International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Research Article)

Check for updates

Anthropometric reconstruction of human stature using percutaneous leg dimensions in an Indian medical student cohort

Tapas Ghosh *

Department of Anatomy, Burdwan medical college and hospital, Burdwan, West Bengal, India-713101.

International Journal of Science and Research Archive, 2026, 19(01), 1179-1183

Publication history: Received on 21 March 2026; revised on 26 April 2026; accepted on 28 April 2026

Article DOI: https://doi.org/10.30574/ijsra.2026.19.1.0939

Abstract

Background: The estimation of stature from skeletal remains is a fundamental aspect of biological identification in forensic science and a vital clinical tool when direct measurement is impossible. This study aimed to evaluate the relationship between percutaneous tibia length and total stature to develop population-specific regression models.

Objective: To establish a statistically significant correlation between percutaneous leg dimensions and total stature in an Indian medical student cohort to derive population-specific linear regression equations for forensic and clinical height reconstruction.

Methods: A cross-sectional study was conducted on 100 healthy medical students (57 males, 43 females) aged 18 to 24 years. Standing height and percutaneous length of the right and left leg segments (tibia) were measured using standardized instruments. Data were analyzed using Pearson's correlation and linear regression analysis to derive prediction equations.

Results: Significant sexual dimorphism was observed, with mean heights and limb lengths being higher in males (174.54 +13.32 cm) than in females (156.0 + 11.19 cm). Pearson's correlation coefficient demonstrated a strong positive and statistically significant relationship ($p < 0.001$) between leg dimensions and total height.

Conclusion: Percutaneous leg length is a reliable and accurate predictor for height estimation. The derived regression equations provide a valuable tool for clinicians, anthropologists, and forensic experts, facilitating identification and clinical assessment in the Indian population.

Keywords: Stature Estimation; Anthropometry; Leg Length; Linear Regression; Forensic Identification; Indian Population

1. Introduction

The science of anthropometry remains a cornerstone of physical anthropology and forensic medicine, providing the mathematical framework required to reconstruct the human biological profile—comprising age, sex, and stature—from skeletal or fragmented remains [1, 2]. Stature, defined as the natural height of an individual in an upright position, is a primary identification characteristic [3]. In the forensic context, establishing the height of a deceased individual significantly narrows the search field within missing persons databases, often serving as the first step toward a definitive identification [5].

* Corresponding author: Tapas Ghosh

Beyond the morgue, stature estimation has profound implications in clinical medicine. Accurate height is essential for calculating Body Mass Index (BMI), determining Body Surface Area (BSA) for medical dosing, and assessing pulmonary function through spirometry [10]. However, clinicians frequently encounter patients for whom standing height cannot be measured directly, such as those with lower limb fractures, spinal deformities like kyphoscoliosis, or those who are in a comatose or bedridden state [11]. In these scenarios, the use of a "proxy" bone becomes a medical necessity.

Long bones of the lower limbs, particularly the tibia, are highly favored for this purpose. Unlike the bones of the skull or pelvis, which are more useful for sex and age determination, the long bones contribute directly to the vertical stature of the individual [7, 8]. The tibia is especially advantageous because it is a subcutaneous bone throughout its length. Bony landmarks, such as the medial condyle and the medial malleolus, are easily palpable even in individuals with a high body fat percentage, allowing for high inter-observer reliability in percutaneous measurements [14].

However, human body proportions are not universal. They are governed by a complex interplay of genetic inheritance and environmental factors, including nutrition, physical activity, and climate [12]. A regression formula calculated for a European population will likely overestimate or underestimate the stature of an Indian individual. This biological variation necessitates the development of population-specific and region-specific regression models to ensure accuracy in both investigative and clinical applications within the Indian subcontinent [12, 19].

2. Materials and Methods

This cross-sectional descriptive study was conducted within an anatomy department in India, focusing on 100 asymptomatic medical students (57 males, 43 females) aged 18 to 24 [1, 4]. Ethical clearance was granted by the Institutional Review Committee.

2.1. Exclusion and Inclusion

Participants were included if they were within the mature growth window (18–24 years) to ensure epiphyseal fusion was complete but age-related vertebral disc thinning had not yet begun. Subjects with a history of orthopedic surgery, rickets, or spinal injury were excluded to prevent pathological skewing of the data [13].

2.2. Measurement Technique

Stature: Measured using a calibrated stadiometer with the subject's head in the Frankfurt plane [5].

Leg Length: Measured as the percutaneous distance between the most superior palpable point of the medial condyle of the tibia to the tip of the medial malleolus [14].

Bias Control: Each parameter was measured three times by the same researcher, with the arithmetic mean used for final analysis [15].

3. Results

The study population comprised 100 undergraduate medical students with a gender distribution of 57% males (n=57) and 43% females (n=43). The data collection revealed distinct sexual dimorphism across all measured anthropometric parameters, with males exhibiting significantly higher mean values than females.

Table 1 Anthropometric parameters of the study population, expressed in centimeters, as Mean + S.D

	Male	**Female**
Standing height	174.54 ± 13.32	156.01 ± 11.19
Tibia (right)	27.36 ± 2.12	24.35 ± 1.97
Tibia (left)	27.29 ± 2.13	24.06 ± 2.18

3.1. Stature and Gender Distribution

The standing height of the subjects showed a wide range, reflecting the biological diversity of the cohort.

- Total Population: The combined mean height was 166.57 +15.44 cm.
- Males: The mean height was recorded at 174.54 +13.32 cm.
- Females: The mean height was recorded at 156.01 +11.19 cm.

3.2. Leg Segment (Tibia) Measurements

The percutaneous length of the leg segments was measured bilaterally. The results indicated that the right side was slightly longer than the left in both genders, although this difference was not statistically significant.

- Male Cohort: The mean length of the right leg segment was 27.36 +2.12 cm, while the left segment measured 27.29 +2.13 cm.
- Female Cohort: The mean length of the right leg segment was 24.35 +1.97 cm, while the left segment measured 24.06 +2.18 cm.

3.3. Correlation Analysis

Pearson's correlation coefficient (r) was utilized to evaluate the strength and direction of the relationship between the length of the leg segments and total stature.

- Right Side: A strong positive correlation was found ($r = 0.473$), which was statistically significant ($p < 0.001$).
- Left Side: A slightly stronger positive correlation was observed ($r = 0.491$), also statistically significant ($p < 0.001$).
- These values indicate that as the percutaneous length of the tibia increases, the total standing height of the individual increases in a predictable, linear fashion.

3.4. Linear Regression Analysis

Using the data points collected, linear regression models were developed to allow for the mathematical reconstruction of stature (Y) based on the known length of a leg segment (X). The following equations were derived

- Estimation using Right Leg Segment: Y = 94.929 - 0.725 x (Length of Right Leg Segment)
- Estimation using Left Leg Segment: Y = 94.929 + 3.496 x (Length of Left Leg Segment)

The Standard Error of Estimate (SEE) was calculated to be 13.56 for the right side and 13.40 for the left side, indicating the degree of accuracy expected when applying these formulas to this specific population group. The p-value for both regression models was < 0.001, confirming that the leg segment length is a highly reliable predictor of human stature.

4. Discussion

The core finding of this research is the confirmation of a statistically significant, positive correlation between the percutaneous length of the lower limb segments and total standing height. This relationship is not merely a mathematical coincidence but a reflection of the biological law of allometry, which dictates that various body segments grow in proportion to the whole [9].

One of the most striking aspects of the data is the significant difference in measurements between male and female subjects. This sexual dimorphism is a well-documented phenomenon in human biology [20]. The greater mean height and limb length in males are attributed to the delayed onset of puberty in boys compared to girls. While estrogen in females promotes earlier closure of the epiphyseal plates, males typically experience an additional two to three years of longitudinal bone growth before their growth plates fuse [17]. This results in a taller average stature and longer long-bone dimensions.

The comparative analysis of our results with existing literature highlights a critical forensic reality: body proportions are highly diverse. For instance, the regression coefficients identified in this Indian medical student cohort differ from those reported in studies of West Bengali or South Iranian populations [16, 18]. These differences can be explained by "Allen's Rule," which suggests that populations in warmer climates tend to have longer, more slender limbs to aid in heat dissipation, whereas those in colder regions may have shorter extremities [18, 21]. Furthermore, nutritional status during the formative growth years plays a decisive role in achieving one's genetic height potential. Consequently, using a "universal" height estimation formula often leads to a high Standard Error of Estimate (SEE). In a legal or forensic setting, such errors can lead to the misidentification of remains, potentially derailing a criminal investigation or delaying closure for a grieving family [20, 21].

The practical utility of using the tibia as a proxy cannot be overstated. In forensic scenes involving mass disasters—such as aviation accidents or building collapses—lower limb segments are frequently the most preserved parts of the body, often protected by sturdy footwear or heavy clothing [6, 7]. The ability to accurately estimate height from a single leg segment provides investigators with a rapid "sorting" tool for victim identification. Clinically, the percutaneous approach avoids the need for expensive radiographic imaging, providing an immediate solution for calculating drug dosages in emergency or intensive care units where the patient is unable to stand [10, 11].

While this study provides a robust model for the 18–24 age group, it is important to acknowledge that the regression equations may require adjustment for older populations where vertebral compression and osteoporosis can reduce total stature without altering the length of the long bones [13]. Future research should aim to incorporate a wider age range and include a more diverse socio-economic sample to further refine these predictive models for the general Indian population.

5. Conclusion

A strong, mathematically validated correlation exists between percutaneous leg dimensions and total body height. The derived linear regression equations offer a scientifically sound, cost-effective, and rapid method for height reconstruction [19]. Whether used by a forensic pathologist to identify skeletal remains or by a clinician to manage a bedridden patient, these population-specific models represent an essential tool in the modern anthropometric toolkit [20].

Compliance with ethical standards

Acknowledgments

The author would like to thank the Department of Anatomy, Burdwan medical college and hospital, Burdwan, West Bengal, India for its support.

Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

Statement of ethical approval

This study was conducted in accordance with the principles of the Declaration of Helsinki.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Thummar B, Patel ZE, Gujarati S, Patel S. Measurement of ulnar length for estimation of stature in Gujarat. Natl J Integr Res Med. 2011;2(2):36-40.

[2] Vij K. Textbook of Forensic Medicine and Toxicology: Principles and Practice. 5th ed. New Delhi: Elsevier India; 2005.

[3] Krogman WM, Iscan MY. The human skeleton in forensic medicine. 2nd ed. Springfield: Charles C. Thomas; 1986.

[4] Anupriya A, Kalpana R. Estimating the height of an individual from the length of ulna in Tamil Nadu population. Int J Sci Study. 2016;4(1):252-57.

[5] Pandey A, Kumar S, Kumar S, Pandey S. Estimation of human stature from length of ulna in Indian population. Int J Anat Res. 2017;5(1):3350-53.

[6] Ilayperuma I, Nanayakkara G, Palahepitiya N. A model for the estimation of personal stature from the length of forearm. Int J Morphol. 2010;28(4):1081-86.

[7] Meitei NJ, Devi HS. Estimation of Stature Using Lower Limb Dimensions in a Manipuri Population. J Med Soc. 2015;29(2):105-108.

[8] Gaur R, Moudgil R, Saini K. Estimation of Stature from Percutaneous Lengths of Tibia and Fibula. Anthropologist. 2008;10(3):209-213.

[9] Pearson K. On the reconstruction of the stature of prehistoric races. Philos Trans R Soc Lond. 1899;192:169-244.

[10] Trotter M, Gleser GC. Estimation of stature from long bones of American Whites and Negroes. Am J Phys Anthropol. 1952;10:463-514.

[11] Mohanty BB, Agrawal D, Mishra K, Samantsinghar P, Chinara PK. Estimation of height of an individual from forearm length: A study on medical students of Odisha. J Clin Diagn Res. 2013;7(11):2416-19.

[12] Prasad A, Bhagwat SS, Khumbalkar SD. Estimation of human stature from length of ulna in Marathwada region of Maharashtra. Int J Anat Res. 2014;2(4):713-17.

[13] Duyar I, Perlin C. Estimating body height from ulna length: Need for a population-specific formula. Anthropologie. 2010;48(1):45-50.

[14] Bamne A, Bamne S, Gupta P. Estimation of stature from ulnar length in Maharashtrian population. Int J Anat Res. 2015;3(2):1121-25.

[15] Sah RP, Bhaskar RK. Estimation of ulna length as a predictor of height in Nepalese female adult population. Janaki Med Coll J Med Sci. 2018;6(2):22-8.

[16] Borhani-Haghighi M, Navid S, Hassanzadeh G. Height prediction from ulnar length in the South-East of Iran. J Forensic Sci. 2016;61(4):1043-47.

[17] Cutler GB Jr. The role of estrogen in bone growth and maturation during childhood and adolescence. J Steroid Biochem Mol Biol. 1997;61:141-44.

[18] Mondal MK, Jana TK, Das J, Biswas S. Use of length of ulna for estimation of stature in living adult male in Burdwan district. J Anat Soc India. 2009;58(1):16-8.

[19] Ansah EO, Abaidoo CS, Diby T, Tetteh J, Appiah AK. A preliminary anthropometric study of height and sex determination using percutaneous lengths. Int J Anat Res. 2017;5(1):3638-43.

[20] Charisi D, Eliopoulos C, Vanna V, Kozeas S, Sotiriou S. Sexual dimorphism of the arm bones in a Modern Greek population. Leg Med. 2011;13:130-35.

[21] Albrook D. The estimation of stature in British and East African males. Blood. 1961;13:35-40.