ORIGINAL RESEARCH

Study the estimation of stature from foot length and breath with its clinical application

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ABSTRACT

Background: Stature is an important indicator of identification, which helps in medical legal cases in the rapid identification of suspects. There are numerous means to establish stature, and their significance lies in the simplicity of measurement, applicability, and accuracy of prediction. This is useful for anatomists to calculate stature in the North Indian population based on foot length and breath. **Aim and Objective:** The estimation of stature from foot length and breath with its clinical application. **Materials and Method**: The data was collected from 300 asymptomatic, healthy medical students (150 males and 150 females) belonging to the North Indian population. The age group ranged from 18 to 50 years. **Observation and Results:** The correlation between foot length and stature (r = 0.219) was greater than that between foot breadth and stature (r = 0.116), indicating foot length to be a better predictor of stature. **Conclusion:** Dimensions of feet can provide good reliability in the estimation of stature. The correlation coefficient was highest between stature and foot length in both males and females.

Key words: stature, foot type, foot breadth, foot length

INTRODUCTION

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

Personal identification from the foot and its segments becomes more important in cases of mass disasters, where there is always a 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 anatomists, anthropologists, and forensic medicine experts.

Stature is the height of the person in upright posture. It is an important physical identity. “Stature” is one of the most important elements in the identification of an individual. It is anatomically complex and includes the dimensions of the legs, pelvis, vertebral column, and skull, and the contribution of each of these to the total varies in different individuals and also in different populations. Ossification and maturation in the foot occur earlier than in the long bones, and therefore, height could be more accurately predicted from foot measurements as compared to those from long bones. There are a lot of variations in estimating stature from limb measurements among people of different regions and races. Hence, there is a need to conduct more studies among people of different regions so that stature estimation becomes more reliable. among people of different regions so that stature estimation becomes more reliable.

Anthropometry constitutes the means of giving quantitative expression to the variations which different individuals or traits exhibit.[2] Determination of stature forms a major domain of medico-legal investigations used in the identification of unknown fragmentary and mutilated remains. The study of fleshed foot variability and utility of foot uniqueness in personal identification has obvious

significance in anthropology and forensic sciences respectively. 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 [3]. The aim of the present study was to find out the correlation between foot length and breath of an individual and to derive regression formulae to estimate the height from foot length of an individual.

MATERIAL AND METHODS

The present study was conducted in the department of anatomy at central India. The sample size was 300 healthy individuals (150 males and 150 females) from the North Indian population. The subjects were within the age range of 18–50 years of age. The subjects are apparently free from any skeletal deformity, and informed consent was obtained from the subjects. Anthropometric measurements of foot length were taken independently on the left and right sides of each individual. The height of the individual was measured in a standing, erect anatomical position with a standing height measuring instrument in centimeters through a stadiometer. 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 the second toe when the second toe was longer than the hallux in centimeters through a measuring scale.

EXCLUSION CRITERIA

Subjects under 18 years of age were excluded.
Subjects with apparent foot anomalies, inflammation, trauma, deformities and surgery (if any) were excluded because of their unsuitability for the investigation.

STATISTICAL ANALYSIS

The data obtained were computed and analyzed using the Statistical Package for Social Sciences (SPSS, version 17.0). The foot index was derived from the formula FOOT BREADTH × 100/FOOT LENGTH.

OBSERVATION AND RESULTS

The data was collected, analyzed, and subjected to Statistical Packages for Social Sciences (SPSS) to determine the correlation of stature with the lengths of feet, and simple linear regression formulas were derived for various combinations.

Table 1: Foot breadth and foot length of males and females in the North Indian mixed population

Parameter (cm)	Side	Sex	Mean ±SD	p-Value
Foot Breadth	Right	MALE	8.984 ±0.716	0.000HS
		FEMALE	8.490 ±0.483	
	Left	MALE	9.602 ±0.573	0.000HS
		FEMALE	8.816 ±0.487	
Foot Length	Right	MALE	26.044 ±1.264	0.000HS
		FEMALE	23.140 ±1.162	
	Left	MALE	25.982 ±1.158	0.000HS
		FEMALE	23.196 ±1.173	

Table 1 shows a comparison between the foot breadth and foot length of males and females belonging to a randomly selected group of North Indian communities. The values obtained for the males were found to be notably higher compared to the females. In males, the mean left foot breadth was appreciably higher than the mean right foot breadth. Similarly, in females, the left foot breadth was substantially higher compared to the right foot breadth. In males, the mean left foot length was smaller compared to the mean right foot length, but it was a very minor difference. In females, the right foot length was slightly lower compared to the left.

Table 2: Foot index of males and females in the North Indian mixed population

Side	Sex	Foot Index Mean ± SD	p-value
Right	MALE	34.556 ± 3.006	0.001HS
	FEMALE	36.542 ± 2.996	
Left	MALE	34.412 ± 2.981	
	FEMALE	36.881 ± 1.904	0.001HS
Right vs. Left	MALE		0.219NS
	FEMALE		0.116NS

Table 2 shows the variation in foot index of males and females belonging to the north Indian community. The mean values obtained for males were found to be significantly lower compared to females. In males, the mean right foot index was significantly higher than the mean left foot index. In females, the left foot index was comparatively higher than the left foot index. p-values obtained for individual left and right feet were highly significant in males and females.

DISCUSSION

Many studies have been conducted on the estimation of stature. Many methods are established for estimating stature from the bones, but this is one of

the easiest. In the present study, we have observed the correlation of breath (in anatomical position) with foot length in the north Indian population studied. Table-I shows that the breath ranges from 8.984±0.716 on the right side and 9.602±0.573 on the left side in males and 8.490±0.483 on the right side and 8.816±0.487 on the left side in females, with a significant correlation between themmales. The table shows that length ranges 26.0446±1.264 on the1.264 right side and 25.982 ±1.158 on the left side in male and 23.140 ±1.162 on the right side and 23.140 ±1.162 on the left side in females, with a significant correlation between them.

Table 2. shows the variation of foot index of males and females belonging to north Indian community. The mean values obtained for the males were found to be significantly lower compared to female. In males, the mean right foot index was significantly higher than mean left foot index. While in females the left foot index was comparatively higher than left foot index. p-Values obtained for individual left and right foot were highly significant in males and females.

Table 3. Comparison of the foot breadth in the present study with the previous studies

Authors	Population	No.	Sex	Mean ±S.D.		p-value
				Right side	Left side	
	North Indian Population	150	M	8.984 ± 0.716	9.602 ± 0.573	0.000HS
		150	F	8.490 ± 0.483	8.816 ± 0.487	
Ozden H. et al. [4] (2005)	Turkey	294	M	9.41 ± 0.99	9.47 ± 1.04	p < 0.001.
		275	F	8.24 ± 1.18	8.23 ± 1.18	
Kewal Krishan [5] (2007)	Himachal Pradesh	123	M	9.52 ± 0.61	9.50 ± 0.61	p < 0.001.
		123	F	8.50 ± 0.68	8.53 ± 0.68	
Agnihotri et al. [6] (2007)	Mauritius Populations	125	M	9.63 ± 0.54	9.62 ± 0.54	
		125	F	8.74 ± 0.50	8.75 ± 0.52	
Manuel Bob et al. [7] (2009)	Nigerians	249	M	9.87 ± 0.53	9.73 ± 0.55	p < 0.001.
		228	F	9.14 ± 0.58	8.52 0.59	
Sen J. et al. [8] (2011)	Bengal (Rajbanshi)	175	M	9.89 ± 0.50	9.90 ± 0.50	p < 0.001.
		175	F	8.99 ± 0.50	9.01 ± 0.50	
Rani M. et al. [9] (2011)	Delhi	150	M	8.524 ± 0.677	8.666 ± 0.683	
		150	F	7.816 ± 0.776	7.962 ± 0.792	
Yamaner et al. [10] (2011)	Turkish Players	407	M	10.01 ± 0.48	10.11 ± 0.53	

The observations in North Indian population co-relate with the study of Sen Jet al. (2011) in which the foot breadth is less on the right side in males and females.In Nigerian population the foot breadth has been reported to be more on the right side as compared to left side in males and females. [11]In studies conducted on Turkish[12], Himachali[11], and Mauration[6] populations the foot breadth was same on both sides in both sexes.

Table 4: Comparison of the foot length in the present study with the previous studies

Authors	Population	No.	Sex	Mean ±S.D.		p-value
				Right side	Left side	
	North Indian Population	150	M	26.044±1.264	25.982±1.158	0.000HS
		150	F	23.140±1.162	23.196±1.173	
Ozden H. et al. [12] (2005)	Turkey	294	M	26.00±1.34	26.04±1.36	
		275	F	23.26±1.07	23.30±1.07	
Kewal Krishan[5] (2007)	H.P.	123	M	24.72±1.19	22.65±1.06	p<0.01 significant
		123	F	24.70±1.21	22.60±1.06	
Agnihotri AK[6] et al. (2007)	Mauritius	125	M	26.17±1.05	26.14±1.06	
		125	F	23.33±1.08	23.28±1.09	
Patel S.M. and Shah[14] G.V.(2007)	Gujrat	275	M	24.44±0.99		Highly significant

		224	F	22.34±1.12		
Jhakhar J. [15] et al. (2008)	Haryana	52	M	25.445±1.286	25.442±1.233	p<0.001
		51	F	25.089±0.948	21.400±0.927	
Bob Manuel [7] et al. (2009)	Nigerian	249	M	26.92±1.02	26.92±0.13	p<0.001
		228	F	25.00±1.33	24.75±0.17	
Sen J[8] et al. (2011)	Bengal (Raj Banshi)	175	M	23.95±1.1	24.01±1.1	p<0.001
		175	F	22.23±1.1	22.26±1.1	
Rani M. [9] et al. (2011)	North Indians (Delhi)	150	M	23.348±1.584	23.460±1.599	p<0.001
		150	F	20.599±	20.691±1.446	
Yamnar [10] et al. (2011)	Turkish Mayer	407	M	26.48±1.24	26.53±1.20	p<0.05

In all three populations, foot length was found to be the same in our study for both sexes on both sides. This co-relates with the studies in Turkish [10] and Mauration [4] populations. In our study, male foot length was greater than female foot length in all three populations. This supports the results in Turkish and Mauration populations as In the Himachali [11] population, the foot length is greater in males and females on the right side than on the left side. There is no significant difference between the foot length of males and females.

Table 5: Comparison of the foot index in the present study with the previous studies

Authors	**Population**	**No.**	**Sex**	**Mean ±S.D.**		**p-value**
				Right side	**Left side**	
	North Indian Mixed Population	150	M	34.556±3.006	34.412±2.981	HS
		150	F	36.542±2.996	36.881±1.904	
Agnihotri [6] et al. (2007)	**Mauritius Populations**	125	M	36.90	36.91	
		125	F	37.62	37.62	
Sen J[8] et al. (2011)	**Bengal Rajbanshi population**	175	M	41.32±1.8	41.30±1.8	
		175	F	40.48±2.1	40.50±2.1	

In our study, Foot index is lower in the North Indian population in both sexes on both sides. The foot index in Haryanvi jats has similar findings to the study conducted by Agnihotri et al. on the Mauration population. He suggests that the deviation point for sex determination is 37. Foot index is more than 37 suggestive of females and less than 37 of males.

In our study, the deviation point in the North Indian population is 36. Foot index is greater than 36 for females and less than 36 for males, which may be due to the sample size containing mixed subjects. This may be due to climatic factors, physical activities, barefoot, nutritional status, or socio-economic status.However, a study conducted by Sen et al. concluded that foot dimensions show significant sex differences. Although statistically significant sex differences are evident for foot index, its practical utility appears to be limited because of considerable overlap. Variability in foot shape is due to numerous factors. Factors contributing to this variability include genetics, environmental, socio-economic, lifestyle, and different ways of wearing shoes. Foot shape characteristics to identify differences due to ethnic backgrounds. Japanese feet are much more similar to the feet of Indonesians than the Caucasoid or Australoid's feet.

The Japanese typically have a wider foot for foot length as compared to the Caucasoid and Australoid, but a similar foot length for height than those of the Southeast Asians and Africans. These differences occur due to both genetic and environmental factors. According to the study by Wunderlich and Cavanagh (2001), adult foot shapes vary based on gender differences. In the study, all anthropometric data for each gender were separately analyzed. Therefore, measurements need to be taken for both genders because they have differences in foot measurements. Our study emphasizes that individual foot measurements are significant for sex determination, but foot index is a good indicator to find out variations in different ethnic groups.

CONCLUSION

The present study has established a definite correlation between stature, foot breadth, and foot length. The correlation between foot length and stature was greater 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 a better predictor of stature than foot breadth. If either of the measurements (foot breadth, foot length, or 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 the 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 a lot of variations in estimating stature from limb measurements among people of different regions and races. Hence, there is a need to conduct more studies among people of different regions and ethnicities so that stature estimation becomes more reliable and the identity of an individual is easily established.

STRENGHTH AND LIMITATION

A more elaborated study for estimation of stature not only on the basis of foot length but also on the basis of other parameters like hand length, cranial sutures, toe length, etc. should be carried out in collaboration with the Anatomy Department to establish regression equations for this part of the world facing not only extremes of terrorism in the form of bomb blasts but also earth quakes, floods, and air crashes where mass deaths occurred, and usually only parts of bodies are available, posing problems for determining identification.

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