Stature Estimation from Anthropometry of Foot in Adults of Border Areas of Punjab

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Abstract

Background: Stature is one of the various parameters of identification of the individuality of a person. Estimation of stature from various measurements of the body is of value in medicolegal investigations as well as in anthropology. The foot measurements are important in forensic field as they can be used as body height predictors for an individual.The current study deals with developing a regression equation for stature estimation from foot breadth and foot length and to find out the correlation between stature, foot breadth and foot length. **Methods:** The data was collected from 500 asymptomatic, healthy adults (250 males & 250 females) belonging to border areas of Punjab region of age group ranged between 18-50 years.

Results: The correlation between foot length and stature (r= 0.337) was more than foot breadth and stature (r= 0.046) indicating foot length to be a better predictor of stature. Linear regression equations were derived for estimation of stature from foot breadth and foot length.

Conclusion: Both foot breadth and foot length showed positive correlation with stature as indicated by the regression coefficient. The results indicate that one can successfully estimate staure from different foot dimensions. The calculated regression formulae show good reliability and applicability of estimate which would be useful for Anthropologists and Forensic Medicine experts.

Keywords: *Stature, Foot length, Foot breadth, Anthropometry, Forensic investigations*

Introduction

Stature (body height) is an important and useful anthropometric parameter for personal identification and helps in narrowing down the investigation process[1]. Though every part of the human body is unique and is different in its own way but still exists a relationship between each part of the body and the whole body. Therefore, many parts of the body have been used to estimate height by different workers globally.[2]

In the present scenario, developing countries suffer as a great impacts of disasters like, bomb blasts, air crashes, tsunami, earthquake, mass suicide, forest fires and others mutilating injuries due to the fast and rapid way of living, so the need to establish the identity from decomposing and incomplete skeletal is important.[2-6] Footprints as valuable physical evidence available in crime scenes may provide useful clues to establish personal identity and can help in including or excluding the possible presence of an individual at the scene of crime. Footprints can be collected from almost all types of crime scenes and the possibility of their recovery at the scenes of sexual offenses and homicides is relatively more.[3]

Forensic identification from the foot and its parts is important as there is increased incidence of recovery of feet (often enclosed in shoe) seperated from the body in mass disasters. Examination of barefoot impressions is important especially in developing countries like India, Malaysia, Thiland, Indonesia where majority of the rural population like to walk barefooted because of socio-

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economic and climatic reasons.[2]

Many previous studies have been done to estimate the stature from length of different long bones with variable degree of success. It was Rutishauser (1968) who for the first time showed that foot length was more reliable for prediction of height. Adult height may be attained during adolescence. As ossification and maturation in the foot occur earlier than the long bones so the height could be more accurately predicted from the foot dimension rather than the long bone measurements.[7]

There is paucity of such studies in the border area of Punjab so In view of above description, a cross sectional survey study is conducted to determine the relationship between foot and stature by calculating correlation coefficient and also to derive regression linear equations.

Materials and Methods

Source of data: The present study was conducted out in the region of Punjab , mainly border areas like Amritsar, Pathankot, Gurdaspur, Dinanagar Districs and their surrounding villages. The material comprised of 500 young healthy adults (250males and 250 females) of the group 18-50 years. The subjects were from colleges, universities and from general public.

Methods of collection of data: The objectives and methods of the study were explained to the study population .Prior to the investigation written informed consent was obtained by taking their signature and thumb impressions.Foot measurements were taken independently on the left and right side of each individual apart from this weight and stature were also recorded. In order to avoid inter-observer error in methodology , the measurements were taken by one observer. Diurnal variations have been reported in the stature of an individual thus, all measurements were taken during afternoon hours in a well lighted room and were recorded in measurement performa.

Land marks and technique involved in anthropometric measurements :

1.Stature: The subject was asked to stand erect barefoot on a level platform against the stadiometer bar ,the head was rest in a Frankfort Horizontal plane arms hanging by the side with his back ,hips and heels touching the bar the feet should touch each other.

2.Foot length: It is the distance from the most prominent posterior part of the heel to the most distal part of the longest great toe or second toe(acropodion).

3.Foot breadth: It is the distance between the most prominent point on the medial aspect of head of first metatarsal and the most prominent point on the lateral aspect of head of fifth metatarsal.

Instruments Used: Slider caliper: It was used for the feet measurements. The measurements were done in centimeters.

Stadiometer/Anthropometric rod: It was used to measure vertical height for stature estimation. The measurements were recorded in centimeters.

Inclusion criteria: Apparently healthy, asymptomatic males ,age between 18 to 50 years of age and only those who were willing to participate to study.

Exclusion criteria : Adults with history of any surgical procedures of limbs, disease, deformities of vertebral column, injury, fracture, amputation were excluded from the study, Also the age below 18 and above 50 years

Statistical Analysis: The data were subjected to statistical analysis using statistical package for social sciences(SPSS21)

Results

A total of 500 (250 males and 250 females) healthy individuals of age groups 18-50 years were included in the present study and percutaneous measurements of length and breadth of foot on both sides were taken separately and analyzed. The following observations were tabulated after statistical evaluation of the observations recorded in the study.

The distribution of age in the study Population shows the mean age of females was 40.29 years and that of males was 33.16 years.

The stature in males varied from 149.35 cm to 195.08 cm (mean-171.39 cm,SD-10.237) whereas in females stature varied from 149.35cm to 182.88cm(mean-160.73cm, SD-7.93). It was observed that males have greater mean value of stature as compared to that of females.(Table -1)

In males, the right foot length (RTFL) ranged from 17.6cm to 29.5cm (mean=24.89cm and SD=1.96 cm) and left foot length (LTFL) ranged from 17.2 cm to 29.1cm (mean=24.92 cmand SD=1.98 cm). In females the right foot length (RTFL) ranged from 15.7cm to 28cm (mean= 23.11cm and SD=1.62) and left foot length (LTFL)ranged from 15.8 cm to 28.1cm. (mean= 23.13cm and SD=1.61 cm).(Table1)

In the table 2 Descriptive statistics shows that In males, right foot breadth varied from 5.6cm to12.5 cm and left foot breadth ranged from 5.1cm to 12.3 with the mean of 9.40 cm and std. deviation of 1.39 cm respectively.In females, right foot breadth varied from 5.0 cm to 11cm and left foot breadth ranged from 5.3cm to 11cm with the mean of 8.79 cm and std. deviation of 0.99 cm respectively. The comparison of respective readings of various parameters studied shows that all parameters have higher values in males than in females.

Table 3 shows correlation between the stature of individual and various parameters studied in the sample population. All the parameters exhibit statistically highly significant ($p <0.001$) positive correlation with the stature except foot breadth in males ,which shows negative correlation.

Correlation co-efficient of the length measurements is higher than the breadth measurements. It is also observed that in males highest correlation is exhibited by left foot length($r= .295$) and the lowest by left foot breadth ($r= -.063$).In females highest correlation co-efficient is exhibited by Right Foot Length ($r= .337$)and lowest by Left Foot Breadth ($r=.046$).

Linear regression analysis of the observations was performed separately for each sex and also for each parameter studied. (Table 5) The equations also exhibit standard error of estimation (SEE). The SEE predicts the deviations of the estimated stature from the actual stature. In males, it ranges between ± 7.80 to ± 4.42.For females SEE ranges from ± 4.51 to ±6.99 . (Table 4)

The accuracy of the regression equations was verified by comparing the estimated stature with actual stature. The estimated stature values are found very closer to actual stature value in both male and females .(Table 5)

Table 1:Comparison of stature and foot length in males and females .

Measurements	Stature		Foot Length			
			Males (N=250)		Females (N=250)	
	Male	Female	Rt side	Lt side	Rt side	Lt side
Mean	171.39	160.73	24.89	24.92	23.11	23.13
Std.Deviation	10.237	7.93	1.96	1.98	1.62	1.61
Minimum	149.35	149.35	17.6	17.2	15.7	15.8
Maximum	195.08	182.88	29.5	29.1	28	28.1

Table 2: Descriptive statistics of foot breadth in males and females.

Measurements	Foot Breadth			
	Males (N=250)		Females (N=250)	
	Rt side	Lt side	Rt side	Lt side
Mean	9.43	9.40	8.79	8.79
Std.Deviation	1.35	1.39	0.99	0.98
Minimum	5.6	5.1	5.0	5.3
Maximum	12.5	12.3	11	11

Table 3: Showing Karl Pearson's Correlation Coefficients between the stature and various parameters studied in sample.

S.NO	Study Parameters	Karl's Pearson Correlation	Sig (2-tailed) ($p<0.05$)	Karl's Pearson Correlation	Sig (2-tailed) ($p<0.05$)
		FEMALE SAMPLE		MALE SAMPLE	
1	Right Foot Length	.293	.000*	.337	.000*
2	Right Foot Breadth	-.070	.272	.106	.095
3	Left Foot Length	.295	.000*	.319	.000*
4	Left Foot Breadth	-.063	.323	.046	.129
* statistically significant value					

Table 4: Linear Regression equations to determine stature from different parameters in sample.

S.no	Parameters	Linear Regression Equations	SEE**
FEMALE SAMPLE			
1	Right foot Length	S= 127.58+1.43 X RFL	6.87
2	Right Foot Breadth	S= 165.66+(-.561) X RFB	4.51
3	Left Foot Length	S=126.99+1.45 X LFL	6.99
4	Left Foot Breadth	S=165.20+(-.509) X LFB	4.54
MALE SAMPLE			
5	Right Foot Length	S= 127.49+1.76 X RFL	7.80
6	Right Foot Breadth	S= 163.82+0.80 X RFB	4.56
7	Left Foot Length	S=130.27+1.65 X LFL	7.77
8	Left Foot Breadth	S=164.71+0.71 X LFB	4.42

Table 5: Difference of Actual Stature and Estimated Stature in Males and Females.

Estimated Stature using Regression Equations for	Mean Estimated Stature (in Cm)	Difference Between Means= Mean Actual Stature – Mean Estimated Stature
Male Mean Actual Stature (171.39)		
Right Foot Length	171.37	0.02
Left Foot Length	171.39	0
Right Foot Breadth	171.38	0.01
Left Foot Breadth	171.38	0.01
Female Mean Actual Stature (160.73)		
Right Foot Length	160.72	0.01
Left Foot Length	160.72	0.01
Right Foot Breadth	160.73	0
Left Foot Breadth	160.73	0

Discussion

The stature estimated in the present study in males varied from 149.35 cm to 195.08 cm (mean-171.39cm) whereas in females stature varied from 149.35cm to 182.88cm(mean-160.73cm).these values are very similar to the findings of Arti et al.[8] The stature obtained by different researchers such as Duyar I et al,Nath S et al, Qamara SR et al, and Ozaslan A et al varies from present study due to variations in the morphology of different population group.[9-11]

Ozdan et al stated that right foot length and left foot length are independent predictor of stature.These findings are supported by the present study. [12]

In a study by Devesh correlation coefficient (r) of 0.698 for males was obtained between stature and left foot length.[13] Karaddi et al observed correlation coefficient obtained separately for right foot and left foot in male students. Correlation coefficient is + 0.82 for right foot and + 0.80 for left foot.[14] In the current study Correlation co-efficient of the length measurements is higher than the breadth measurements. It is also observed that in males highest correlation is exhibited by left foot length(r= .295) and in females it is exhibited by Right Foot Length (r= .337)Deopa Deep also observed a significant and positive correlation between foot length and height in individuals of Uttarakhand region.[15] Charnalia showed the significant correlation between height and foot length.[16]

Vidya CS in her study concluded that left foot is slightly lengthier than that of right foot in both thesexes. The different regression equations of various studies has been derived by different researchers globally.[17] These formulae are applicable for population specific from which the data has been collected.[18] Sen & Ghosh in 2008, recommended that it would be unwise to use same equations for stature estimation in both the gender .one should derive the different equations for male and females.[19] It is concluded that dimensions of feet has good predictive value in estimation of stature. Foot length is a reliable and strong parameter to estimate stature of an individual. The calculated regression formulae show good reliability and applicability of estimate. Also these regression equations are population specific because of many factors like racial, ethnic and nutritional factors and geographical variations, which play an important role in human development and growth. There is necessity for the different regression equations for both genders because of difference in gender stature and foot length as both parameters have higher values in males.

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