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ORIGINAL ARTICLE

A Cross Sectional Descriptive Study for Estimation of Stature from Foot Length in South Indian Population

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Abstract:

Identification can be done by a myriad of methods and of them includes the measurement of stature by foot length The Study population includes the faculty and students of a tertiary medical care college and hospital and the residents of a district in South India between the ages group of 21-40 years. 200 members consisting of 100 male and 100 female were chosen by stratified random sampling. The height was measured by using standard height measuring instrument and foot length by a vernier calliper. A highly significant correlation was found between Stature and RFL (r=0.811) with the strength of association being more in males (r=0.677) than females (r=0.592). A highly significant correlation was also found between Stature and LFL (r=0.823) with the strength of association again being more in males (r=0.707) than in females (r=0.582). Between the two feet, the stature showed highly significant strong correlation with LFL (r=0.823) when compared to RFL (r=0.811). By comparing the r and r^2 values in different study groups it is seen that pooled sample shows better correlation than individual sex. Regression equations were developed for individual sex and also for the pooled data. Stature showed a highly significant positive correlation with both foot lengths with the RFL exhibiting a slightly stronger association. Regression equation for stature developed in this study with respect to the pooled data exhibited a better goodness of fit for the Left foot length

Keywords: Stature; Foot length; Correlation; Regression equation.

Introduction:

Identification is an area of science which deals with establishing the unique characteristics of an individual and this field has seen lot of advancements in recent times. An individual's exact identity can be established by multiple methods which are both accurate and reliable such as fingerprinting, DNA analysis, retinal scans, etc to name a few. But challenges arise in cases especially in the dead where only partial identification is possible at times. In such cases, developing suitable methods which can be utilised rapidly with a fair degree of accuracy may prove to be quite useful. One such method is our area of interest where we are looking at the correlation of foot length with the stature of an individual. Stature is a primary identification characteristic and it progressively increases with age, becoming a constant at around 21 years. It is well known that there is a definite relationship between the height of a person and their various body parts like the length of head, torso, limbs, etc and the ratio between them is a constant for a particular age and sex. Estimating the height of an individual by measuring the various body parameters including foot length has been of immense interest not only for forensic experts but likewise for anatomist and anthropologists alike.[1]

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Materials and Methods:

The Study population includes the students and staff of a tertiary medical training centre and residents of district in South India between the ages group of 21-40 years. This original research was approved by the institutional ethics committee. 200 members consisting of 100 male and 100 female participants were selected for the study by using stratified random sampling based on age. General physical examination was conducted to know the health status and rule out any deformities in the subject.

The aim and objective of the study was explained and informed consent of the subject was taken. The measurement was made on the standing subject, his right leg being slightly bent and drawn backwards so that the body rested mainly on the left foot, to measure left foot and vice versa was done for the other foot. A vernier calliper was horizontally placed along the medial border of the foot. The fixed part of the outer jaw of the calliper was applied to the most prominent point of the back of the heel (pternion) and the mobile part of the outer jaw is approximated to the tip of the hallux or the tip of the second toe (acropodian) when the second toe is larger than hallux, and it was measured in centimetres approximated to the nearest millimetre. This was done separately for each foot to obtain the right foot length (RFL) and left foot length (LFL) respectively. The stature of each subject was recorded by asking him/her to stand erect with bare foot on the base of the standard height measuring instrument in a standing position. Then the subjects were asked to stand without support, with arms by the side of the body, head in steady position. The stature was measured from the ground to the highest point on the

subject's head with the help of horizontal thin plate in close contact with the scalp in centimetres and approximated to the nearest millimetres.

The data was tabulated, analysed and subjected to Data were analysed using SPSS v 22 software. If there is statistically significant difference ($p<0.05$) in means among any of the data groups then the data was tabulated and further correlation (to test the strength of association) and regression analysis was done.

Inclusion Criteria: a) Adults above the age of 21 years and below 40 years. b) Healthy individuals.

Exclusion Criteria: a) Adults with. b) Any Chronic illness.

c) Endocrine disorders (Dwarfism, Gigantism, Cretinism etc).

d) Individuals with deformities of Foot (Flat Foot), Lower limbs (Knock-Knee) and Vertebral Column (Scoliosis, Kyphosis).

Results:

Table 1. Comparison of mean of stature, RFL and LFL between male and female.

Variables	Stature in cm	RFL in cm	LFL in cm
Male	169.43±6.45	25.37±1.38	25.17±1.43
Female	155.94±5.67	23.24±1.09	22.94±1.03
Significance	t=16.380; p<0.001**	t=12.264; p<0.001**	t=12.886; p<0.001**

Table 2. Correlation coefficient (r), Regression coefficient (b), and value of constant (b) between foot lengths and stature

		Total	Male	Female	P-value
RFL Vs. Stature	Correlation Coefficient (r)	0.811	0.677	0.592	p<0.001*
	Regression Coefficient(b)	4.489	3.158	3.087	p<0.001*
	Value of constant (a)	53.591	89.297	84.203	p<0.001*
LFL Vs. Stature	Correlation Coefficient (r)	0.823	0.707	0.582	p<0.001*
	Regression Coefficient(b)	4.469	3.189	3.203	p<0.001*
	Value of constant (a)	55.195	89.163	82.477	p<0.001*

Table 3. Regression equation for the prediction of stature by right and left foot length.

	RFL	LFL
Total (Pooled)	Stature=53.591+4.489×RFL (r2 = 0.657 p<0.001*)	Stature=55.195+4.469×LFL (r2 = 0.678 p<0.001*)
Male	Stature=89.297+3.158×RFL (r2 = 0.459 p<0.001*)	Stature=89.163+3.189×LFL (r2 = 0.500 p<0.001*)
Female	Stature=84.203+3.087×RFL (r2 = 0.351 p<0.001*)	Stature=82.477+3.203×LFL (r2 = 0.338 p<0.001*)

Discussion:

The accurate estimation of stature is one of the key objectives during medico-legal autopsy. Stature estimation has been attempted on based on length of long bones, diameters of the skull, forehand length, etc by many workers in the past. However, little importance is been given for estimation of stature from foot length. Stature estimation can be really challenging when mutilated or fragmented body parts are presented for autopsy. The present study aims at finding answers to some of these problems. Table 1 compares the Stature, RFL and LFL between males and females wherein the mean male stature was found to be 169.43 cm (SD=6.45 cm) which was more than the mean female stature which was found to be 155.94 cm (SD=5.67 cm). These findings are consistent with similar studies done by Sonali Khanapurkar et al.,[1] Arif Rasheed Malik et al.,[2] Jakhar et al.[3] The finding were in contrast with studies by Rajesh et al.[4] and Mansur et al.[5] who found a lower mean stature in males and a higher mean stature in females. Study by Rameswarapu Babu et al.[6] found higher mean stature in both sexes when compared to our study The mean male RFL & LFL were 25.37 cm and 25.17 cm respectively which was more compared to its female counterparts which measured 23.24 cm and 22.94 cm respectively and this difference was found to be statistically significant. This could be attributed to attainment of maturity earlier in females compared to males and thereby necessitating the development of sex specific linear regression.

The mean RFL and LFL of males in present study was more in comparison to findings by Rajesh et al.,[4] Devesh et al.,[7] Mansur et al.[5] and Mehul et al.,[8] The female mean RFL was more than the those found by Mehul et al.[8] & Rajesh et al.[4] Female mean LFL is similar to Patel et al.,[9] other studies are in contrast with present study.

Table 2 measures the Pearson's correlation co-efficient (r), regression co-efficient (b) and value of constant (a) of stature with RFL and LFL among male and female respectively. A highly significant correlation was found between stature and RFL (r=0.811) with the strength of association being more in males (r=0.677) than females (r=0.592). A highly significant correlation was also found between stature and LFL (r=0.823) with the strength of association again being more in males (r=0.707) than in females (r=0.582). Between the two feet, the stature showed

Table 4. Regression equations for stature and foot length (present study in comparison with others).

Study Author	Region Conducted	Stature In Relation To RFL	Stature In Relation To LFL				
		Total	Male	Female	Total	Male	Female
Present study	South India	Stature=53.591+ 4.489×RFL	Stature=89.297 +3.158×RFL	Stature=84.203 +3.087×RFL	Stature=55.195 +4.469×LFL	Stature=89.163 +3.189×LFL	Stature=82.477 +3.203×LFL
Rahul et al.[8]	Moradabad, UP	y=90.32+3.07x	y=116.51+2.07x	y=14.75+6.39x	y=91.74+3.02x	y=115.45+2.11x	y=7.23x-3.62
Rameswarapu et al.[6]	Ghanapur, AP	y=47.971+4.782x	y=82.830+3.468x	y=73.523+3.615x	y=50.350+4.691x	y=80.955+3.547x	y=79.83+3.349x
Verma et al.[10]	Ghaziabad, UP	y=56.910+4.363x	y=53.918+4.497x	y=78.200+3.427x	y=56.088+4.393x	y=57.951+4.642x	y=73.568+3.620x
Sumita et al.[11]	Moradabad, UP	y=63.00+4.17x	y=69.99+3.93x	y=89.82+2.95x	y=64.99+4.09x	y=70.93+3.89x	y=93.17+2.81x
Jitender et al.[3]	Rohtak, Haryana	y=47.631+4.889x	y=86.620+3.414x	y=73.132+3.721x	y=43.852+5.047x	y=80.671+3.648x	y=65.194+4.068x
Mansur et al.[5]	Nepal	----------	y=2.74x +100.1	y=2.66x +96.31	----------	y=2.738x +100.2	y=2.66x +96.40
Mehul C Upadhyay et al.[8]	Jamnagar, Gujarat	----------	y= 86.96 ± 3.40RFL	y= 77.35 ± 3.61RFL	----------	y= 84.64 ± 3.49RFL	y= 78.92 ± 3.53RFL

(y = Stature & x = corresponding combined foot length from the respective study).

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highly significant strong correlation with LFL (r=0.823) when compared to RFL (r=0.811). By comparing the r and r^2 values in different study groups it is seen that pooled sample show better correlation than individual sex, for estimating stature from foot length which is in agreement with our present study. It is also observed that left foot length shows better correlation to estimate stature than right foot length in this study and it supported by work of previous researchers (see table 4) and even international agreement for paired measurement at Geneva recommends to consider the left foot measurement than right foot. With respect to sex, males show better correlation as compared to females in most of the studies (as listed in table 4) and present study is in agreement with the same.

Table 3 shows the linear regression formulas for stature estimation from RFL and LFL independently as well as based on sex. The individual formulas for stature prediction from either sex irrespective of the side of the foot chosen, was not effective in predicting fluctuations in stature in >50% of the population (highest was r^2=0.5 in LFL for males). Whereas the overall formula for stature from RFL shows a 65.7% (r^2=0.657) and LFL shows a 67.8% (r^2=0.678) effectiveness in predicting variations in stature in the population which would be adequate considering the variables being examined.

Table 4 offers a table of comparison for the regression equation developed in the present study with others.

Conclusion:

Our study draws the following conclusions

- The relationship between stature and the foot lengths are highly significant with mean male foot lengths being higher than the female counterparts
- Stature showed a highly significant positive correlation with both foot lengths with the RFL exhibiting a slightly stronger association.
- The formula for stature developed in this study with respect to the pooled data (irrespective of sex) had a better goodness of fit for the LFL.

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