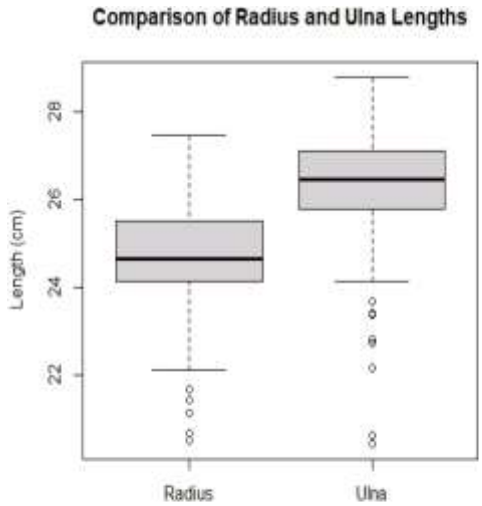

Figure-2: **Boxplot of Radius and Ulna Lengths**

Interpretation: Figure 02 indicates that Ulna length is generally greater than Radius length, with a few outliers present in both variables.

Table-2: Correlation Analysis between Radius Length and Ulna Length

variable	Correlation Coefficient(r)	95% confidence interval	t_value	Df	p-value
Rad-L vs Uln-L	0.649	0.595 – 0.697	18.997	497	<0.001

Interpretation: A strong positive correlation was observed between Radius length and Ulna length (r = 0.649, P<0.001). This indicates that individuals with greater Radius length tend to have greater Ulna length. The association was statistically significant.

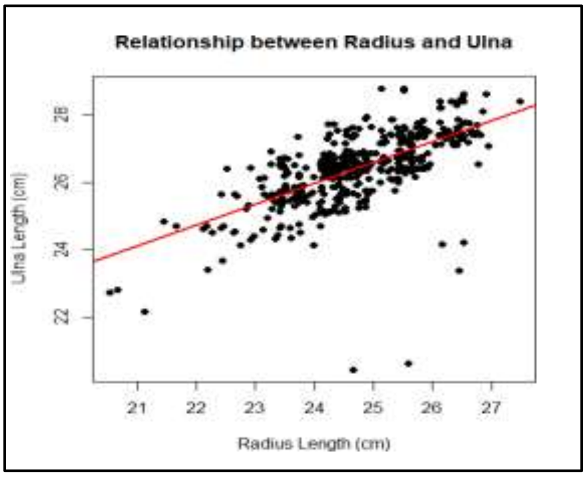

Figure-3: **Scatter plot showing the relationship between radius and Ulna length**

Interprettion: Figure 03 shows a positive linear relationship between Radius and Ulna lengths. The fitted regression line indicates that Ulna length tends to increase as Radius length increases.

Table-3: Linear Regression Analysis for Prediction of Ulna Length from Radius Length

variable	Estimate(B)	Std. Error	t-value	p-value
Intercept	11.077	0.808	13.71	<0.001
Radius Length (Rad-L)	0.621	0.033	19.00	<0.001

Interpretation: The linear regression model showed that Radius length was a significant predictor of Ulna length (β = 0.621, p < 0.001). For every 1 cm increase in Radius length, the predicted Ulna length increased by approximately 0.62cm.

Table-4: Model Summary of the Linear Regression Model

R^2	Adjusted R^2	Residua Standard Error	F-statistic	p-value
0.421	0.420	0.781	360.9	<0.001

Interpretation: The regression model was statistically significant (F = 360.9, p < 0.001) and explained 42.1 % of the variation in Ulna length (R^2 = 0.421).

Table-5: Regression Coefficients for Prediction of Ulna Length from Radius Length

Parameter	Coefficient (β)
Intercept	11.077
Radius Length (Rad-L)	0.621

Regression Equation: Uln - L = 1 1 .077 + 0.621 (Rad - L)

Interpretation: The regression coefficient for Radius length was 0.621, indicating that for every 1 cm increase in Radius length, the predicted Ulna length increases by approximately 0.62 cm. The intercept value (1 1 .077) represents the estimated Ulna length when Radius length is zero.

Table-6: Paired t-test Comparison of Radius and Ulna Lengths

Comparison	Mean Difference	95% CI	t-value	df	p-value
Rad-L vs Uln-L	-1 .700	-1 .777 to -1 .622	-43.1 8	498	<0.001

Interpretation: The paired t-test showed a statistically significant difference between Radius and Ulna lengths (t = -43.1 8, p < 0.001). The mean difference was -1 .70 cm, indicating that the Ulna length was significantly greater than the Radius length.

DISCUSSION

The parallel findings were supported by multiple prior studies which emphasize that measurements of long bones of the forearm increase the precision, reliability and scientific validity for stature estimation. In the current study, the ulna showed a slightly stronger correlation with stature compared to the radius. Similar findings were reported by Kachare RV(2021), Humara Gul et al. (2020)[1 1] and Atul S. Keche et al. (2020)[1 2], who concluded that ulnar length is one of the best predictors of stature. The present findings are also comparable with the study conducted by Senthil Kumaran et al. (201 4)[1 3] , Jwala Kandel and Salmalee Yadav (2025)[1 4,] where both radius and ulna showed strong positive correlation with stature and emphasized that combined forearm bone measurements improve the accuracy of the regression equation. The regression equations derived in the present study support the concept that stature estimation is population-specific. This observation agrees with the findings of Trotter and Gleser, who stated that regression formulae vary among populations because of differences in ethnicity, nutrition, heredity, and environmental conditions.

CONCLUSION

- The current study shows a strong positive relationship between stature and the percutaneous length of long bones of the forearm. This was a cross-sectional study, and data were collected from specific regions, so the results may not apply to all population groups.
- The results indicate a significant positive relationship between Radius and Ulna lengths. Individuals with longer Radius lengths generally tend to have longer Ulna lengths.
- The regression analysis further showed that Radius length is a significant predictor of Ulna length, suggesting its usefulness in estimating Ulna length.

REFERENCES

1. Kachare RV, Vaswani V, Dode PS, Waghmare SS. Estimation of stature from percutaneous length of ulna in rural government medical college and hospital in Marathwada region of central Maharashtra. J Indian Acad Forensic Med 2021 ;43(4):31 6-1 9.
2. Kaore DA, Kamdi DA, Kaore DS. Stature estimation from ulnar length. Natl J Integrated Res Med.201 2;3(2):51 -6.

3. Gaur R, Kaur K, Airi R, Jarodia K. Estimation of stature from percutaneous lengths of tibia and fibula of scheduled castes of Haryana State, India. Ann Forensic Res Anal. 2016;3(1):1025-30.
4. Anas IY, Esomonu UG., Zagga AD. Prediction of stature of Hausa ethnic group using hand length and breadth. J Med Trop. 2010;12:30-32.
5. Introna F., Di Vella G. and Petrachi S. (1993). [Determination of height in life using multiple regression of skull parameters]. Boll. Soc. Ital. Biol. Sper. 69, 153–160.
6. Chiba M. and Terazawa K. (1998). Estimation of stature from somatometry of the skull. Forensic Sci. Int. 97, 87–92.
7. Musgrave J.H. and Harneja N.K. (1978). The estimation of adult stature from metacarpal bone length. Am. J. Phys. Anthropol. 48, 113–119.
8. Meadows L. and Jantz R.L. (1992). Estimation of stature from metacarpal lengths. J. Forensic Sci. 37, 147–154.
9. Holland T.D. (1995). Estimation of adult stature from the calcaneus and talus. Am. J. Phys. Anthropol. 96, 315–320.
10. Byers S.N., Akoshima K. and Curran B. (1989). Determination of adult stature from metatarsal length. Am. J. Phys. Anthropol. 79, 275–279.
11. Gul H, Nizami SM, Khan MA. Estimation of body stature using the percutaneous length of ulna of an individual. Cureus. 2020;12(1):e6599. doi:10.7759/cureus.6599.
12. Keche AS, Keche HA. Ulnar length – A tool for stature estimation. Indian Journal of Forensic Medicine and Toxicology. 2020;14(3):200-204
13. Senthil Kumaran M, Bastia BK, Kumar L. Estimation of stature from the percutaneous lengths of the radial and ulnar bones in Gujarati population. Indian Internet Journal of Forensic Medicine and Toxicology. 2014;12(1 &2):7-10.
14. Kandel J, Yadav S. Estimation of Stature from Percutaneous Length of Radius and Ulna in Nepalese Medical Students. Journal of Nobel Medical College. 2025;14(2):27–31. doi:10.3126/jonmc.v14i2.87822.