# Estimation of Stature from Living Adult Females belonging to Tamil Population using Percutaneous Tibial Length

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## Abstract

Establishment of the identity of an individual from dismembered remains or skeletal remains is a common problem encountered by the Forensic Pathologist and can be a challenging task. In addition to age and sex, stature is an anthropological parameter that is indispensable in establishing the identity of an individual. In the present study, we have analyzed the relationship between stature and percutaneous Tibial lengths (PCTL) and derived a regression equation for a specific population. The parameters namely, the stature and percutaneous Tibial lengths (PCTL) of both lower limbs were measured in 115 females belonging to Tamil population and recorded. The subjects were in the age group of 21-30 years. Analysis of the results involved the use of the Pearson's correlation to derive the relationship between the parameters and establish the dependence of the stature on the length of the left and right Tibia respectively in the study subjects. The results from this present study attest to the utility of the percutaneous Tibial lengths (PCTL) in determination of the stature in females belonging to the Tamil population.

***Keywords:*** *Stature, percutaneous Tibial lengths (PCTL), Regression equation, Females, Tamil population.*

## Introduction

The establishment of the identity of a decedent individual whose identity is unknown can be a challenging task to the Forensic Pathologist during post-mortem examination. The complete skeleton is not available at the scene of crime in many common forensic situations such as mass disasters, aircraft crashes and other transportation accidents and thus the problem can be more confounding when the dead body is mutilated, dismembered or skeletonized. In many scenarios, only the limbs or part of a limb is available.

Age, sex and stature are the three most important parameters that help in determining the biological profile and thus confirm the identity of the individual. The stature is an essential and useful anthropometric parameter that helps to determine the individual physical identity of the remains. Determination of stature involves two main methods, the first being the anatomical method when the skeleton is intact[1]. The second is the mathematical method, the application of which becomes incumbent on the forensic expert when the body is dismembered and the long bones are available. The mathematical method entails the use of regression formulae which have been hitherto established and are both race and sex specific[2].

A combination of factors such as genetic differences, isolation, climate and nutrition underlie these differences in regression formulae between various populations. This necessitates research to establish regression formulae that are population specific.

The greatest contributor to standing height in anatomical terms is the lower limb and most regression formulae use the long bones namely the Tibia or the Femur[3]. The lengths of the long bones of the lower limb are more reliable than bones of the upper limb for predicting stature[4]. The Femur length is the best predictor of an individual's stature but its measurement in living subjects is fraught with methodological constraints, in that the femur head is inaccessible and cannot be reached. It is more useful in studies using documented cadavers, i.e. that of known individuals whose height was recorded before death and at autopsy the Femur length can be measured and used for deriving regression equations. The Tibia on the other hand is a different

prospect. As the landmarks are subcutaneous and easily accessible, the percutaneous Tibial length (PCTL) can be measured in living subjects. Besides the fact that the Tibia is amenable to percutaneous measurement, it also resists degradation and is able to retain its anatomical form long after death and thus plays an important role in anthropological research[5-7].

Our study involved living female subjects belonging to the Tamil population to measure the percutaneous tibial length (PCTL) and assess its mathematical correlation with stature. In a situation where the body is dismembered, the same parameter i.e. PCTL can be measured and the height determined using regression equations. We have thus derived regression equations to determine the stature using the percutaneous Tibial length in female individuals of the Tamil population.

## Materials and Methods

The study was conducted after obtaining approval from the institutional human ethics committee of Chettinad Hospital and Research Institute. A total of 115 females in the age group of 21-30 years were selected for this study. Research participants with congenital or acquired skeletal defects, previous history of fractures involving the lower limbs or the spine, malnourishment, endocrinopathies etc. that could introduce inaccuracies in the study were carefully excluded.

The objectives of the study and the procedure was clearly explained to the subjects and the measurements were made after obtaining a written informed consent from them.

The anthropometric measurements for this study comprising of the stature of the individual and the percutaneous Tibial lengths of both the left and right lower limb were made using standard protocols. The measurements were made by the same observer at fixed time in the day between 9 to 11 am to avoid diurnal stature variation and to rule out inter-observer errors[8-9].

The standing height was measured using a stadiometer with the barefooted participant standing upright on the baseboard of the instrument[10-11]. The subject's head was maintained in the Frankfort horizontal eye-ear plane by supporting the subject's chin and the height was measured as the distance between the utmost point on the vertex and the heel.

The percutaneous Tibial length (PCTL) is the measured distance between the Tibiale Mediale (the medial most superficial point on the upper border of the medial condyle) and Spherion Tibiale (tip of the medial malleolus). Standard protocols were employed to measure the PCTL on both the left and right side independently in cm using a pair of spreading calipers[11-12]. The subject was made to stand and keep one foot on a stool so as to create a 90$^{o}$ angle between the flexor surface of the leg and the thigh and thus accentuate the bony landmarks on the medial aspect of the Tibia. The Spherion Tibiale was located at the lowest point on the medial malleolus. The specific location of the Tibiale Mediale was found by palpating the site bounded by the medial femoral condyle and the medial tibial condyle and the superior medial border of the Tibia located. Both landmarks were marked using a skin marking pencil and the distance between them measured using the spreading calipers.

## Results

The observed values for the stature in female Tamil subjects with respect to the percutaneous Tibial length in both the right and left lower limb were recorded and statistical analysis was done using SPSS Version 21 software. The results of the analysis are tabulated in Tables 1 and 2. The estimated mean height of the female subjects was 156.7 cm with a standard deviation of 4.2 cm. The mean percutaneous lengths of the right and left Tibia were estimated to be 33.54 cm (with a standard deviation of 1.01 cm) and 33.56 cm (with a standard deviation of 1.02 cm) respectively.

The Pearson's correlation coefficient r for stature with respect to the length of the right Tibia was 0.816 with regression coefficient (b) of 3.36($p<0.01$). Similarly, the Pearson's correlation coefficient r for stature versus the length of the left Tibia was 0.807 with regression coefficient (b) of 3.34($p<0.001$).

The data was used to prepare scatter diagrams (Fig. 1 and 2) by plotting the stature versus the lengths of the right and left Tibia. From these plots, the Regression equations for stature were derived as 3.36 x [Right Tibial length] + 44.03 and 3.34 x [Left Tibial length] + 44.45 using the right and left Tibial lengths respectively.

**Table 1: Significant statistical parameters for Right and Left Tibia in Females**

| Parameter | Dependent Variable | |
|---|---|---|
| Mean Stature (cm.) | 156.7 | |
| | Independent Variable | |
| | Right PCTL (cm.) | Left PCTL (cm.) |
| Mean Length (cm.) | 33.54 | 33.56 |
| Standard Deviation | 1.01 | 1.02 |
| Correlation Coefficient (r) | 0.816 [p<0.001] | 0.807 [p<0.001] |
| Coefficient of Determination (R2) | 0.665 | 0.651 |
| Regression Constant | 44.03 | 44.45 |
| Regression Coefficient (b) | 3.36 | 3.34 |
| Standard Error of Estimate (cm.) | 2.45 | 2.50 |

**Table 2: Regression equation for Stature estimation from PCTL in Females**

| PCTL | Regression equation for Stature |
|---|---|
| Right PCTL (cm.) | y1 = 3.36 x Right PCTL (cm.) + 44.03 |
| Left PCTL (cm.) | y2 = 3.34 x Left PCTL (cm.) + 44.45 |

Fig. 1 and 2 are scatter diagrams prepared by means of plotting the values for stature against the lengths of the right and left Tibia from subjects and Table 2 shows the linear regression equations for determination of stature with respect to Tibia on each side.

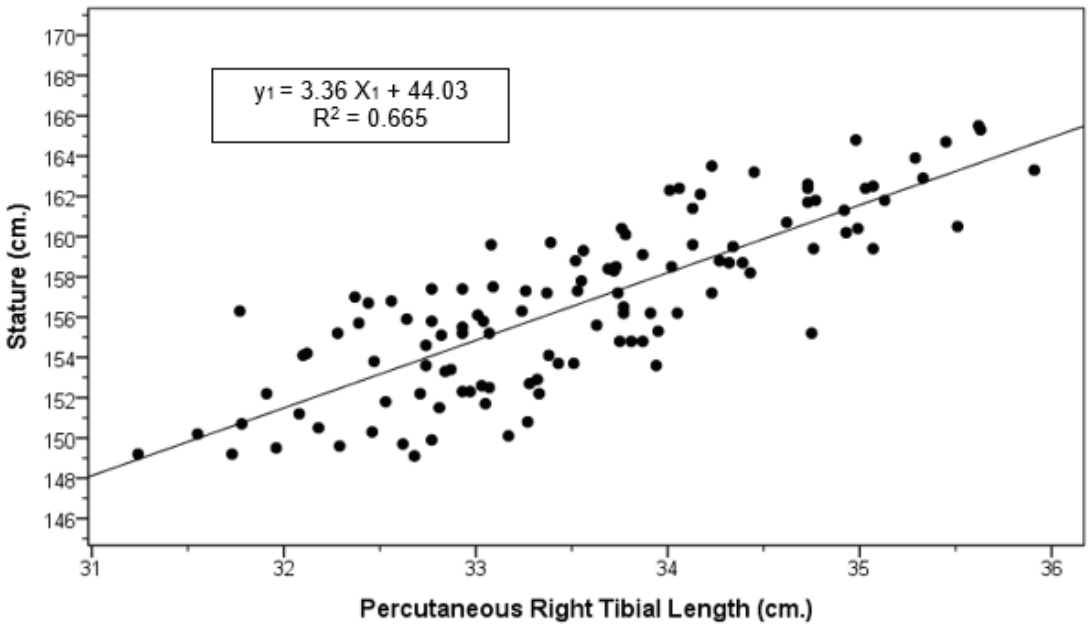


**Fig. 1: Correlation between Right PCTL ($X_1$) and Stature ($y_1$) in Females**

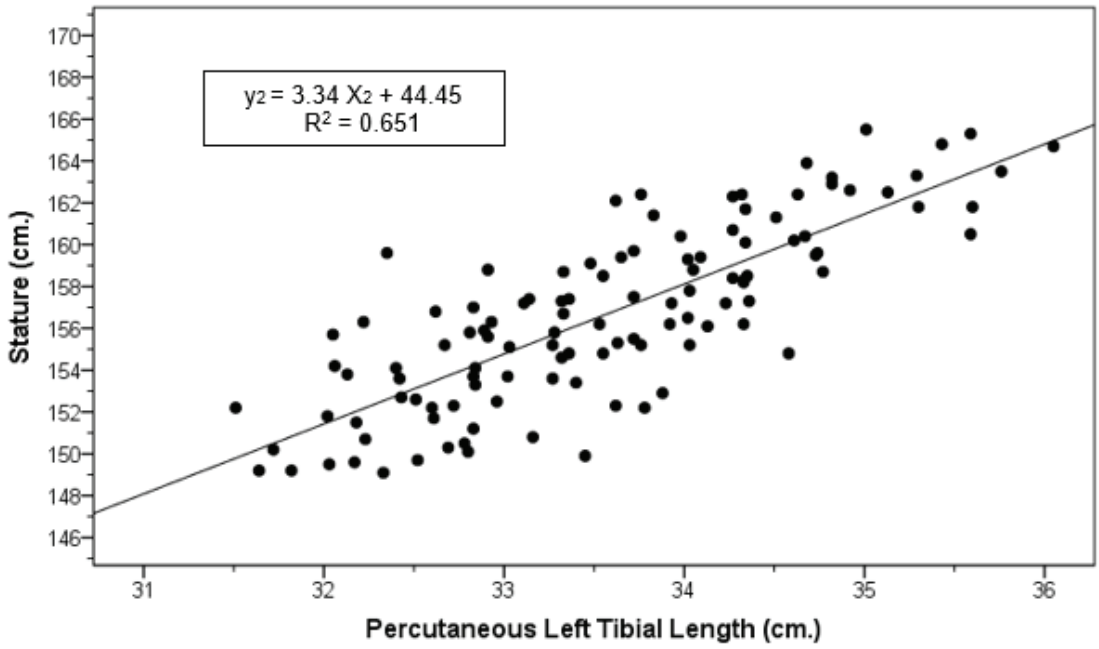


**Fig. 2: Correlation between Left PCTL ($X_2$) and Stature ($y_2$) in Females**

## Discussion

The estimation of stature can be a challenging problem to the forensic expert when bodies are mutilated or fragmentary skeletal remains are available. In most medico-legal cases, the body is either dismembered or skeletonized and the anthropometric measurements are used to assess the stature of the decedent individual. Regression formulae for stature estimation are population specific and have been developed by several investigators from long bones using documented skeletal remains of decedent individuals whose stature was already recorded before death in populations of European White or African Black ancestry[13-15]. Such documented skeletal remains are not available in Indian populations and the alternative is to use percutaneous measurements of long bones using living individuals as the regression formulae developed for one population cannot be indiscriminately applied to another population.

This study was conducted on living adult female Tamilian subjects with the aim of deriving a linear regression equation that can be used for estimating the stature using the percutaneous Tibial length. We find a statistically significant positive correlation between Tibial length and stature and the proposed equations will predict stature from Tibial length, as attested by the lower p-values obtained while performing the regression analysis.

We compared our findings of stature, mean right and left percutaneous tibial length as well as the regression equations derived by us for Tamilian female population with the results of other investigators pertaining to different ethnic populations in the Indian subcontinent and the data has been tabulated for comparison (Tables 3 and 4). The equations derived by us for the Tamil population are different from that derived for other populations thus confirming the population specificity of the regression equations.

There are minor variations in the mean stature as well as the mean percutaneous Tibial lengths between the studied group and other ethnic populations in the Indian subcontinent. These differences could be attributed to a multitude of factors that have a bearing on the person's growth and body proportions such as nutrition and dietary habits, genetic factors, physical stress, lifestyle, environmental conditions etc. The distal segments of the limbs are more sensitive to environmental factors[16]. Research studies have suggested that the proportional change in the distal segments of the limbs is related to improvement of socioeconomic conditions, nutrition

and health status[17]. Given the fact that improvement in socioeconomic and health conditions will continue in the Indian subcontinent in the future, this will have an impact on bones of the lower extremities and specifically the Tibia in this context. Thus, the population will grow taller, the increase in length of the Tibia will be both absolute and proportional. Stature is a constantly changing target for forensic experts owing to secular trends and allometric changes in long bones. As per the Miller and Jantz study, the secular change is more marked in the lower limbs than the upper limbs, and the change in the distal bones is greater than that in the proximal bones. If the long bones change their proportion with time, then their relationship with stature will also change[18]. Thus, the older stature formulae that rely on a certain relationship of long bone length to stature may lose their efficacy over time. Linear regression analysis studies correlating stature to Tibial length will have to be done afresh every generation to ensure accuracy of stature estimation.

**Table 3: Comparison of Mean Stature and Mean Tibial length in Females**

| Name of the Researcher | Year | Population for study | Mean Stature (cm.) | Mean Tibial Length (cm.) | |
|---|---|---|---|---|---|
| | | | | Right | Left |
| Present Study | 2020 | Tamil Nadu | 156.7 | 33.54 | 33.56 |
| Kavyashree19 | 2018 | Karnataka | 158.87 | 34.96 | 33.03 |
| Akilesh Trivedi20 | 2014 | Madhya Pradesh | 155.3 | 36.10 | 36.03 |
| Ashita Kaore21 | 2012 | Karnataka | 156.187 | 32.19 | 32.14 |

**Table 4: Comparison of Regression Formula for Stature (Y) in Females from length of Right Tibia ($X_1$) and Left Tibia ($X_2$)**

| Name of the Researcher | Year | Population for study | Regression Formula | |
|---|---|---|---|---|
| | | | Right Tibia | Left Tibia |
| Present Study | 2020 | Tamil Nadu | Y=3.36X1 + 44.03 | Y=3.34X2+ 44.45 |
| Kavyashree19 | 2018 | Karnataka | Y= 1.069X1 + 122.54 | Y=1.03X2 + 123.78 |
| Akilesh Trivedi20 | 2014 | Madhya Pradesh | Y=1.373X1 + 105.724 | Y=1.35X2 + 106.64 |
| Ashita Kaore21 | 2012 | Karnataka | Y=1.678X1 + 102.16 | Y=1.379X2 + 111.86 |

Table 4 shows a comparison of the regression formulae derived by us with that of other investigators for other ethnic populations in the country. All investigators were able to demonstrate a positive correlation between stature and Tibial length which thus affirms the relationship between the two parameters.

## Conclusion

The conclusion from this study is that the regression equations that have been formulated by us can be utilized to estimate the stature with reasonable accuracy in adult female individuals belonging to the Tamil population in situations such as mass disasters where the body is dismembered and the lower limb bones are available. The formulae derived are both ethnic and sex specific and cannot be used for other ethnic groups.

We recommend further studies on a larger scale and involving stature groups to develop separate equations separately for short, medium and tall statured individuals. Such stature group specific regression equations will further reduce errors in stature estimation and provide more accurate height estimates than a single general formula[22].

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**Informed Consent:** Obtained from all the participants

**Ethical Clearance:** Necessary ethical approval was obtained from the Institutional Ethics Committee, Chettinad Academy of Research and Education, Kelambakkam – 603103.

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