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Original Research Paper

Correlation of Stature and Foot Length among Medical Students from Southern Parts of India

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Abstract

Stature is one of the primary characteristics of identification of human beings. The main concern of the Forensic investigations in mass disasters is to establish personal identity of unknown and dismembered human remains. Like other body parts, the foot of a person exhibits biological correlation with height. The present study is a cross sectional study undertaken with aim to find out the correlation of percutaneous measurement of foot length with the height of a person and to estimate the stature from foot length among a group of medical students. The sample of the study included 305 (142 males and 163 females) medical under graduate students of age group between 18 to 22 years who were born and brought up in Southern Parts of India (Puducherry, Tamil Nadu, Karnataka, Kerala and Andhra Pradesh). Maximum foot length and height were measured by Vernier calliper and stadiometer respectively. Predictive equations using linear regression were derived**.** The correlation between stature and foot length was found to be statistically significant. Regression equation derived was Stature = 58.145 + 4.421 x Foot Length. The accuracy of stature determination by this method is reported to be 71%.

Key Words: Foot length, Stature, Regression equation, Identification

Introduction:

In Forensic anthropology, identification of unknown and dismembered human remains is achieved under two different contexts. One is by "estimation," where an identification profile is prepared from unidentified remains in the hope of eventually identifying the said remains.

The second one is called "evidentiary", where a stature derived from long bones or body parts is shown to be consistent with the "known" stature of a particular missing person with the likelihood of a correct identification.

In certain cases, where stature is the biological characteristic of interest, both of these contexts can occur. [1] "Height" is a generally accepted descriptor of an individual that forensics, public and law enforcement authorities recognize and understand. [2]

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German anthropologist Breitinger conducted the most comprehensive study including 2428 male athletes where he measured their stature and limb proportions to estimate the height from corresponding long bone measurements.

This is so far the largest study of measurements on living individuals used for estimates of stature from the skeleton. [3] Anthropologist Trotter and the statistician Gleser developed regression equations based on measurements of long bones from World War II casualties, where identity of each individual was known, as well as their stature while living.

Thus, both the actual stature and the skeletal measurements were known. They concluded that stature is in ''a state of flux'' and stressed not to use a regression equation for a different population than the one for which it had been developed. [3]

Foot size and hence the foot length bears a biological correlation with height and it suggests that the stature might be estimated from foot length. The foot is useful in the context of identification of dismembered remains, as in most of the cases it is protected by the shoe.

In such situations, different methods developed over the time by different researchers worldwide help us to estimate the stature and thereby the identity of the deceased.

Earlier studies by Robbins, Topinard and Martin put forth many foot length/stature

percentages for various populations ranging from 14.9 to 18.1.

Among those, the most popular was the finding given by Topinard i.e. maximum foot length divided by 0.15 reveals the stature of a person. Few authors suggested multiplication factors calculated by dividing the stature by foot length. [4, 5] But these methods have very high estimation error. Later on, many researchers developed regression methods, which impose a simple relationship between the size of a specific body part and stature. [6-13]

All these methods to determine stature make assumptions about proportions of the human body. However, people come in a variety of body shapes with lot of individual variation based on age, sex, race, geography, ethnicity and ancestry and to account for this, separate formulae are needed for different groups and populations. Even in our country, people from different regions of India bear different morphological features depending on the geographical location, racial distribution and ethnic characteristics hence single data cannot be applied to the entire nation. [2]

With this viewpoint current study was undertaken to develop the standards for south Indian population.

Materials and Methods:

The present study is a cross sectional descriptive study conducted including 305 medical undergraduate students (142 males and 163 females) who were born and brought up in Tamil Nadu, Pondicherry, Karnataka, Kerala and Andhra Pradesh (Southern part of India) and between the age group of 18 to 22 years.

Students with congenital or acquired skeletal deformities and those who did not belong to southern parts of India were excluded from the study. Informed consent was obtained from all the participants.

Height (stature) was measured by making the subject stand barefoot on the board of a standard stadiometer with both feet in close contact with each other, trunk braced along the vertical board, and head oriented in ear–eye plane. The measurement was taken in centimeters by bringing the horizontal sliding bar to the vertex. For the foot length, measurements were collected from the left foot as per recommendation of International agreement for paired measurements at Geneva (1912). [14]

The foot length was measured as a straight distance between the posterior most projecting point of heel and the anterior most projecting point (the end of great toe or second toe) when placed on flat surface.

This measurement excluded any nail extending over the end of the toe.

Measurements were taken at fixed time of the day (i.e. between 2 pm to 4 pm) to avoid diurnal variation and were collected by a single person to eliminate the observer bias. The observations were tabulated and analyzed using MS Excel 2010 and regression equation was derived by linear regression analysis.

Observations and Results:

The mean, standard deviation, range of stature of the study population distributed sex wise. In males, stature ranges from 154.7 cm to 188.0 cm with a mean value of 172.42 and standard deviation was 6.25. The stature in females ranges from 146.0 cm to 175.0 cm with mean value of 158.83 and standard deviation was 6.19. (Table 1)

Present study shows that in the males, left foot length varied from 22.2 cm to 29.0 cm with mean value of 25.57 cm and standard deviation was 1.31. Whereas, in case of females, length of left foot varied from 20.4 cm to 26.0 cm with mean value of 23.05 cm and standard deviation was 1.18. (Table 2)

The mean ratio index for the total study population was 14.662. For males, it was observed to be 14.834 and for females, it was 14.514 with standard deviation 0.555 and 0.528 respectively. (Table 3) The regression equations were derived separately for male and female subjects as well as for the combined data. (Table 4) The coefficient of co-relation (r) was 0.842 for combined data. The values of coefficient of determination (r^2) were 0.472, 0.453 and 0.71 respectively for male, female and combined data. Hence, the accuracy of estimation of stature was 47% and 45% for male and female data respectively.

Whereas the regression equation developed for the combined data could determine the stature of any subject irrespective of sex with 71% accuracy.

Discussion:

Stature is one of the characteristics that may be used to identify an individual. From birth to adulthood, stature increases until a maximum is reached. However, even during growth, stature is not a fixed measurement for any individual. It increases rapidly during puberty and reaches maximum at adulthood. It is known to decrease slightly during the day, and with age, especially after about the age of 30 years.

To overrule this variation, the present study subjects were selected between the age group of 18-22 years. There are many studies [6-13] in which researchers attempted to

establish correlation between stature and foot dimensions. The present study extends the findings of previous studies by exploring data i.e. foot lengths (left) and height using linear regression models.

In our study, stature in males was in the range of 154.7 cms to 188 cms with the mean of 172.42 cms. Similarly, stature in females was in the range of 146 cms to 175 cms with the mean of 158.83 cms. It was observed that males have taller stature compared to females.

The fact that males are constitutionally taller than females as the age of puberty being 2-3 years later in them as compared to females gives them the additional time for growth.

This explains that formula for one sex cannot be applied for other sex.

Agnihotri et al [6] studied 250 medical students from a medical college in Mauritius concluded that there is a highly significant difference between sexes with average foot length of males being significantly greater than females. It is evident that, our study is in correlation with these findings.

Stature ratio index in the present study was 14.662 for combined data while it was 14.834 and 14.514 for male and female subjects respectively. This observation is consistent with study by Phillip TA [7] (Male-14.250 and female-14.280) and Robbins [4] (Combined data-14.976, Male-15.199 and female-14.750) where the authors measured the foot outline length.

Krishan K [8] studied only male Gujjar population from North India and developed a division factor of 0.1512, which is slightly more than our findings.

Correlation coefficient of foot length and stature suggests a linear and significant relationship in present study. Similar results were observed in studies by others. [8-13]

Conclusion:

The present research exhibits a significant correlation between foot length of a person and his/her stature.

The regression thus equation developed, could determine the stature of any subject irrespective of sex with 71% accuracy.

This study was done including the subjects residing particularly in South Indian region hence the observations can be applied with fair accuracy to South Indian population.

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Table 1: Sex Wise Distribution of Stature

Stature (in cm)	Male(n=142)	Female (n=163)	Total
Mean	172.42	158.83	165.62
SD	6.25	6.19	9.2
Minimum	154.7	146	146
Maximum	188	175	188

Table 2: Sex Wise Distribution of Left Foot Length

Foot length (in cm)	Male(n=142)	Female (n=163)	Total
Mean	25.57	23.05	24.31
SD	1.31	1.18	1.77
Minimum	22.2	20.4	20.4
Maximum	29	26	29

Table 3: Foot Length to Stature Ratio Index

	Mean Ratio Index	SD
Male	14.834	0.555
Female	14.514	0.528
Combined population	14.662	0.563

Table 4: Regression Equation for Estimation of Stature from Foot Length

	Regression equation	S.E.E.	r	r^2
Male	Stature = 88.611 + 3.277 x FL	4.553	0.687	0.472
Female	Stature = 72.239 + 3.765 x FL	4.947	0.673	0.453
Combined population	Stature = 58.145 + 4.421 x FL	5.02	0.842	0.71

FL- foot length, r - coefficient of co-relation, r^2-coefficient of determination