ORIGINAL ARTICLE

Estimation of Stature from Foot Length in a Tribal District Population of India

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Abstract

Background: Prediction of stature of an individual from skeletal remains or mutilated parts of body is a difficult task since many times even remains are not found in preserved condition. Moreover, it is well known that same anthropometric formula for estimation of stature is not applicable for all the races since anthropometric variations for different races and even for geographical areas exist. Hence the present study was planned to evaluate correlation between foot length and stature of a tribal district population of India. Materials and Methods: In the present study a total of 100 subjects including 23 male and 77 female were enrolled. Stature was measured from vertex to ground after keeping both foots parallel to each other on the ground. Foot length was measured from posterior most point of the heel to anterior most point of the foot using a calibrated foot board. Regression equations obtained from the data using SPSS software. Results: The mean observed stature of males was 169.97 cm and mean of the foot length was 25.00 cm. Pearson correlation coefficient 0.572 in male was highly significant. In females observed mean stature was 154.20 cm and mean foot length was 22.71. Calculated Pearson correlation coefficient 0.771 in females was also highly significant. The predictive stature observed in male was 169.97 cm with 3.26 as standard deviation while it was 154.20 cm in females with 5.51 as standard deviation. Conclusion: Among tribal district population of this part of India foot length and stature have good correlation. The calculated regression equations can be used for estimation of stature of males and females of this regional population.
Keywords: Foot Length, Height, Skeletal Remains

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Introduction

Identification of individual from isolated parts of body is difficult task not only for common people but also for law enforcing agencies and forensic experts. It is a great and significant issue of individual identity in the events like murders, accidents, wars and mass disasters.[1] Estimation of stature is essential and important component of such investigations which becomes more difficult if only few parts of the body or some skeletal remains or amputated and mutilated limbs are available.[2,3] Reconstruction of height of such cases are done by using knowledge of Anthropometry which is a science of methods and techniques of measurement of living as well as skeletons of individuals.[4]

In the field of anthropometry and forensic medicine determination of stature is not a new thing. Many authors worked on it using intact long limb bones like femur, tibia, humerus, radius and short bones like clavicle and dimensions of hand etc and various methods, formulae and regression equations prepared for estimation of stature.[1,5,6,7] Less literature is available regarding correlation between foot length and stature[8] which may not be applicable to all the races[9] since each race requires its own formula[10] It is because of various factors such as ethnicity, nutritional factors, and environmental conditions which play important role in the

development and growth of human beings.[10,11] Telkka A[12] also suggested that each racial group need a different formula for stature estimation and for that purpose regional studies of the subjects are very much needed. Moreover, combined effects of heredity and life style pattern of human beings greatly affect morphology of their feet[13]. Hence the present study was conducted in a tribal district of north Andhra Pradesh India to evaluate correlation if any between foot length and stature for local population and obtained regression equations which will be useful for estimation of stature.

Materials and Methods

Equal number of subjects from both rural and urban background including 23 males and 77 females after taking informed consent was enrolled for the study. The subjects and their family members were native of Adilabad district- a tribal district of north Andhra Pradesh India.[14] They were in between the age group of 16 to 50 years (Figure-1). The study population represented all major communities of the region like General Category, Other Backwards Class (OBC), Muslims, Schedule Cast and Schedule Tribes (Table- 1). Subjects with acquired or congenital skeletal deformities were excluded from the study.

Figure-1: Age wise distribution
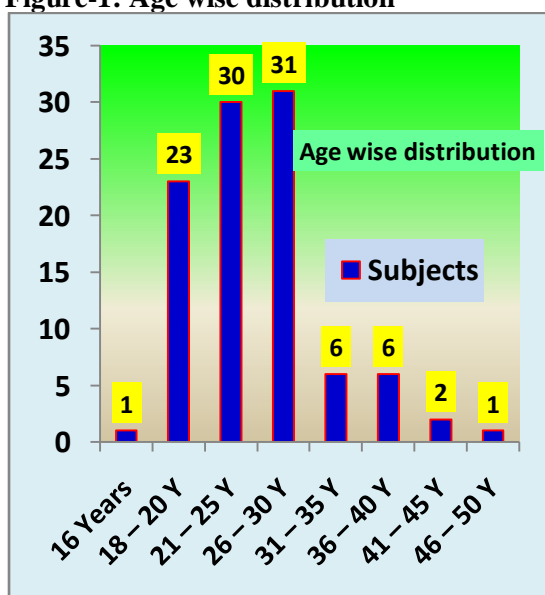
Stature was measured from vertex to ground after asking the subjects to stand erect, bare foot keeping both foots parallel to each other on the ground and palms of hand turn inward and fingers pointing downwards against a wall and heels, buttocks and back touched the wall.[6,15] Right feet was taken as standard foot of measurements. For measurement of foot length the subjects were asked to stand on a calibrated foot board with their back against the wall so that the posterior most point of the heel will touch the wall. A vertical stop was placed against the anterior most point of the foot. The foot length was measured as the distance between the anterior most point of the foot and the posterior most point of the heel. The measurements were taken in centimeters.[16] Linear regression analysis was done using SPSS software to obtain equations for stature estimation.

Table- 1: Category wise distribution

Social Category	No. of Subjects
Backward Class	49 (49%)
Schedule Cast	26 (26%)
Muslims	13 (13%)
General Category	7 (7%)
Schedule Tribes	5 (5%)
Total	**100**

Results

The mean stature of males was 169.97 cm with standard deviation of 5.71. The minimum and maximum stature was 157 cm and 192 cm respectively. Most of the males 65(84.42%) were in between the range of 161 cm to 175 cm with majority 30(38.96%) of them were in the range of 166 cm to 170 cm. In females mean stature was 154.20 cm with a standard deviation of 7.15. Minimum height was 139 cm while the maximum stature was 167 cm. Height of majority of females 10(43.48%) was in between the range of 156 cm to 160 cm (Figure- 2).

Figure- 2: Range of heights
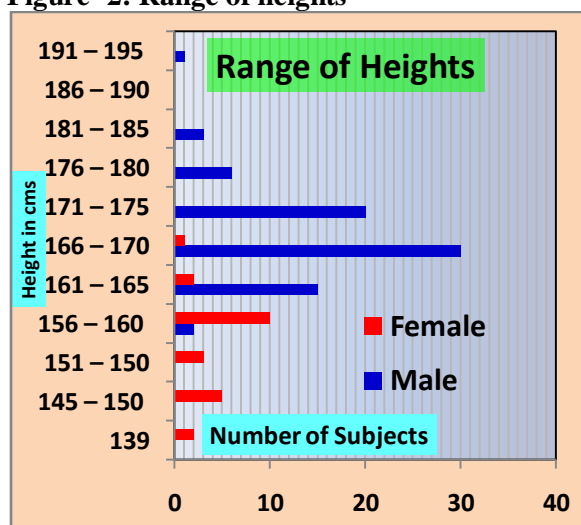
Among males, mean of the foot length was 25.00 cm and 1.08 as standard deviation. Using linear regression analysis a constant (94.18) and Pearson correlation coefficient (0.572) were obtained for the foot. The regression coefficient shows significant (p<0.01) correlation between foot length and the height. Mean foot length of females was 22.71 cm while minimum was 19.4 cm and maximum 25.3 cm. The Pearson correlation coefficient was 0.771 and the constant was 60.96. Regression coefficient indicates significant correlation between foot length of females and their heights (Table- 2).

The predictive value for stature observed in male was 169.97 cm with 3.26 as standard deviation while it was 154.20 cm in females with 5.51 as standard deviation (Table- 3). A regression equation can be formulated using the values obtained by linear regression analysis and the stature can be estimated using that standard equation[13,17] which is:
S = Constant + Regression coefficient X FL
Where S = Stature, and FL = Foot Length. Thus the obtained equation for males is;
S = 94.18 + 0.572 X FL While for females it is;
S = 60.96 + 0.771 X FL

Table- 2: Descriptive statistics

Sex		Minimum	Maximum	Mean	SD	Constant	r	p value
Male	Stature	157	192	169.97	5.71	94.18	0.572	<0.01*
N=77	Foot	22.2	28.0	25.0	1.08			
Female	Stature	139.0	167.0	154.20	7.15	60.96	0.771	<0.01*
N=23	Foot	19.4	25.3	22.71	1.34			

SD = Standard Deviation, r = Correlation coefficient, *=Significant

Table- 3: Predictive stature

Sex	Values	Minimum	Maximum	Mean	SD
Male N=77	Predictive Value	161.49	179.08	169.97	3.26
Female N=23	Predictive Value	140.61	164.83	154.20	5.51

Discussion

Mean foot length of males in the present study is 25.00 cm, while in case of females it is 22.71 cm. Oommen A et al[16] in Mangalore region of Karnataka, south India found mean right foot length of males as 26.22 cm while it was 23.69 cm in females. Kurrey P and Singh A[18] found mean right foot length as 24.80 cm in Bhopal region of central India. The reviewed studies indicate that there are little differences in foot lengths at various regions of India. It can also be said that foot length of females are lesser in all the regions in comparison to their male counterparts. The observed higher values of foot length and stature in the present study in case of males are in conformity with the above mentioned studies. Height of males is higher in comparison to females which is an inherent characteristic of males. It could be because of association of Y chromosome with stature in males.[19,20]

In the present study we found good correlation between right foot length and stature in males

and females but the correlation coefficient is higher in females than male as we found it 0.572 in males and 0.771 in females suggestive of better correlation in females than males. Obtained regression equations for males- S = 94.18 + 0.572 X FL and for females- S = 60.96 + 0.771 X FL can be used for estimation of stature in males and females respectively. Shalini Chaudhary[20] in Kolhapur district of western India found good correlation between foot length and height and suggested that foot length provides more reliable estimate of stature than foot breadth. Anil et al[21] in Turkish University students aged between 17 and 25 observed a significant correlation between foot length and height. Saxena SK[22] studied 100 nigerian adult male and found significant correlation between the stature and hand length, hand breadth and sole length. Philip TA[23] also suggested that from foot size stature can be estimated using regression equations. Charnalia[24] established correlation between foot length and height although correlation was less in comparison to foot breadth in males. Raju et al[8] used footprints for measurement purpose and found very good correlation between footprint length and stature of females of southern part of India. So it is well known that there is a definite and strong relationship between stature and foot length of both the genders but variations do exists among the sizes of foots in various regions. It is because of the individual morphology of a foot which is a result of heredity and environmental conditions.[23] Moreover, the regression equations for both the male and female are different in all the geographical regions as well as different races which indicate need of specific regional formulas for estimation of stature.

Conclusion

Right foot length and stature among males and females have good correlation in this tribal district of Andhra Pradesh India. The population has mean foot length of 25 cm in males and 22.71 cm in females. They have mean heights of 169.97 cm and 154.20 cm in males and females respectively. The obtained regression equations S = 94.18 + 0.572 X FL for male and S = 60.96 + 0.771 X FL for females can be used for

estimation of stature of males and females of this tribal district population respectively.

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