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Original Research Article

Correlation of Anthropometric Measurements of Proximal Tibia with Its Length for Stature Estimation in Forensic Analysis

Yogi Anupkumar Balakrishnan [1], S Vikram [2], Ajay Ningaiah [3], Tejaswi H Lokanathan*[4].

[1] Associate Professor, Department of Anatomy, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, BG Nagara, Nagamangala, Mandya District, Karnataka, India.

[2] Professor, Department of Anatomy, Surabhi Institute of Medical Sciences, Mittapally Village, Siddipet Mandal, & District, Telangana, India.

[3] Associate Professor, Department of Anatomy, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, BG Nagara, Nagamangala, Mandya District, Karnataka, India.

*[4] Professor, Department of Anatomy, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, BG Nagara, Nagamangala, Mandya District, Karnataka, India.

ABSTRACT

Background: Estimation of stature is one of the commonly used methods in forensic analysis to establish identity of individuals. Estimation of stature from fragments of long bones is done by deriving linear regression equations. The objective of the present study was to derive a simple regression equation for estimating length of the tibia using the morphometry of proximal end of tibia.

Materials and methods: In this descriptive study carried out in the department of anatomy of a medical college, anthropometric measurements of proximal end of 150 dry human tibiae were collected irrespective of the sex and side. The parameters measured included the mediolateral length of the proximal end, the anteroposterior length of the medial and lateral condyle of tibia, anteroposterior length of the intercondylar area, and the circumference of proximal end of tibia. The measurements were done using Vernier calliper and measuring tape. Length of the tibia was estimated by using simple regression analysis.

Results: The following linear regression equations were derived. Length of tibia can be calculated by, 29.2749 + (1.1925 × Mediolateral length) ±1.1926, 27.6418 + (2.333 × Anteroposterior length of lateral condyle) ±1.132, 21.8342+(3.2614 ×Anteroposterior length of medial condyle) ±1.328, 33.542 +(0.8952 × Anteroposterior length of intercondylar region) ±1.474, 23.1902 +(0.76379 × Circumference of proximal end) ± 1.134

Conclusion: The study revealed that there is a positive correlation between the measurements of proximal end of tibia and its length. The equation derived would help in forensic analysis to estimate the stature of an individual.

KEY WORDS: Humans, Tibia, Linear Models, Forensic Anthropology, Body Height.

Corresponding Author: Dr. Tejaswi H Lokanathan, Professor, Department of Anatomy, Adichunchanagiri Institute of Medical Sciences, Adichunchanagiri University, BG Nagara, Nagamangala, Mandya District, Karnataka -571448, Ph:9986322186

E-Mail: drtejaswihl@gmail.com

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INTRODUCTION

Identification is the process of recognizing an individual using various features-physical and biological [1]. Identification of an individual isof great medicolegal importance. Forensic experts and anatomists are frequently consulted for establishment of identification in living as well as deceased by the court of law [2]. One of the commonest criteria used for identification is estimation of stature. Accurate estimation of stature in turn requires length of one or more long bones [3]. The long bones of the lower limb, femur and tibia have been reported to have direct correlation with the stature of the individual [4]. Tibia accounts for 22% of the total body length [5]. Tibia is often preferred by the researchers as it is reported to resist erosion and also maintain anatomical shape even after a long burial time [6].

Tibia is the medial and the larger bone of the leg. It has a shaft with two expanded ends, proximal and distal. The proximal end of tibia, expanded transversely, is a weight bearing surface. It transmits the body weight through the femur. The proximal end of the tibia has massive medial and lateral condyles, an intercondylar area and tibial tuberosity. The condyles overhang the shaft's proximal posterior surface and both have proximal articular surfaces separated by an irregular intercondylar area. The proximal tibial surface slopes posteriorly and downwards relative to the shaft's long axis; the tilt is more marked in habitual squatters [7].

Various anthropometric parameters of tibia such as percutaneous tibial length, measurements of proximal and distal end of the tibia have been used for estimation of maximal tibial length and also the stature of the individual [8-10]. The morphometry of proximal end of the tibia not only helps in estimation of length of tibia and hence stature, it is also of great importance in designing proximal tibial implants essential for orthopaedic surgery [11]. Literature review does suggest paucity of researches based on measurements of proximal end of tibia in estimation of tibial length and also stature.

The present research was hence undertaken with the objective of providing accurate measurements of various dimensions of proximal end of tibia, length of tibia and also arrive at simple regression equation which would further help in estimation stature and also tibial length from measurements of fragments.

MATERIALS AND METHODS

This prospective descriptive study was carried out on 150 dry, adult, human tibias of both sides, randomly collected from the Department of Anatomy of a medical college in south India. The sample size was estimated as 144. This was arrived after a pilot study during which medio-lateral length of proximal end of 15 tibia was measured. This revealed that the mean mediolateral length was 65.9 mm with standard deviation of 12. Hence using allowable error of +-2 with the risk of 5%, the sample size was arrived at 144.

One hundred and fifty fully ossified and processed dry tibia bones of both sides were included in the study. Unossified bones with or without defects were excluded from the study.

Data was collected by measuring the following parameters of the proximal end of the tibia by using Vernier calliper.

1. Mediolateral length of proximal tibia (MLL)
2. Anteroposterior length of medial condyle (APML)
3. Anteroposterior length of lateral condyle (APLL)
4. Anteroposterior length of intercondylar region (APIL)
5. Circumference of the upper end (C)
6. Length of the tibia (L)

Mediolateral length was measured as the maximum distance from the lateral side of the lateral condyle to medial side of the medial condyle (figure 1), using the Vernier calliper [8]. Antero posterior length of medial condyle, is measured as the maximum anterior-posterior distance of the medial condyle (figure 2). Antero posterior length of lateral condyle is measured as the maximum anterior-posterior distance of the lateral condyle (figure 2). Anteroposterior length of intercondylar area is measured as the maximum distance from the anterior intercondylar area to the posterior intercondylar area (figure 2). Circumference of the upper end or proximal end is measured as the maximum circumference at upper end of the tibia, and is measured with a measuring tape (figure 3). Length of tibia is measured as the vertical distance from the most superior point on the medial tibial condyle to the most inferior point on the medial malleolus (figure 4) [12].

The 150 tibiae were measured and subjected to analysis. The mean and standard deviation were measured for each parameter. Following this the standard error of estimate and coefficient of determination was calculated followed by Pearson's coefficient. A simple regression formula is then obtained which will show the relationship between the proximal dimensions of tibia to the length of tibia.

RESULTS

The mean and standard deviation of parameters measured, standard error of estimate and coefficient of determination and the Pearson's coefficient is mentioned in the table 1, 2 and 3 respectively.

Fig. 1: Measurement of mediolateral length of proximal end of tibia.

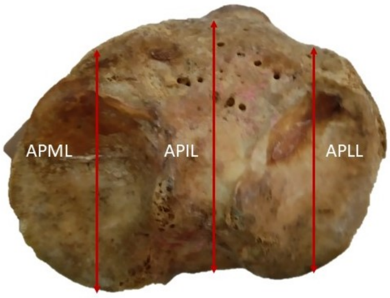

Fig. 2: Measurement of anteroposterior length of medial condyle, lateral condyle and intercondylar area.

Fig. 3: Measurement of circumference of proximal end of tibia.

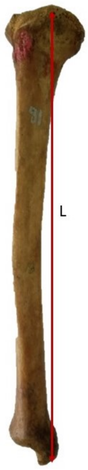

Fig. 4: Measurement of length of tibia.

Using the measurements mentioned in the tables 1-3, the following simple regression formulae were derived for estimating the length of tibia:

· Length of Tibia = 29.2749 +(1.1925 × Mediolateral length) ±1.1926

· Length of Tibia = 27.6418 +(2.333 × Anteroposterior length of lateral condyle) ±1.132

· Length of Tibia = 21.8342+(3.2614 ×Anteroposterior length of medial condyle) ±1.328

· Length of Tibia = 33.542 +(0.8952 × Anteroposterior length of intercondylar region) ±1.474

· Length of Tibia = 23.1902 +(0.76379 × Circumference of proximal end) ± 1.134

Parameters	Mean	Standard deviation
Meido-lateral length of the proximal end	7.02	0.2957
Anteroposterior length of the medial condyle	4.85	0.1612
Anteroposterior length of the lateral condyle	4.27	0.4148
Anteroposterior length of the intercondylar area	4.59	0.2545
Circumference of proximal end	18.93	1.2633
Length of Tibia	37.65	1.4866

Table 1: Mean and standard deviation of parameters in centimetres.

Parameters	Standard error of estimate:	Coefficient of determination
Meido-lateral length of the proximal end	1.1926	0.367
Anteroposterior length of the medial condyle	0.9014	0.6347
Anteroposterior length of the lateral condyle	1.1321	0.4317
Anteroposterior length of the intercondylar area	1.474	0.0234
Circumference of proximal end	1.1345	0.4214

Table 2: Standard error of estimate and coefficient of determination in centimetres.

Parameters	Pearson's coefficient
Mediolateral length of the proximal end	0.606
Anteroposterior length of the medial condyle	0.7967
Anteroposterior length of the lateral condyle	0.6571
Anteroposterior length of the intercondylar area	1.1532
Circumference of proximal end	0.649

Table 3: Pearson's coefficient.

DISCUSSION

Estimation of stature is an important aspect of identification and long bones are most useful in its estimation. Several studies have derived linear regressions to estimate the maximum length of long bones from the measurement of its fragments [13]. Determination of length of tibia is important in the estimation of stature [14].

In our present study, we derived regression equations to measure the length of tibia from its proximal dimensions in the tibia of south Indian population. The current study has demonstrated strong correlation between the proximal dimensions with the length of tibia. similar studies have been done to determine the length of humerus [15]. The mean of various parameters of proximal end, in the present study correlates with the study Gupta et al [16].

Research conducted by Holland TD reports estimation of adult stature from fragmentary tibias. In this study, eight measurements of the proximal end of each tibia were taken to the nearest 0.1 mm using a Vernier sliding calliper. One day later, 20 percent of the tibias were remeasured; the pool of measurements was culled to five. The five measurements included biarticular breadth, medial condyle articular width, medical condyle articular length, lateral condyle articular width, and lateral condyle articular length. Estimation of adult stature using the proximal tibia was possible due to a linear relation that held between stature and dimensions of the proximal end of the tibia [13].

Uehara K et.al., measured, anterior-posterior (AP) and medial-lateral (ML) lengths of the tibia on computed tomography scans and found that AP to ML ratio had a negative correlation with ML length, indicating that small knees were longer in the AP direction. Most prostheses had AP mismatch up to 5 mm for small knees especially in women. The authors reported that this data would help in designing the optimal tibial component for Asian-Pacific population [17].

Study done by Chibba K et.al., in south Africa, provide univariate and multivariate regression equations for estimation of total skeletal height and maximum tibial length from various measurements of the tibia. In the same study, when standard error of estimate was measured, it was found to be higher than those obtained for intact long bones, the equations derived from this study provided a reliable estimate of skeletal height and living stature in the absence of intact long bones [18].

Liu Z et.al., in China, studied reconstructed 3D models of the 179 arthritis knees using CT data. They found that the mediolateral dimension (69.6 ± 9.2 mm) and anteroposterior dimension (46.1 ± 6.1 mm) were less, when compared to those of Westerners. It was observed the medial anteroposterior dimension (47.1 ± 7.2 mm) was much larger and closer to middle point of ML dimension than lateral anteroposterior dimension (42.9 ± 6.3 mm). It was found that Only half of the prostheses they used in clinic matched the resected bony surface of Shanghai population very well in mediolateral, anteroposterior and aspect ratio dimension [19].

According to our study, we have provided five different equations for estimation of tibial length. The prototype of the equation is: Length of tibia = constant + [A x segment measurement] +/- standard error of estimate.

One of the limitations of the study was, we did not measure the parameters of tibia in living using MRI scans. We wish to further our research by measuring the dimensions of tibia in living and correlate the same with the findings of the present study. And also, the regression equations obtained are specific to south Indian origin and hence generalising the results of the study requires further research in different ethnicity and geographical area.

CONCLUSION

The regression equations provided in the current study can estimate length of the tibia and the same can also be used for estimation of stature. The findings of this study can be utilised for forensic analysis, as well as for reconstructive surgeries involving proximal tibia. However, caution needs to be applied in generalising these results in individuals of different ethnic and geographical origin.

Author Contributions

Dr Yogi Anupkumar Balakrishnan and Dr. Vikram S have contributed sufficiently to the concept, design of the study and intellectual content. Dr Yogi has done Extensive literature review.

Dr. Ajay Ningaiah has contributed to the analysis and interpretation of the data and manuscript writing with proof editing.

Dr. Tejaswi H L has contributed in the writing of the manuscript, proof editing and overall organising and supervision of the course of the project.

ORCiD

Yogi Anupkumar Balakrishnan:
https://orcid.org/0000-0002-5968-342X 2.
S Vikram: https://orcid.org/0000-0002-8046-2840
Ajay Ningaiah:
https://orcid.org/0000-0003-4141-5782 4.
Tejaswi H Lokanathan:
https://orcid.org/0000-0001-9214-8202

Conflicts of Interests: None

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