Estimation of Stature from Dimensions of Foot

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Background*:* Establishing personal identity is one of the main concerns in forensic investigations. Estimation of stature forms a basic domain of the investigation process in unknown and co-mingled human remains in forensic anthropology. The objective of the present study was to set up standards for estimation of stature from the foot length and breadth.

Methods: The study samples were constituted than 120 medical students (60 males and 60 females) of Sri Devaraj Urs Medical College, Kolar. The participants were aged between 18 and 21 years. Two anthropometric measurements viz. foot length and foot breadth will be taken independently on the left foot of each individual. The results were tabulated and then regression equation was derived.

Results: The correlation between stature and all the foot measurements was found to be positive and statistically significant (P value<0.001). Regression equations were derived for estimation of stature from the measurements of the foot.

Conclusion: The present study indicates that anthropometric measurements of foot length and breadth are valuable in the estimation of stature. Foot length measurements estimate stature with greater accuracy when compared to foot breadth measurements.

►*Implication for health policy/practice/research/medical education:* Estimation of Stature from Dimensions of Foot

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1. Introduction:

Anthropometry is a series of systematized measuring techniques that express quantitatively the dimensions of the human body and skeleton. It is often viewed as a tradition and perhaps the basic tool of biological anthropology. It is finding increased use in medical sciences especially in the field of Forensic Medicine. Relationship that exists between different parts of the body and height has been of great interest to anthropologists, for many years. "Stature" is one of the most important elements in the identification of an individual.

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There is an established relationship between stature and various body parts like head, trunk, upper and lower extremities. This allows a forensic scientist to estimate stature from different parts of the body. With the increasing frequency of mass disasters, homicides, air plane crashes, blasts train and road accidents etc., there is always need for such studies which help in identifying the deceased from fragmentary and dismembered human remains. In such a situation, measurements of hands and feet provide good approximation about the height of a person (1).

Some of the authors have successfully tried to estimate stature from percutaneous body measurements (2-6), some from the isolated long bones (7-9) and some focused their attention on the estimation of stature using radiographic material.

The purpose of the present study is to analyze the anthropometric relationship between dimensions of feet and stature and to devise regression formulae to estimate stature from these dimensions.

2. Materials and Methods:

The present study consists of a cross-sectional sample of 120 subjects (60 males and 60 females), confidence interval 8, percentage 50, and population 600 (MBBS admissions 150 per year), ranging in age from 18 to 22 years. The procedure, aims and objectives of the study was informed and explained in a group for participants. A written valid informed consent is taken from each research participant. A small group of ten students are taken for measurements each day at a fixed time to avoid diurnal variations.

Two anthropometric measurements viz. maximum foot length and maximum foot breadth will be taken independently on the left foot of each individual. The left foot was selected for measurement as per recommendation of the international agreement for paired measurements at Geneva (1912) (10). Besides these, stature of each subject will also be recorded. All the measurements will be taken in a well-lighted room. Before taking the measurements, each subject would be asked to remove the shoes. The measurements are taken by one observer in order to avoid inter-observer error. The measurements will be taken using standard anthropometric instruments in centimeters to the nearest millimeter according to the techniques described by Valois (11).

Foot length

It is the distance from the most prominent part of the heel backward to the most distal part of the longest toe (2nd or 1st).

Acropodian: It is the most forwardly projecting point on the head of the 1st or 2nd toe whichever is larger when the subject stands erect.

Pternion: It is the most backwardly projecting point on the heel when the subject is standing upright with equal pressure on both the feet.

Instrument: Sliding caliper.

Technique: The measurement is made on the standing subject, his right leg being slightly bent and drawn backward so that the body-rests mainly on the left foot, which one is to be measured. The caliper is horizontally placed along the inner border of the foot.

Foot breadth

It is the distance between the points of the anterior epiphyses (distal) of the 1st metatarsal, the most prominent of the inner side of the foot (Metatarsal-Tibiale), and the joint of the anterior epiphyses of the 5th metatarsal, the most prominent of the outer side (Metatarsal-Fibulare).

Metatarsal-Tibiale: It is the most medially projecting point on the head of the 1st metatarsal bone when the subject stands erect.

Metatarsal-Fibulare: It is the point most laterally projecting on the head of the 5th metatarsal bone, when the subject stands erect.

Instrument: Sliding caliper.

Technique: The measurement which is taken in the dorsal region of the foot ‘loaded’ as in the preceding measurement is oblique with regard to length.

Table 1: Descriptive statistics of foot dimensions.

		Foot length (left)	Foot Breadth (left)
Minimum	Total (120)	17.7	6.1
	Males (60)	19.2	7.0
	Females (60)	17.7	6.1
Maximum	Total (120)	27.1	10.3
	Males (60)	27.1	10.3
	Females (60)	24.6	9.6
Mean	Total (120)	22.7	8.9
	Males (60)	23.2	9.1
	Females (60)	22.2	8.7
Standard Deviation	Total (120)	1	0.49
	Males (60)	1	0.5
	Females (60)	1	0.48

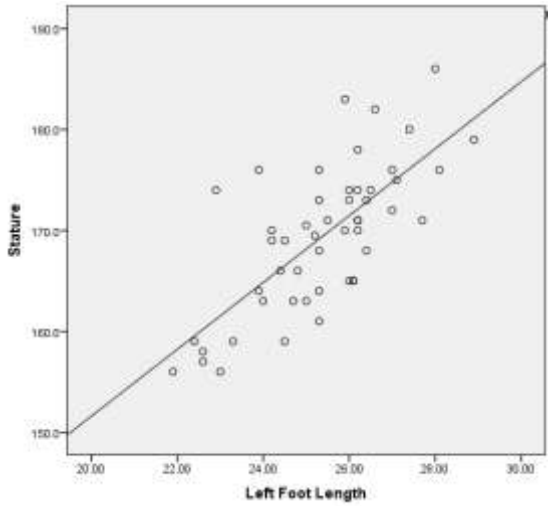

Fig. 1. It shows relation of stature with left foot length in males.

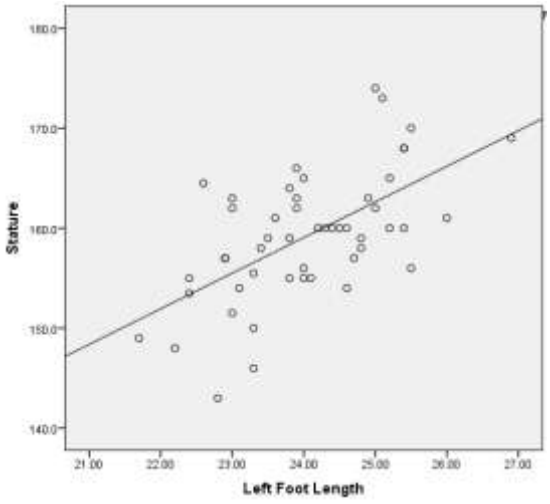

Fig. 2. It shows relation of stature with left foot length in females.

Statistical analysis

The primary outcome is to derive a regression equation for each parameter. Correlation coefficient will be calculated for each parameter. We analyzed our data using SPSS (version 16.0.2).

3. Results:

Table 2 depicts the Correlation coefficient and regression equation for the foot length and foot breadth. These regression formulae may be applied in stature estimation from the foot and its various segments independently. It is observed that stature can be estimated more accurately from foot length measurements than foot breadth measurements.

4. Discussion:

Pearson was the first person to estimate the stature from limb bones, many studies

Table 2: Linear regression models for reconstruction of stature from foot dimensions.

	Regression model	S.E.E	Correlation co-efficient (r)	p-value
Foot length	69.346 + 3.663 x (foot length)	4.568	0.636	<0.001 Statistically significant
Foot breadth	112.483+4.619 x foot breadth	5.488	0.375	<0.001 Statistically significant

have followed and lot of regression equations have been developed. However the measuring bone or part of the body and the method employed were different. The adult stature is attained by the age of 18 years. Hence in the present study all the subjects selected were above 18 years. The maximum and minimum foot length and breadth mean and SD are depicted in the Table 1.

The foot length and breadth are more for males compared to females.

These regression models may be applied in stature estimation from the foot and its various segments independently. It is observed that stature can be estimated more accurately from foot length measurements than foot breadth measurements. These regression models may be applied in stature estimation from the foot and its various segments independently. It is observed that stature can be estimated more accurately from foot length measurements than foot breadth measurements.

In our study it was observed that the foot length and foot breadth was more for males as compared to females. The foot length and breadth observed in our study were similar to that of the other Indian studies but was lesser compared to the foreign authors. The aim of this study was to obtain a regression formula for estimation of stature from foot length and foot breadth and compare that with the regression formula of other authors.

The regression formula for foot length and foot breadth calculated for males and females is depicted in Table 2.

Macdonnel[12] conducted study on 3000 people and his regression formula for stature based on foot length was 166.457+4.031 (foot-25.688) +/-2.9.

Patel held a study in Gujarat to derive a regression equation and the formula is 75.45+3.64 X foot length. A study conducted by Qamra (13), Singh and Phookan showed that foot length was more accurate than the foot breadth, which is in agreement with our study.

Gordon after conducting a study on foot length and foot breadth for estimation of stature concluded that regression equations containing both foot length and foot breadth were better than individual parameters.

Agnihotri *et al* developed a relationship between foot length and stature using linear and curvilinear regression analyses on 250 medical students and concluded that general multiple linear regression model was highly significant (14).

5. Conclusion:

In the present study the foot length and foot breadth were included in the investigation. Linear regression equations are derived which can be of immense help to the police in solving crimes. Stature, foot length and foot breadth are positively and significantly correlated with each other.

While calculating the regression equation it is noted that there is a linear relationship between the 3 parameters and which is corroborating with the previous studies. However there is variation in the slope and intercept of the equation which may be due to racial differences.

It was observed that the regression models derived from foot length measurements were more reliable than those from foot breadth measurements in the prediction of stature in forensic examinations.

This study was conducted on a diverse population as is the population of our country. Hence it is possible to determine the height of a person by using these formulae with a fair accuracy in our place.

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