Estimation of Height from Measurement of Foot Breadth and Foot Length in Adult Population of Rajasthan

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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 current study dealt 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.

Material and Methods: The data was collected from 500 asymptomatic, healthy medical students (267 males & 233 females) belonging to Rajasthan of age group ranged between 17-25 years. The study was conducted at Jawahar Lal Nehru Medical College, Ajmer, Rajasthan.

Results: The correlation between foot length and stature (r= 0.756) was more than foot breadth and stature (r= 0.624) 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 (r). The tibialis foot type was commonest followed by fibularis and then by indeterminate type.

Key words: stature; foot type; foot breadth; foot length; correlation.

Introduction

Personal identification means determination of individuality of a person. It may be complete (absolute) or incomplete (partial). Complete identification means absolute fixation of individuality of a person. Partial identification implies ascertainment of only some facts about the identity of the person while others still remain unknown. Age, sex and stature are the primary characteristics of identification.[1]

Personal identification from foot and its segments becomes more important in cases of mass disasters, where there is always likelihood of recovering feet (often enclosed) in shoes separated from the body. Assessing the height of an individual, from measurements of different parts, has always been of immense interest to the anatomists, anthropologists and forensic medicine experts.

Anthropometry constitutes the means of giving quantitative expression to the variations which different individuals or traits exhibit.[2] Origin of anthropometry dates back to as early as ancient Egypt and Greece. The artists then formulated various standard canons for the human body.[3]

Like other parts of the body such as head, trunk, lengths of upper and lower limb, the foot size also displays a definite biological correlation with stature. On the basis of this relationship, it is possible to predict the stature from the foot and its segments.[4]

Material and Methods

The present study was carried out on 500 (267 males and 233 females) young and healthy Medical Students belonging to Rajasthan, of age group ranged between 17-25 years studying at Jawahar Lal Nehru Medical College, Ajmer, Rajasthan. The subject having any disease of foot or deformity was not included in this study. The height, foot breadth & foot length were measured. Independent linear regression equations and multiplication factors were derived. The left foot was selected for measurement as per recommendation of the international agreement for paired measurements at Geneva (1912).[5]

Foot breadth was measured as a direct distance between the most prominent point on the medial aspect of head of first metatarsal and most prominent point on lateral aspect of the head of fifth metatarsal by spreading calliper in centimetre. Foot length was measured as a direct distance from the most prominent point of the back of the heel to the tip of the hallux or to the tip of second toe (when the second toe is longer than hallux) by spreading calliper in centimetre.[6]

Stature of the individual was measured in standing erect anatomical position by stadiometer. The measurements were taken at a fixed time between 9:00 a.m. to 2:00 p.m. to eliminate diurnal variation and by me only to avoid personal error in methodology. The obtained data was then statistically analysed by linear regression analysis.

Results

A total of 267 males and 233 females were included in the study. The study group included the individuals aged between 17- 25 years with a mean age of 19.97 ± 1.13 years. There is significant correlation coefficient between stature and foot breadth ($r = 0.677$, $p < 0.0001$ for male and $r = 0.439$, $p < 0.0001$ for female), stature and foot length ($r = 0.763$, $p < 0.0001$ for male and $r = 0.652$, $p < 0.0001$ for female), stature of entire subjects and mean foot breadth ($r = 0.624$, $p < 0.0001$) and stature of entire subjects and mean foot length ($r = 0.756$, $p<0.0001$). It means that there is strong positive correlation between stature, foot breadth and foot length. Linear regression equations were derived for estimation of stature from foot breadth and foot length.

The commonest type of foot seen in males was tibialis type, which was 84.3% followed by fibularis type which was 14.6% and then by indeterminate type with 1.1%. The commonest type of foot seen in females was tibialis type, which was 85% followed by fibularis type, which was 13.7% and then by indeterminate type with 1.3%.

**Table 1: Stature, Foot breadth, Foot length, correlation coefficient, regression equation in Male, Female and Pooled**

	Male	Female	Pooled
Total number	267	233	500
Stature range (cm)	152-185	125.3-182.9	125.3-185
Mean stature (cm)	166.43	160.91	163.86
S.D. of stature	7.72	6.45	7.65
Foot breadth range (cm)	7.5-11	7.5-11	7.5-11
Mean foot breadth (cm)	9.07	8.68	8.89
S.D. of foot breadth	0.77	0.64	0.74
Foot length range (cm)	21.5-29.5	20-27.5	20-29.5
Mean foot length (cm)	24.71	23.56	24.17
S.D. of foot length	1.63	1.37	1.62
Correlation Coefficient (r) for Stature and Foot breadth	0.677	0.439	0.624
Regression equation for Stature and Foot breadth(FB)	Stature= 104.84+ 6.79 x FB	Stature= 122.28+ 4.45 x FB	Stature= 106.167+ 6.49 x FB
Correlation Coefficient (r) for Stature and Foot length	0.763	0.652	0.756
Regression equation for Stature and Foot length(FL)	Stature= 77.24+ 3.61 x FL	Stature= 88.83+ 3.06 x FL	Stature= 77.471+ 3.57 x FL

Table 2: Age v/s Stature, Foot breadth and Foot length

Age in years	Mean stature (cm)		Mean foot breadth (cm)		Mean foot length (cm)	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
17	175.0	161.6	9.2	9.0	25.2	23.1
18	171.9	162.4	9.6	8.6	25.7	23.8
19	169.2	160.2	9.3	8.6	25.2	23.5
20	165.1	159.7	8.9	8.7	24.5	23.5
21	164.9	161.8	8.9	8.8	24.4	23.5
22	166.7	163.0	9.2	8.7	25.0	24.1
23	173.7	-	9.5	-	26.0	-
24	166.0	163.5	9.5	8.8	24.6	24.2
25	167.0	-	9.5	-	25.6	-

Table 3: Gender distribution of the subjects studied

Gender	Pooled	
	No.	%
Male	267	53.4
Female	233	46.6
Total	500	100

Graph 1: Pearson correlation between Foot breadth and stature

r=0.624, p<0.0001
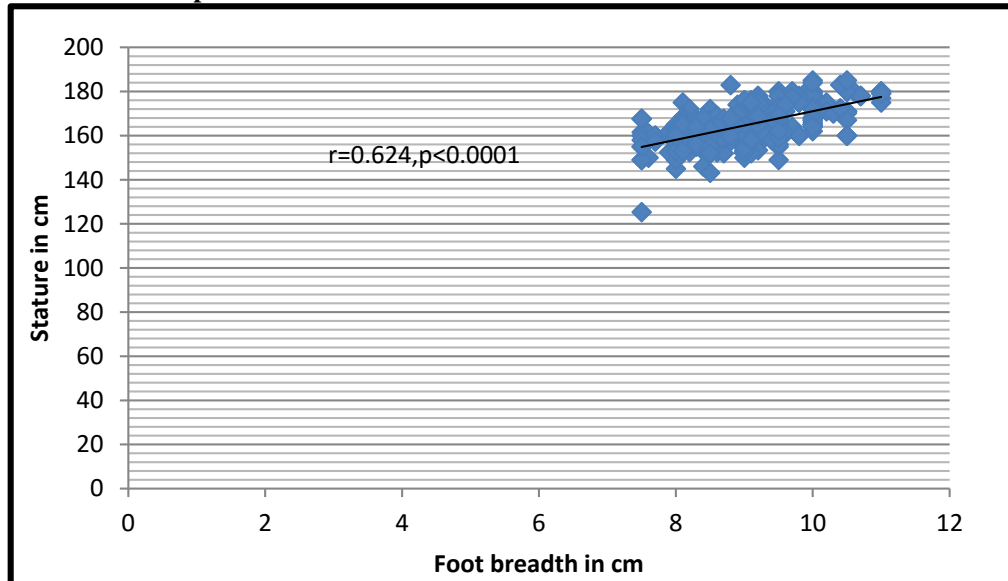
Graph 2- Pearson correlation between Foot length and stature

r= 0.756, p<0.0001
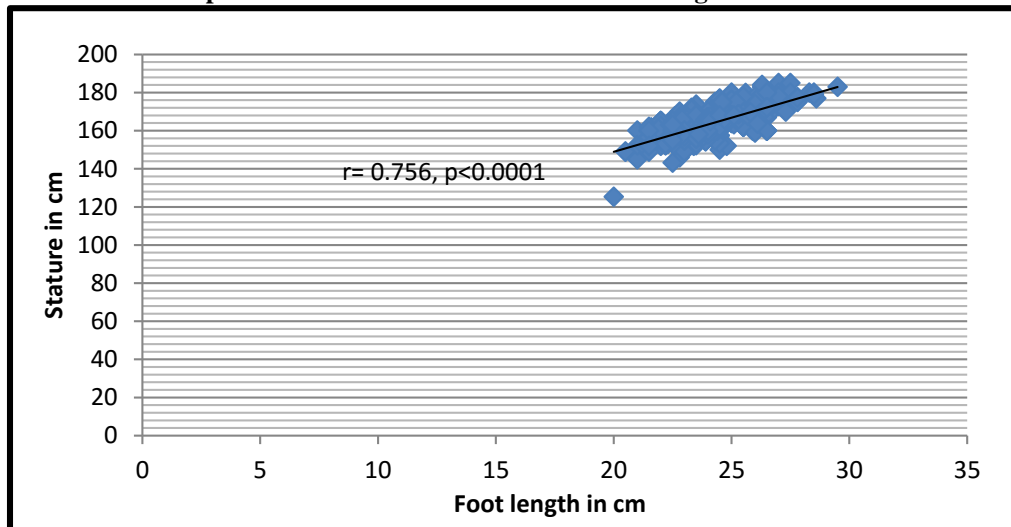
Discussion

The estimation of stature is considered as one of the important parameters in identification of a person. The body parts show biological correlation with stature. This fact has been utilized by many workers to use body parts or skeletal remains to estimate stature. The vertical height of a person needs an equally firm base to support it, which is provided by the feet. This implies that increase in the height is associated with an increase in foot dimensions. There are several studies conducted on the foot, to use it for identification analysis. The earlier of these were morphological studies. Some workers like Charnalia[7], Das et al.[8], Pal et al.[9] conducted these type of studies. Qamra et al. (1980) measured height, foot length and foot breadth of 1015 adults which included 519 males and 496 females aged between 17 to 32 years belonging to North India. They developed methods for estimating height from foot length and foot breadth.[10] Robbins LM[11] in her study used foot print dimensions to estimate weight. The foot

has been used to estimate stature in several studies in different endogamous groups, where nomograms have been derived to reconstruct stature from the foot dimensions. These types of studies in different communities become essential, as several factors which include genetic and environmental, are known to affect stature and foot morphology as well as dimensions.

Her study concluded that foot print dimensions were representative of only plantar portion of the foot, not the size of actual foot. She also concluded that the size of foot outline was intermediate between footprint and shoe size. Giles E and Vallandigham PH (1991) studied the correlation between foot length, shoe length and height using the database of U S Army personnel including 6082 males and 1330 females.[12] Surinder Nath and Divya Chug (2001) conducted study on male and female Brahmins of Sundernagar of Himachal Pradesh (H.P.) and derived regression formula for calculating height from foot length and hand length.[13] Agnihotri et al. (2007) correlated foot length and stature in Mauritians (125 males and 125 females). They also derived regression equations to calculate height. However, they used right foot for analysis.[14] Sen et al. (2008) studied the foot measurements and stature of 350 Rajbanshis of West Bengal (175 males and 175 females) and derived several formulae to reconstruct height from these measurements.[15] Kanchan et al. (2008) studied the relationship between stature and foot dimensions among Gujjars, a North Indian endogamous group. They measured stature, foot length and foot breadth of 200 subjects comprising of 100 males and 100 females. They derived multiplication factors and regression equations from foot dimensions to estimate stature.[16] The foot was used to determine the sex of an individual by Gulsah et al.[17] and Danbarno et al.[18] In the present study, the foot type was noted and an attempt was made to find the relation between stature and foot dimensions (foot breadth and foot length) in the study groups using statistical methods. As per the recommendation of the International agreement for paired measurements, left foot is to be used for measurements. But studies conducted by Das et al.[8], Anadi Pal[9], Robbins LM[11], Gulsah et al.[17] have not shown any statistically significant interside difference. Robbins in her study concluded that either of the foot could be used for estimation of height.[11] Bhavana and Nath S (2009) correlated stature with femur length, tibial length, fibular length , foot length and foot breadth in 503 male and 508 female Shia Muslims of Delhi. They derived nomograms to estimate stature from the measurements of lower limb.[19]

Table No.1 shows correlation between stature, foot breadth, foot length, correlation coefficient, regression equation in male, female and pooled. Table No.2 shows age v/s stature, foot breadth and foot length. Table No.3 shows gender distribution of the subjects studied. Graph 1 & 2 shows Pearson correlation between foot breadth and stature & foot length and stature respectively.

Conclusion

The present study has established definite correlation between stature, foot breadth and foot length. Regression equations have also been established. The correlation between foot length and stature was more than foot breadth and stature indicating foot length to be a better predictor of stature in males and females. On the whole foot length can be considered as a better predictor of stature than foot breadth. If either of the measurement (foot breadth, foot length, stature) is known, the other can be calculated and this would be useful for Anthropologists and Forensic Medicine experts. It will help in medicolegal cases in establishing identity of an individual, when only some remains of the body are found as in mass disasters, bomb explosions, accidents etc. It will also help in establishing identity in certain civil cases. There are lot of variations in estimating stature from limb measurements among people of different region & race. Hence there is a need to conduct more studies among people of different regions & ethnicity so that stature estimation becomes more reliable & identity of an individual is easily established.

Abbreviations

cm - CENTIMETRE
FB – FOOT BREADTH
FL – FOOT LENGTH
p – SIGNIFICANCE VALUE
r – CORRELATION COEFFICIENT
SD – STANDARD DEVIATION

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