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Research Article

Correlation of Percutaneous Length of Tibia with Body Height and Estimation of Stature in Living North Indian Males

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Abstract: Stature reconstruction is important as it provides a forensic anthropological estimate of the height of a person in the living state, playing a vital role in identification of individuals from grossly mutilated skeletal remains especially in mass disasters. In the present study an attempt has been made to estimate the height of an individual from the percutaneous tibial length (PCTL) as measured by the surface anatomical landmarks that is between the most prominent palpable part of medial condyle of tibia and tip of medial malleolus with the help of spreading vernier calipers. The study was done on 150 males' students in the age group of 18 to 24 years from Kanpur city after taking permission from Institional ethical committee. The data was tabulated and analysed statistically. A positive correlation was found between the length of tibia and the estimated height. A linear regression formula was derived for the estimation of height from the length of right or left side tibia.
Keywords: Height, Medial condyle of tibia, Medial malleolus, Percutaneous tibial length, Regression formula.

INTRODUCTION

The "Height "or Stature of an individual is an inherent character and is considered as one of the important parameter of personal identification [1]. Stature is defined as "height of body in standing position" [2]. In mass disasters like explosions, railway and aircraft accidents identification is difficult by routine methods and only part of body that can help in identification of skeleton as at least a part of it will be available. Many studies have been conducted on the estimation of stature from various body parts like hands, trunk, intact vertebral column, upper and lower limbs, individual long and short bones, foot and footprints [3]. Extensive works has been done on correlation of measurements of various body parts with stature of a person in India and abroad [4]. In contrast to most advanced countries, documented skeleton remains are not available in India for establishing the norms of stature reconstruction. Hence researchers have focused their attention towards living population groups of India and have taken relevant bone lengths over the skin (Percutaneous measurement) and correlated them with the stature to find out the degree of relationship between them and subsequently formulated regression formula from long bones for reconstruction of stature [5, 6].

As the lower limb length is the greatest contributor to the standing height, hence most predictive equations are based on length of femur, tibia and fibula [7]. Tibia, easily accessed for percutaneous measurement as compared to other long bones, and was taken as subject matter of the present study. Each race requires its own formula for estimation of stature since there lies variations in the length of limb bones relative to stature, race, sex, side of body, climate, heredity and nutritional status [8]. The present study was undertaken because at present we depend on foreign formulas which do not fit correctly with our Indian population and secondly authors hypothesize that with improved socioeconomic conditions especially in India, the height of new generation is increasing. Population is getting taller and therefore relationship between height and length of long bones might be changed, thus fresh formula is needed for each generation. The aim of the study was to correlate percutaneous length of right and left tibia in male with the body height and thus estimate stature by derived regression formula.

MATERIALS AND METHODS

This observational study was conducted on 150 male undergraduate medical students from

G.S.V.M. Medical College, Kanpur, in the age group of 18 to 24 yrs after taking their informed consent and permission from Institional ethical committee. The subjects with any obvious congenital or acquired deformity of spine or extremities were not included in this study. The standing height of the subject was measured with the help of a Stadiometer. Then the tibial length of each subject was measured. Subject was asked to stand and keep his foot on a wooden stool. Angle between flexor surface of leg and that of thigh was maintained at 90^0. Two points were marked with skin marking pencil on tibia, the upper point and lower point. Upper point was the medial most superficial point on upper border of medial condyle and lower point was the tip of medial malleolus. Distance between the two points was measured with the help of spreading caliper, to determine tibial length in centimeters (cms).

RESULTS

The height of study population ranged between 151cm to 190 cm and it was divided into four quartiles and the maximum numbers of subjects (more than 50%) were in the range of 161-170 cms. as shown in table no. 1. The mean height of the above subjects was 168.56 cm, the Standard Deviation (S.D.) was 6.50 cm, the Coefficient of Variation (C.V.) was 0.03856 and the Standard Error of Mean (S.E.M.) was 0.52.

Table 1: Showing distribution of number of subjects and their percentage according to height

Sl. No.	Range of Height (in cms)	Number of subjects	Percentage
1	151-160	20	13.33
2	161-170	80	53.33
3	171-180	46	30.67
4	181-190	04	2.67
5	Total	150	100

Tibial length was in the range of 31-45 cm and the maximum numbers of tibia (119) were in the range of 36-40 cm. The mean was 37.23 on Right side and 37.33 on Left side. The Standard Deviation (S.D.) was 2.06 cm on right side and 2.03 cm on left side, the Coefficient of Variation (C.V.) was 0.055 cm on right side and 0.0543 cm on left side and the Standard Error of Mean (S.E.M.) was 0.1655 cm on right side and 0.1631 cm on left side. Small value of co-efficient of variation indicated no significant variation in the right and left tibial length. Statistically as observed by the P value (>0.05) there was no significant difference in the length of tibia of right and left side.

Table 2: Showing distribution of tibia according to the range of tibial length

Length of Tibia in cm	Right Tibia	Left Tibia
31-35	26	25
36-40	119	119
41-45	5	6
Total	150	150

Table 3: **Formulation of regression formula for calculating the stature from the length of tibia**

Observations	Right	Left
Independent variable (x)	Length of Tibia (x_1)	Length of Tibia (x_2)
Intercept (a)	80.03	79.26
Regression coefficient (b)	2.37	2.39
Correlation coefficient (r)	0.75	0.75
Coefficient of determination (R^2)	0.5701	0.5617
Regression formula: y = a + bx	$y_1=80.03+2.37x_1$	$y_2=79.26+2.39x_2$

y = Estimated height, x= Tibial length (x_1 or x_2)

Regression analyses of the observations were done for estimating individual's height from the measurement of tibial length. Simple correlation coefficient (r) between height and right and left tibial length was 0.75(r_1 and r_2) respectively suggesting a positive correlation between the length of tibia and the estimated height.

After statistical analysis height can be estimated by using linear regression formula derived for estimation of height from length of right or left side tibia.

$y_1 = 80.03 + 2.37\ x_1$ (Right side), $y_2 = 79.26 + 2.39\ x_2$ (Left side)

y_1 and y_2 are estimated heights from right and left tibial length, x_1 and x_2 are right and left tibial length respectively. From these regression equations the mean stature was calculated to be 168.36 cms.

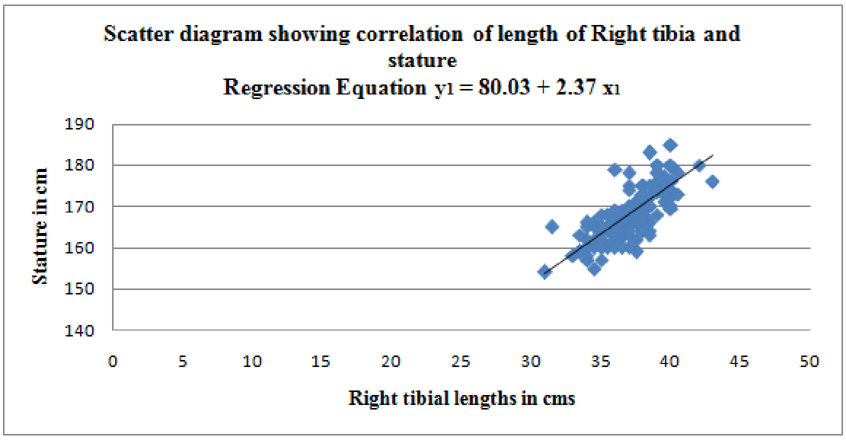

Fig. 1: Showing correlation of length of Right tibia and stature

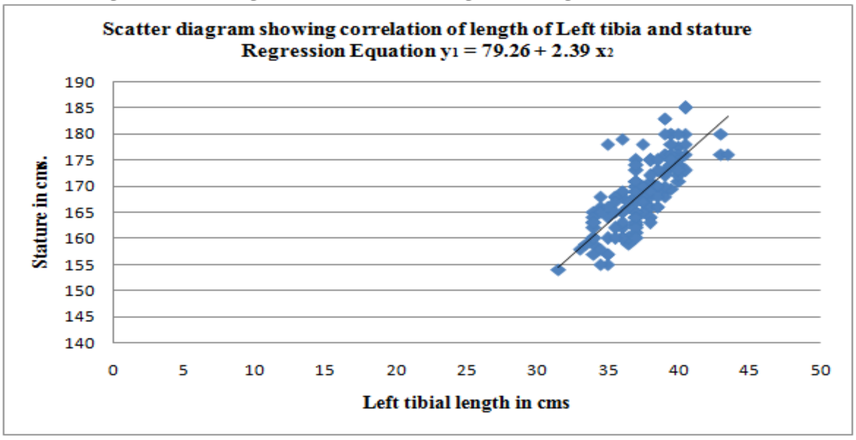

Fig. 2: Showing correlation of length of Left tibia and stature

DISCUSSION

The establishment of stature requires special attention in cases where bodies are found in highly decomposed and mutilated state or only fragmentary skeletal remains are available. Present study was conducted on living north Indian male subjects to correlate the percutaneous tibial length with body height in different stature groups. A simple linear regression equation was derived which can be used for the estimation of height. The average estimated stature came out to be 168.36 cm in with an average error of less than 1 cm when estimated and actual stature was compared.

Karl Pearson was the first person to estimate stature through regression equation. He estimated stature as 169.2 cm in male which differs from the findings of the present study [9]. Pearson calculated stature in French cadaver and that to, only from the right side tibial length, whereas the present study was carried out in Indian living subjects in which the tibial length of right and left side were considered.

It was also found by the study of Dupertuis Wesley C.S. *et al*. that different equations are required for the estimation of the stature for Black and White males [10]. Similarly Trotter and Gleser reported that each group of White Negroes, Mongolian and Mexicans need different formula to estimate the stature precisely [11]. Allbrook D. compared the estimated stature (172.06 cms) in British male population derived from the length of dried tibia and the estimated stature from the percutaneous tibial length. There was no difference in stature obtained from two different sets of tibia [12].

India is a subcontinent where population is subdivided into various castes and tribes and resides in various states. The stature not only differs in state wise but also varies according to different castes and tribes as studied by Bhargava Indra and Kher G.A. who estimated mean stature of Barelas (tribe) as 161.5 cm and that of the Bhils (tribe) as 160 cm, in Madhya Pradesh. Similarly Bose reported average stature for Bengalis (East) as 166.6 cm, M.P. Patel *et al*. calculated stature as 173.4 cm in Gujarati people and Mohanty reported the stature for male Oriya population as 162.2 cm [7, 13-15].

It is also seen that the stature of a person differs not only state wise but also in the different regions of the same state. Kolte P.M. and Bansal P.C. estimated an average stature of 163.7 cm for male amongst the people of Marathwada region, whereas Patil T.L. et al calculated the average stature as 161.9 cm for male of Vidarbha region, in Maharashtra [16, 17]. Above estimated height is less as compared to the study done in our region (North India).

Mukta Rani *et al*. estimated the stature of Delhi population (Central North India) between 18-22 years age group. A significant positive correlation of percutaneous tibial length (PCTL) with body height in males was found. Their estimated average stature was 169.5 cm [18].

Similarly Bhavna and Surinder Nath in their study on male Shia Muslims of Delhi, found that in case of the long bones of the lower limb, tibial length exhibits the highest value of correlation (r= 0.718) with stature followed by fibular and femur length. Their estimated stature was 167.69o6 cm for males [1]. It is clear from the above discussion that the stature measured by tibial length varies not only between different states but also among the different regions of the same state and hence necessitates the formulation of new formula for estimation of stature.

CONCLUSION

In the present study the height of 150 males were measured along with their PCTL in cms. The mean height was observed to be about 168.56 cm. The mean PCTL was 37.23 on Right side and 37.33 on left side. For estimation of height from the PCTL of tibia, a simple regression equation was derived which is as follows:

Stature = 80.03 + 2.37 x PCTL (Right side),
Stature = 79.26 + 2.39 x PCTL (Left side)

The estimated height so found was excepted within a range of an error and were in close approximation with that of the observed height. Hence, it is possible to determine the height of a deceased person whose mutilated leg portion is only available by using the data and formula derived from the present study.

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