Regression Formula for Stature Determination from Percutaneous Tibial Length among the Female Meitei Population of Manipur

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Abstract

Stature is one of the important parameters for personal identification when only parts of human body, such as limbs are available for identification as in cases of natural disasters, rail and aircraft accidents, wars and terrorist bombings. Studies have reported significant differences in proportion of limb dimensions due to hereditary, environmental, ethnic and dietary factors, which also influence the stature of a person. Therefore, population-specific formulae are necessary for estimation of stature in medico-legal cases. A cross-sectional study was conducted on Indigenous Manipuri Meitei female subjects between the age group of 21-25years. 'Meitei' is the majority community in the state. The calculated sample size was 72. Considering a dropout rate of 5%, a total of 75 Meitei female subjects were studied in Department of Forensic Medicine and Toxicology, Regional Institute of Medical Sciences, Imphal. The study period was from August 2018 to July 2020. The findings of the study have been used in estimating the stature from Tibial Height by deriving a new Regression Formula which is specific for the population. The following is the developed regression equation of stature of female (Y) on her tibial length (X): Y= 107.83 + .60 X +.71. It will be of immense importance in medico-legal investigations thereby benefitting the society in general.

Key words: *Stature, percutaneous tibial length, female Meitei population, Regression formula.*

Introduction

Stature is one of the important parameters for personal identification when only parts of human body, such as limbs are available for identification as in cases of natural disasters, rail and aircraft accidents, wars and terrorist bombings. ''Stature is defined as natural height in an upright position''.[1] There exists a strong relationship between stature and dimensions of different body parts, particularly bone lengths, which forms the basis for stature estimation.[2] The lengths of long bones of lower limb provide better estimates of stature as compared to the bones of upper limb.[3] The tibia is ideal in this application as it resists erosion and keeps its anatomical shape for long even after burial.[4] Tibia accounts for 22% of the total body length.

Studies have reported significant differences in proportion of limb dimensions due to hereditary, environmental, ethnic and dietary factors, which also influence the stature of a person.[5] Therefore, population-specific formulae are more reliable for estimation of stature in medico-legal cases.

According to Bertillon after the age of 21 years the dimensions of the skeleton remain unchanged.[6] Earlier studies have established that the Regression equation provide greater reliability in estimating stature.[7]

The present work was carried out on indigenous female Meitei subjects of Manipur. The data collected

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were analyzed to generate a Regression Formula for estimation of stature.

Materials and Methods

A Cross-sectional study was conducted on Indigenous Manipuri Meitei female subjects between the age group of 21-25years. 'Meitei' is the majority community in the state. The calculated sample size was 72. Considering a dropout rate of 5%, a total of 75 Meitei female subjects were studied in Department of Forensic Medicine and Toxicology, Regional Institute of Medical Sciences, Imphal. The study period was from August 2018 to July 2020. Subjects with any obvious congenital or acquired deformity of spine or extremities were not included in the study.

The sample size was calculated from the following equation:

Total Sample size (n) = $[(Z_\alpha + Z_\beta)/c]^2 + 3$, therefore (n) equals to 72.

$Z_\alpha = 2.576$ (99% confidence level)

$Z_\beta = 1.282$ (90% power)

$c = 0.5 \times \log [(1+ r)/ (1-r)]$ equals to 0.465

r = 0.434 (from study done by TrivediA et al[8])

Procedure:

Standing Height (Stature) of the subject was measured in a standing position on a standard stadiometer with both feet in close contact with each other with the trunk straight along the vertical board, and the head adjusted in frankfurt-horizontal plane (eye-ear plane). The measurement was taken in centimeters by bringing the horizontal sliding bar to the vertex. For measuring the per-cutaneous right tibial height, the study subject was asked to sit with knee placed in the semi flexed position and the foot partly inverted to relax the soft tissues and make the bony landmarks prominent. Two points were marked by skin marking pencil. The medial most point on the upper border of medial condyle of the tibia and the Tip of medial malleolus of the tibia were the Upper and the Lower points respectively. The distance between the two points was measured with the help of Spreading Calipers to determine tibial height. All the measurements were taken by the investigator with the same instrument to avoid any technical and/or inter-observer error and to maintain reproducibility. The measurements were taken three times and their mean value was considered for estimation of height.

Results and Observations

Table-1: Demographic profile of the subjects

Demographic profile	Minimum	Maximum	Mean±SD
Age (yrs)	21.0	25.0	22.26±1.01
Tibial length (cm)	25.0	41.0	34.93± 2.46
Stature (cm)	148.0	179.0	164.14±7.88

It is observed from the table-1 that, average age of the subjects considered in the present study is found to be 22.26 years with a standard deviation of 1.01 years. The youngest and oldest ages of them are 21 years and 25 years respectively. Mean and standard deviation (SD) of tibial length (cm) / per-cutaneous length of tibia (cm) are 34.93 cm and 2.46 cm with minimum and maximum values of 25 cm and 41 cm respectively. The average stature is noticed as 164.14 cm with SD of 7.88 cm. The shortest stature in the sample is found to be 148.0 cm as

against the tallest of 179.0 cm.

Table 2: Descriptive statistics of tibial length (PCTL)

Statistics of Tibial length (PCTL)	Female
Range	25.0 - 41.0
Mean±SD	34.93± 2.46
SE	.28
CV	7.04
95% Confidence Interval for mean	34.36-35.50
P-value	<0.001
Remark	very highly significant

SD: standard deviation; SE: standard error of mean; CV: coefficient of variation;

df: degree of freedom; P-value: probability due to chance factor

A detailed description of tibial length in female subjects is set forth in table-2 indicating the range of PCTL is 25.0 cm to 41.0 cm. Female has the length of 34.93 cm which found to be highly significant (P<0.001). Over all mean PCTL is 34.93 with SD of 2.46. The coefficient of variation of individual tibial length among females is 7.042. 95% Confidence Interval for mean of female signifies that the normal range of PCTL is 34.366 cm to 35.501 cm for female.

Table 3: Simple linear Regression Equation of Stature on Tibial Length (PCTL)

Regression Statistics	Female Meitei subjects
Independent variable (X = PCTL)	X = PCTL for female
Intercept (β0)	107.83
Regression coefficient (β1)	.60
Correlation coefficient (r)	.60**
Coefficient of determination (R2)	.36
Std. error of estimate (SEE)	4.71
P-value	<.001
Regression equation (Y= β0+ β1 X + ε)	Y= 107.83 + .60 X +.71
F-value	42.083
P-value	<.001

*****: Correlation is significant at the 0.01 level (2-tailed);***

In order to establish average relationship between stature and tibial length, in terms of their original unit of measurement i.e., cm, a simple linear regression equation of stature on tibial length (PCTL) is developed taking stature as dependent variable while tibial length, independent variable. The proposed equation is given by

$$\mathbf{Y= \beta_0+ \beta_1 X + \varepsilon};$$

where Y is dependent variable/ predicted value; X, independent variable;

β_0, Y-intercept; β_1, regression coefficient/ slope of the regression line;

ε; Standard error of estimate (SEE)/ residual.

In table-3, relevant regression statistics are depicted along with developed regression equation based on the present data.

The following is the developed regression equation of stature of female (Y) on her tibial length (X):

$$Y= 107.83 + .60 X +.71$$

There is a general difference of 107.83 cm. between stature of female and her tibial length as depicted by β_0=107.83. Again β_1=0.60 illustrates an augmentation of 0.60 cm in stature when one cm enhances in her tibial length. And the residual/ error term is found to be 0.71cm. Here, R^2 is found only 0.36 but it is still highly significant (P=<.001) and it highlights that the variation of stature of female can be explained by 36% of her tibial length through the developed equation. The equation so developed is tested by F-test and found a very highly significant (F=42.08; P=<.001). In other words, the developed equation is treated as best fit and henceforth it may be used to detect the stature of female for any given value of her tibial length.

Supplementarily, the table reveals that there is a positive association between stature of female and her tibial length (r=0.60) which is still a very highly significant statistically.

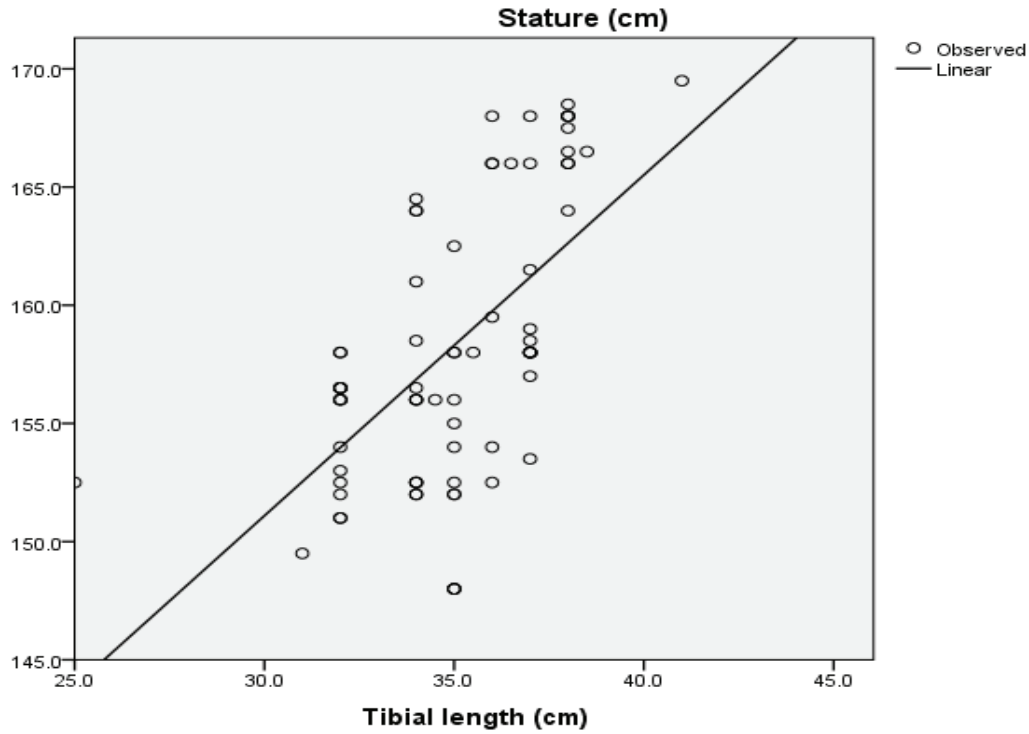

Fig-1: Showing average relationship between stature of female and her tibial length through fitted regression line.

Discussion

In the present study, correlation between Percutaneous Tibial Length and Stature is established by framing Regression Equation among living indigenous female 'Meitei' population in the state of Manipur which is the major community in the state. Until now no studies have been done so far on this topic.

In the present study, in order to establish average relationship between stature and tibial length, in terms of their original unit of measurement i.e. cm, a simple linear regression equation of stature on Percutaneous Tibial Length (PCTL) is developed taking stature as dependent variable while Tibial Length as independent variable. The following is the developed Regression Equation of stature of female (Y) Meitei subject on her tibial length (X): Y= 107.83 + .60 X+.71. Similar study has also been conducted by Didia BC et al[9], Chibba K &Bidmos MA[10], Saraji N[11] &Mukta R et al[12] on different population groups.

In the present study, the Regression Formula derived for female Meitei subject is Y= 107.83 + .60 X +.71 where X is the value of PCTL (Percutaneous Tibial Length) whereas in a study done by Bhavna et al[13] in their study on Shia Muslims in Delhi, derived the following linear regression equation was derived: Height in cm =84.74+2.27x (PCTL) ±3.67, which exemplifies the fact that the regression equation derived will be population group/region specific. This justifies the present study on indigenous Meitei population. The estimated stature was 154.40 cm for females and concluded that there is a positive correlation between stature and percutaneous tibial length which is also similar to the present study.

Chavan SK et al[14] in the year 2009 estimated the mean height of female to be 151.41 cm ± 5.04 cm. Mean PCTL was 34.44 cm ± 2.10 cm for female. They also derived a Regression Formulae for female but their findings are different from the present study which may be due to difference in environmental, ethnic and dietary factors which influence the stature of the person.

Izzet Duyar and Can Pelin[15] conducted a study on 231 randomly selected Turkish, age ranging from 18-34 years for estimation of height from tibial length in different stature groups. The derived regression equation for different stature groups were:

Short Stature =951.94+1.890 x TL, Medium Stature =944.82+2.057 x TL,

Tall Stature =1224.15+1.530 x TL, General Formula Stature=678.68+2.738 x TL

Their findings concluded that group specific formulae were more accurate for subjects in the extreme height categories and grouping depending on tibia length could be used to identify the stature group to which a specimen belongs. The results obtained by them were different from the present study result which may be due to various factors like health and nutrition, stress, socioeconomic conditions, climate, changes in body proportions over time and between populations and genetic variations which also influences the growth of bones thus giving different results.

The results of the present study validate and support the hypothesis that, there exists a strong relationship between stature and the Percutaneous Tibial Length. The present study also clearly demonstrates that the derived Regression Equation can be used for the estimation of stature from Percutaneous Tibial Length in indigenous female Meiteis of Manipur.

Conclusion

Studies have reported significant differences in the proportion of limb dimensions due to hereditary, environmental, ethnic and dietary factors which influence the stature of the person. This highlights the need for development of population specific regression formulae. Tibia being subcutaneous is accessible for measurement in living subjects. In the present study, correlation between Percutaneous Tibial Length and Stature is established by framing Regression Equations among living indigenous Meitei female population in the state of Manipur. This cross sectional study has been carried out on 75 indigenous Meitei female subjects between the

age group of 21 to 25 years of age living in Manipur. The findings of the study have been used in estimating the stature from Tibial Height by deriving a new Regression Formula which is specific for the population. It will be of immense importance in medico-legal investigations thereby benefitting the society in general.

Ethical Clearance: Taken

Conflict of Interest: Nil

Source of Funding: Nil

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