

# Percutaneous Tibial Length Measurement for Estimation and Correlation of Stature in Nepalese Males

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## ABSTRACT

**Introduction:** Estimation of stature is an important step in identification of an individual, which often is required in medio-legal practice. It provides a valuable indicator for unknown individual in a population. Through the remains of human skeletal or body parts stature of an individual can be estimated. **Methods and Materials:** Percutaneous tibial length (PCTL) is measured in present study to estimate the stature by formulating simple regression equation. The PCTL was measured by the surface anatomical landmarks that is between most prominent part of medial condyle of tibia and tip of medial malleolus. **Result:** Positive correlation was found between the length of tibia and estimated height. A linear regression formula was derived for estimation of height from the length of right and left tibia. **Conclusion:** Estimated height and observed height were closely related within the range of error. Differences in length of right and left tibia showed statistically non-significant.

**Key words:** Medial condyle, medial malleolus, percutaneous tibial length, regression formula, stature, forensic anthropology

## INTRODUCTION

Forensic anthropology is the sub-discipline of physical anthropology that implies the techniques of osteology and skeletal identification to problems of legal concern<sup>1</sup>. Stature is defined as the natural height in an upright position<sup>2</sup>. Stature of an individual is considered as one of the important parameter for personal identification and is an inherent character<sup>3</sup>. Long bones that makeup the greatest proportion of stature i.e. the femur, tibia and fibula are more accurate than humerus, radius and ulna<sup>4</sup>. Due to the increased frequency of accidents, air plane crashes, mass disasters etc. this type of study is needed which helps in identifying the deceased from fragmentary and dismembered human remains<sup>5-10</sup>. Many authors around the world have successfully tried to estimate the stature from percutaneous body measurements. Many authors have correlated body height with length of femur, tibia, foot length and foot breadth<sup>11,12</sup>. Main contributor in height of an individual are the lower limb bones, hence the most predictive equations are based in the length of femur, tibia and fibula<sup>13</sup>. This study however focuses on tibia, as it resists erosion and keeps its anatomical shape for long time after burial. 22% of total body height is contributed by tibia alone<sup>14</sup>. The stature and length of bone of an individual is directly influenced by numerous factors like age, gender, race, geographical climate, nutrition and genetic factors. These factors give the idea that the co-relation for one given region is not ideal for another region<sup>3,15-20</sup>. So, it

becomes necessary to the researchers to have a study on a regional basis.

There are many ways of estimating body height from long bones, one of the accurate and easy way is by deriving the regression formulae for major long bones. However, this formula cannot be generalized to all population and hence it is necessary to derive equations in a particular population which can be applied for estimation of stature from skeletal remains<sup>17</sup>.

## MATERIAL AND METHODS

A cross sectional study on 151 Nepali male students from Nepalgunj Medical College was done for the time period of one month of September 2017. Their age group ranging from 18-24 yrs. Parameters like age, gender, height in cm and percutaneous tibial length (PCTL) were noted. Students with history of major trauma or fracture of leg were excluded.

For measurement of tibial length, individuals were asked to stand and keep his foot in a wooden stool. Angle between flexor surface of leg and that of thigh was maintained at 90°. Upper point at the upper border of medial condyle of tibia and lower point at the tip of medial malleolus was marked by skin marking pencil. Distance between two points was measured with the help of spreading caliper to determine length in cm.

Height of an individual was measured in a standing position with both feet close contact with each other with trunk in upright position. The head was adjusted in Frankfurt plane. Measurements were taken in centimeters with the help of stadiometer.

## RESULTS

The range of height was from 154.1-186 cm in present study and was divided in four quartiles. Maximum number of subjects i.e. 71 were within the range of 171-180 which is

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47.02%. The average height of subject was 169.76cm with 7.02 standard deviation and 0.57 standard error.

Sno	Range of Height	No. of Subjects	%
1	151-160	16	10.59
2	161-170	60	39.74
3	171-180	71	47.02
4	181-190	4	2.65
	Total	151	100

**Table I: Showing distribution of number of subjects and their percentage according to height**

Length of tibia was in the range of 26-45 cm in which the maximum number of tibia i.e. 99 were in the range of 36-40. The mean for right and left tibia were 36.881 and 36.883 respectively with standard deviation 2.052 in right tibia and 2.03 in left tibia. Standard error for both tibias were found to be 0.17. Statistical analysis was not significant ( $P>0.05$ ) regarding the length of right and left tibia.

Sno	Range of Tibia	Right Tibia	Left Tibia
1	26-30	1	1
2	31-35	51	51
3	36-40	99	99
4	41-45	1	1

**Table II: Showing range of tibial length in accordance with the distribution of tibia**

For estimating individual height, regression analysis was done by measuring tibial length. Linear correlation coefficient ( $r$ ) between height and the right tibia was 0.798 and to that of left tibia was 0.807 suggesting a positive co-relation between the length of tibia and estimated height.

After statistical analysis height can be estimated by using linear regression formula derived from the measured length of right and left side.

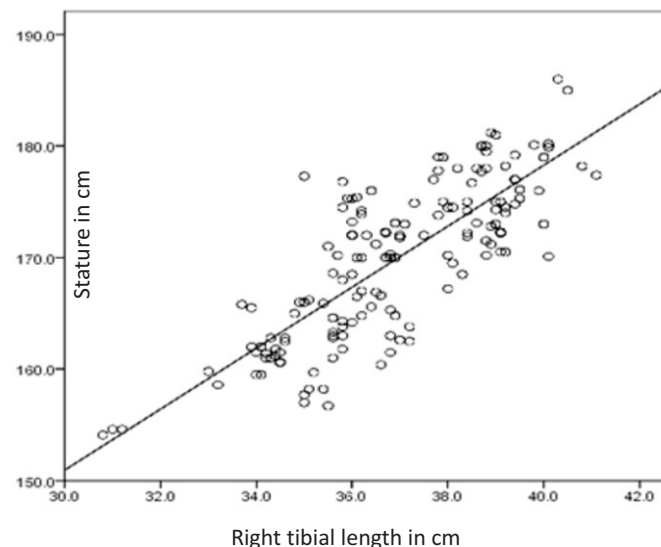
$$y_1 = 68.922 + 2.734x_1$$

$$y_2 = 68.951 + 2.787x_2$$

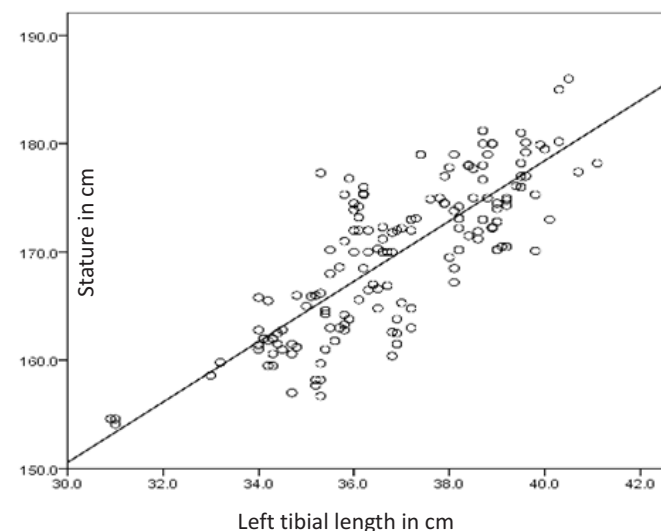
Observations	Right	Left
Independent variable (x)	Length of tibia( $x_1$ )	Length of tibia( $x_2$ )
Intercept(a)	68.922	68.951
Regression coefficient (b)	2.734	2.787
Correlation coefficient (r)	0.798	0.807
Coefficient of determination ( $R^2$ )	0.791	0.807
Regression formula: $y = a + bx$	$y_1 = 68.922 + 2.734x_1$	$y_2 = 68.951 + 2.787x_2$
Mean $\pm$ SD (Estimated Stature)	169.61 $\pm$ 5.59	169.85 $\pm$ 5.67

**Table III: Formulation of regression equation for calculating the stature from the length of tibia**

$y_1$  and  $y_2$  are estimated height right and left tibial length.  $x_1$  and  $x_2$  are the length of left and right tibia respectively. From the regression equation the mean stature was calculated from the right tibia as 169.61 $\pm$ 5.59 and from left tibia as 169.85 $\pm$ 5.67.



**Figure 1: Showing correlation of stature and right tibial length**



**Figure 2: Showing correlation of stature and left tibial length**

## DISCUSSION

Where bodies are found in highly decomposed and mutilated state or only skeletal remains are available the establishment of stature requires special attention. Earlier studies have established that the regression equations provide greater reliability in estimating stature<sup>18</sup>. Present study was carried out on living Nepalese male to correlate the percutaneous tibial length with body height in different stature groups. To estimate height a simple regression equation was derived.

In 1899 Karl Person, the first person to estimate stature through regression equation, estimated stature as 169.2 cm in male<sup>15</sup>. Pearson chose cadavers for calculation of stature and measured only the right-side tibia but our study focuses on the living population in Nepal and the measurements of both tibiae. Study by Trivedi et al in 2014 in Gwalior region in India found that mean height of male to be 164.5 cm, mean right PCTL 38.26cm and mean left PCTL 38.22 cm. The regression equation for right tibia was  $y_1=110.76+14.04x_1$  and for left tibia was  $y_2=103.71+1.59x_2$ <sup>21</sup>.

In 2014 study in northern India by Gupta et al have shown that the mean height of 168.56cm. The mean tibial length was shown as 37.23 and 37.33 for right and left side respectively. The regression formula derived was  $y_1=80.03+2.37x_1$  for right side tibia and  $y_2=79.26+2.39x_2$  for left side tibia<sup>22</sup>. Present study shows the mean height of 169.76cm, the mean tibial length for right and left side as 36.881 and 36.883 respectively. The derived regression equations as  $y_1=68.922+2.734x_1$  for right tibia and  $y_2=68.951+2.787x_2$  for left tibia. The stature of Delhi population by Mukta et al was established in 18-22 years group. It was found that there is significant positive correlation of PCTL with body height in male. Estimated average stature was found to be 169.5 cm<sup>23</sup>. Kolte PM and Bansal PC in Marathwada region estimated average stature of 163.7 cm for male whereas Patil et al in Vidarbha region in Maharashtra India found that the average stature as 161.9 cm which shows the differences in height according to region<sup>24,25</sup>. Bhargava and Kher estimated mean stature of Barelais (tribe) as 161.5 cm and that of Bhills (tribe) as 160 cm, in Madhya Pradesh India<sup>26</sup>. Bose in Eastern Bengal reported average stature for Bengalis as 166.6cm<sup>27</sup>. Bhavna and Surendra Nath in their study on Shia Muslim male in India derived the linear regression equation as height in cm=  $84.74+2.27 X (PCTL) \pm 3.67$ <sup>3</sup>. Present findings are similar to that of Yayim Yilli, Agnihotri et al, Chaven et al, who observed that there are no statically significant differences in the length of right and left tibia in males<sup>28,29,18</sup>.

## CONCLUSION

Percutaneous length of right and left tibia showed statically no significant in males, thus showing bilateral symmetry. The observed height and estimated height were in a close approximation within a range of error. It was thus concluded that there is a possibility of determining the stature of a

deceased person whose only body part available is a mutilated leg, fairly accurately to some extent. However, the formulae derived cannot be generalized to all population groups, hence it is necessary to derive regression equations which are region wise and population specific.

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