DOI: 10.7860/JCDR/2025/79860.21555

Original Article

Anatomy Section

Estimation of Stature from Left Tibial Length in Young Adult Males: A Cross-sectional Study

KAVITA DHIDHARIA[1], HINA SHARMA[2], PRITESH MENARIA[3]

ABSTRACT

Introduction: Estimation of stature by measurement of various bones is of immense value in the identification of an individual. Tibial length measurement is a reliable anthropometric parameter commonly used for estimating an individual's stature, especially in forensic and archaeological contexts. It provides accurate results due to the strong correlation between tibial length and overall body height.

Aim: To find the relationship between the stature and length of the left tibia of an individual and derive a linear regression equation to calculate the height from the length of the left tibia.

Materials and Methods: The present analytical cross-sectional study was conducted in the Department of Anatomy, Pacific Medical College and Hospital, Udaipur, Rajasthan, India, from June 2023 to June 2024. Sample population was 200 males between the age group of 17 years to 24 years. Spreading calipers was used to measure left tibial length in the sitting position. The bony prominences used for this were medial malleolus of the tibia and medial epicondyle of left lower limb. The height was measured by stadiometer. Statistical analysis was done to determine the regression equation for stature estimation. The relationship between tibial length and height was established using a regression equation and then the p-value for the slope (regression coefficient) of that equation was calculated. Statistical Package for Social Sciences (SPSS) V 30 software was used for statistical analysis.

Results: The mean height of male subjects was found to be 162.47 cm. Mean percutaneous length of left tibia (x) was found to be 35.99 cm for males. The correlation coefficient was 0.658 and the regression equation was Y=71.361+2.575X (Tibial Length).

Conclusion: The present study reveals that a positive and statistically significant correlation exists between the percutaneous tibial length and stature.

Keywords: Anthropometry, Osteometry, Skeletal abnormalities, Standing height

INTRODUCTION

Assessment of height from different bones by anatomists and forensic anthropologists helps establish the identity of an individual. Stature refers to the height of an individual when standing [1]. Estimating a person's stature plays a significant role in numerous medicolegal situations and can be utilised during large-scale disasters. Anthropometric characteristics have a direct relationship with sex, shape, and form of an individual [2]. Extensive work has been conducted on stature estimation from various body parts like hands, limbs, short bones, footprints, etc., [3] Standing height is contributed maximally by lower limb length; hence, most predictive formulae are based on the length of femur, tibia, and fibula [4]. Tibia is easily approachable for percutaneous measurement and can be fairly used for stature [5]. Different studies on various populations have found a positive correlation between stature and percutaneous tibial length [6-8].

A lack of literature on young adult males in the catchment of the tertiary healthcare center of Udaipur was detected, and so this study was carried out to fill the gap. The study aimed to find the relationship between the stature and length of the left tibia of an individual and derive a linear regression equation to calculate the height from the length of the left tibia.

MATERIALS AND METHODS

The present cross-sectional study was carried out in the department of Anatomy, Pacific Medical College and Hospital, Udaipur, Rajasthan, India, from June 2023 to June 2024. Institutional ethical clearance was obtained (IEC/2023/24).

Inclusion and Exclusion criteria: Male subjects aged 17 to 24 years with normal musculoskeletal development and with no history of growth disorders were included. Individuals with a history of fractures, deformities, or surgeries involving the left lower limb or tibia. Presence of congenital or acquired skeletal abnormalities. Subjects with chronic illnesses affecting bone growth (e.g., rickets, osteogenesis imperfecta, endocrine disorders). Participants with postural defects or limb length discrepancy and those unwilling to participate or unable to cooperate during the measurement process were excluded.

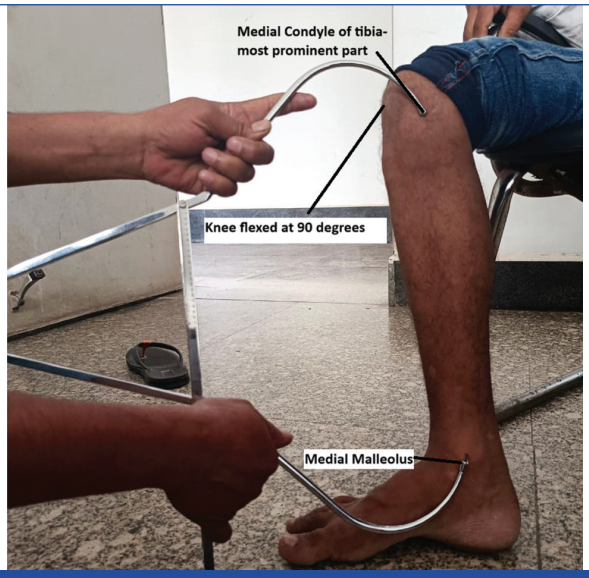
The left tibia was selected for measurement in this study following the guidelines of the International Biological Programme (IBP), which recommends the use of the left side unless there is a contraindication or deformity [9]. Measurements from one side also reduce variability arising from limb dominance or minor injuries, consistent with anthropometric protocols [10]. Females were excluded from the present study to avoid gender-based variability in anthropometric parameters. Additionally, the inclusion of only males allows for a homogeneous sample, improving internal validity and simplifying the interpretation of results for the targeted population.

Study Procedure

Technique of stature measurement: It was taken as a straight distance from the highest point on the head (vertex) to the floor with the subject standing erect with head in the Frankfort-Horizontal plane (eye ear plane). The subject stood barefoot with both feet together, arms resting alongside the trunk, and eyes directed straight ahead. Standing height was measured using a stadiometer.

Percutaneous Length of Tibia (PCTL): It was measured by spreading calipers. Intraobserver/interobserver variability in the measurement of tibial length was minimised by using standardisation of the measurement protocol. Precise anatomical landmarks (medial malleolus and prominence of the medial condyle of the tibia) were defined. The subjects were made to sit on a stool with their knee and hips flexed at 90 degrees each, because in this position, soft

tissue relaxes and bony points become more prominent. The most prominent upper palpable bony part of the tibia at the medial side of the leg was taken as the upper bony prominence, and the maximum convexity of the medial malleolus was taken as the lower bony point to measure the tibial length [Table/Fig-1]. The same instrument was used each time for all measurements. The mean value of three measurements per subject was taken.



[Table/Fig-1]: Technique of stature measurement of Percutaneous Length of Tibia (PCTL).

STATISTICAL ANALYSIS

Statistical analysis was done using SPSS V30 software. The relationship between tibial length and height was established using a regression equation, and then the p-value for the slope (regression coefficient) of that equation was calculated.

RESULTS

The mean height measured was 162.47 cm with a standard deviation of 2.57, and the range was 9 cm. The minimum PCTL that was measured was 32.76 cm, and the maximum was 42.75 cm [Table/Fig-2].

Description	Stature (cm) (Y)	PCTL (cm) (X)
Mean	162.47	35.99
Standard deviation	2.57	1.98
Range	9	9.9
Minimum	147	32.76
Maximum	156	42.75

[Table/Fig-2]: Mean, standard deviation, range, minimum values and maximum values of stature and Percutaneous Tibial Length (PCTL) of males (in cm).

The correlation coefficient (r) of left tibia with stature was 0.658 and p-value is 0.032. The confidence interval for r: 0.72, 0.83. This interval indicates a strong and statistically significant positive correlation between tibial length and stature.

Regression equation was calculated to be:

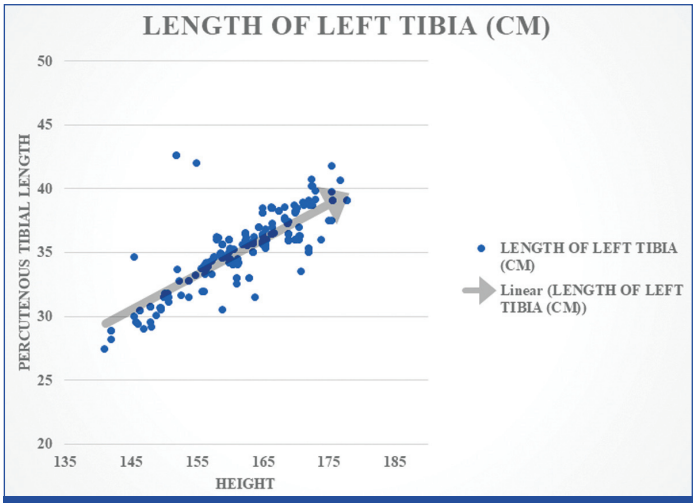
Y=71.361+2.575X (tibial length).

Where, 'Y' is the estimated height and 'X' is left tibia length in centimetres [Table/Fig-3].

Coefficient of determination (R2): 0.60 means 60% of the variation in stature can be explained by tibial length. The Standard Error of Estimate (SEE): ±2.943 cm represents the average deviation of actual stature from the predicted value.

DISCUSSION

The present study, conducted among young adult males of a tertiary medical center revealed a strong positive correlation (r=0.658)



[Table/Fig-3]: Scatter diagram with regression line for estimation of stature from left tibial length of males.

between percutaneous tibial length and stature, with a regression equation: Stature Y=71.361+2.575X (Tibial Length) (cm).

Ghosh T in a West Bengal population reported a correlation coefficient of r=0.94 with the regression equation Y=69.11+2.69X [5]. Saini N et al., observed similar outcomes in Rajasthan with r=0.98 [6]. These findings underscore the regional consistency in the reliability of tibial length as a stature predictor.

Globally, Duyar I and Pelin C (2003) noted that stature estimation from tibia must be stratified by stature groups to enhance prediction accuracy [11]. Their Turkish population data showed that group specific equations reduce prediction errors, especially for extreme height ranges. Likewise, Saco-Ledo G et al., in a Spanish population reinforced the value of population specific and stature specific regression models for increased accuracy [12]. A comparative data of Indian studies on stature estimation from tibial length is depicted in [Table/Fig-4] [5,6,8,13,14].

Study	Population	Sample size	Correlation coefficient (r)	Regression equation	Remarks
Ghosh T (2019) [5]	West Bengal	470 subjects	0.94	Y=69.11+2.69X	Consistent findings
Saini N et al., (2013) [6]	Rajasthan	100 adults	0.98	Y=68.9514+2.5902X	Includes both sexes
Khatun SS et al., (2016) [8]	India (mixed)	200 adults	0.86	Y=67.08+2.75X	Percutaneous method
Trivedi J (2014) [13]	Gwalior	270 males	0.4416 (Lt tibia)	Y=103.712+1.59X	Tibia of both males and females
Kavyashree AN et al., (2018) [14]	South India	350 subjects	0.78	Y=77.64+2.35X	Tibia of both males and females

[Table/Fig-4]: Comparative data of Indian studies on stature estimation from tibial length [5,6,8,13,14].

The present study reinforces the use of percutaneous tibial length as a dependable parameter for stature estimation in young Indian males. The practical applicability of these findings is significant. In forensic anthropology and disaster victim identification, especially in mass disasters, train accidents, or war zones where fragmented skeletal remains are recovered, the regression formula derived from tibial length can aid in narrowing down individual identity. Furthermore, in orthopaedics and reconstructive surgery, especially in cases of limb deformities, growth abnormalities, or post-traumatic reconstructions, such anthropometric data can be invaluable for prosthesis design and predicting anatomical dimensions in the absence of full-body imaging. Thus the current study offers relevant clinical and forensic implications for stature estimation from accessible tibial landmarks.

Impact of soft tissue and body proportions: One of the overlooked aspects in percutaneous measurements is the variability introduced by soft tissue thickness and distribution. Subcutaneous fat, muscle bulk, and oedema can affect the accuracy of identifying bony landmarks, particularly in obese or muscular individuals. Although seated posture with 90-degree flexion of hip and knee helps relax soft tissues, slight variations still exist depending on nutrition, hydration, and physical activity levels. Moreover, individual body proportions such as leg-to-torso ratio can influence how tibial length scales with overall height, thereby adding individual variability [15].

Limitation(s)

This study, while statistically sound, has a few limitations:

- **Gender limitation:** The sample included only males to maintain homogeneity, which restricts the applicability of findings to females. Sexual dimorphism in bone length and proportions demands gender-specific equations.
- **Age and nutritional range:** The age group was limited (17-24 years), and nutritional status was not controlled. Nutritional deficiencies during adolescence can affect bone growth, influencing tibial length and final adult stature.
- **Regional scope:** The findings apply primarily to young adult males and may not be generalised to other ethnic or regional populations without further validation.
- **Measurement precision:** While steps were taken to reduce inter and intra-observer variability, minor human errors in landmark identification or instrument placement may persist.

CONCLUSION(S)

A moderate statistically significant correlation existed between height and PCTL, and there is a minimum standard error of estimation in stature. Future studies on both males and females of the tibia of both sides with defined nutritional status are recommended for better evaluation of larger population.

Acknowledgement

The authors acknowledge the experts whose works are discussed and cited in this manuscript for their invaluable assistance. The authors also acknowledge the Pacific Medical College Udaipur, Rajasthan India, for their assistance in publishing the present article.

REFERENCES

[1] Ugochukwu EG, Augustine EO, Samuel E, Ifechukwude B. Estimation of stature from stride length and lower limb length of efiks in Calabar South, Cross River State, South-South Nigeria. J Anat Soc India. 2021;70(4):216-20. Doi: 10.4103/JASI.JASI_63_20.
[2] Trotter M, Gleser G. Estimation of stature from long bones of American Whites and Negroes. Am J Biological Anthropology. 1952;44-109. Available from: http://doi.org/10.1002/ajpa,1330100407.
[3] Krishna K. Estimation of stature from footprint and foot outline dimensions in Gujjars of North India. Forensic Sci Int. 2008;175(2-3):93-101. Available from: http://doi.org/10.1016/j.forsciint.2007.05.014.
[4] Mohanty N. Prediction of height from percutaneous tibial length amongst Oriya population. Forensic Sci Int. 1998;98(3):137-41. Available from: http://doi.org/10.1016/S0379-0738(98)00144-3.
[5] Ghosh T. Estimation of stature from percutaneous length of tibia amongst Bengalee population-an observational study in a teaching institution in West Bengal, India. Int J Res Med Sci. 2019;7(5):1653-57. Available from: http://dx.doi.org/10.18203/2320-6012.ijrms2019165.
[6] Saini N, Chauhan S, Katara P, Parashar R. A correlational study between stature and percutaneous tibial length in adult makes and females of Rajasthan. Indian Journal of Basic and Applied Medical Research. 2013;3(1):21-26.
[7] 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.
[8] Khatun SS, Sharma N, Jain SK, Gupta A. Estimation of stature from percutaneous tibial length in Indian population. Int J Anat Res. 2016;4(3):2571-76. Available from: http://dx.doi.org/10.16965/ijar.2016.278.
[9] Weiner JS, Lourie JA. Human biology: A guide to field methods (International Biological Programme). Blackwell Science Ltd. 1969.
[10] Ulijaszek S, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. Br J Nutr. 1999;82(3):165-77. Doi: 10.1017/S0007114599001348.
[11] Duyar I, Pelin C. Body height estimation based on tibia length in different stature groups. Am J Phys Anthropol. 2003;122(1):23-27. Doi: 10.1002/ajpa.10257.
[12] Saco-Ledo G, Porta J, Duyar I, Mateos A. Stature estimation based on tibial length in different stature groups of Spanish males. Forensic Sci Int. 2019;304:109973. Doi: 10.1016/j.forsciint.2019.109973.
[13] Trivedi J. Body height estimation based on tibia and femur length in Different Stature Groups. The International Journal of Indian Psychology. 2022;10(4):2149-54. Doi: 10.25215/1004.203.
[14] Kavyashree AN, Bindurani MK, Asha KR, Prabha L. Estimation of stature by morphometry of percutaneous tibia. Indian J Clin Anat Physiol. 2018;5(3):308-13.
[15] Krishan K, Kanchan T. Measurement error in anthropometric studies and its significance in forensic casework. Ann Med Health Sci Res. 2016;6(1):62-63.

PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Anatomy, Pacific Medical College and Hospital, Udaipur, Rajasthan, India.
2. Professor and Head, Department of Anatomy, Pacific Medical College and Hospital, Udaipur, Rajasthan, India.
3. Assistant Professor, Department of Anatomy, Pacific Medical College and Hospital, Udaipur, Rajasthan, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Hina Sharma,
22, Hazareshwar Colony, Udaipur, Rajasthan, India.
E-mail: drsharmah@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jun 12, 2025
- Manual Googling: Jul 24, 2025
- iThenticate Software: Jul 26, 2025 (16%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Jun 11, 2025**
Date of Peer Review: **Jun 25, 2025**
Date of Acceptance: **Jul 28, 2025**
Date of Publishing: **Oct 01, 2025**