



Original Research Article

## Estimation of Stature & Sexual Dimorphism from Dimensions of Sole in Living and in Cadavers

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### ABSTRACT

**Introduction:** Estimation of stature of individual from measurement of different parts of body has always been of particular interest to the anthropologist for long time. In forensic medicine also the estimation of stature from the foot length, foot breadth forms an important piece of evidence in court of law.

**Materials and Methods:** Present study was done with 200 subjects (100 males and 100 females) and also 50 cadavers (25 Males and 25 Females) age above 25 years, in the Department of Anatomy, Krishna Institute of Medical Sciences, Karad and different Medical colleges in western part of Maharashtra. Measurements like foot length, foot breadth were taken independently on the right and left side of each individual. Stature of each individual was also recorded. These parameters were analyzed using a standard computer programme. Duration of the study was one year.

**Results:** In present study, males show higher mean values in each anthropometric dimension than among females. Concerning bilateral asymmetry, only the foot breadth in females showed statistically significant asymmetry and the right side shows preponderance over the left side in this right handed sample. Correlation coefficients of the length measurements are higher than that of breadth measurements in both the sexes. In females, the highest correlation is exhibited by left foot length ( $r = 0.670$ ). Regression equations were derived for the stature estimation.

**Conclusion:** With help of results of the present study the dimensions of feet can successfully be used for estimation of stature and sexual dimorphism by law enforcement agencies and forensic scientists.

**Key words:** stature estimation, foot length, foot breadth, sexual dimorphism.

### INTRODUCTION:

All the human being occupies this globe to the same species i.e. Homosapiens.

<sup>[1]</sup> No two individuals are alike in all their measurable traits; even genetically identical twins (Monozygotic) differ in some respects. These traits tend to undergo change in varying degrees from birth to death, and

skeletal development is influenced by number of factors producing differences in skeletal proportions between different geographical areas. Anthropometry is a series of systematized measuring techniques that express quantitatively the dimensions of human body and skeleton. The ultimate aim of using anthropometry in forensic science is

to help the law enforcement agencies in achieving 'personal identity' in case of unknown human remains.<sup>[2]</sup> Anthropometric characteristics have direct relationship with sex, shape, and from an individual and these factors are intimately linked with each other.<sup>[3]</sup> Relationship between the dimensions of individuals' body segment and whole body has been of interest to artists, anthropologists, scientists, for many years.<sup>[4]</sup> Artist use dimensional relationships in depicting the ideas of beauty, and this resulted in creation of rules of body proportions. The earliest evidence of use such rules come from the ancient Egyptians. Applications of anthropological study are very vast anthropological measurements are utilized for designing proper equipments for industries, defense forces.<sup>[5]</sup>

In management of patients of burns body surface area is calculated from height and weight where foot-length helps in estimation of height. This study can be useful in artificial limb centers in calculating appropriate length of prosthesis.<sup>[5]</sup> This study also be useful in corrective surgeries for leprosy patients, amputation of limb surgeries for accidental injuries. The derived formulae can help to calculate stature in case of patients suffering from spine disorders like kyphoscoliosis. The data collected can be useful in further anthropological studies also. This study is also helpful in forensic medicine for if a foot specimen of medico legal case is found we can estimate the probable stature of that person. So an attempt is made to establish a relation between foot length, foot breadth and stature of an individual.

## **MATERIALS AND METHODS**

The present study consists of a cross-sectional sample of 200 male and females and 50 cadavers from western part of Maharashtra age above 25 years.

The sample for the present study taken from different medical colleges in western part of Maharashtra such as:-

- i. Krishna Institute of Medical Sciences University Karad.
- ii. B.J Medical College Pune.
- iii. Bharati Vidypeeth Pune.
- iv. Smt. Kashibai Navale Medical College and General Hospital Pune.

Ethical clearance was given by ethical committee KIMS karad. Anthropometric measurements viz. Foot Length, Foot Breadth, were taken independently on the right and left side of each individual with vernier caliper. Stature of each individual was also recorded.

- Only right handed subjects were considered for in the present study.
- All the measurements were taken in a well lighted room.
- Before taking the measurements, each subject was asked to remove the shoes.
- The measurements were taken by one observer (AS) in order to avoid inter-observer error.
- The measurements were taken using standard anthropometric instruments in centimeters to the nearest millimeter according to the techniques described by Vallois.<sup>[6]</sup>
- The subjects included in the study were healthy and free from any apparent symptomatic deformity.
- All the measurements were taken at fixed time between 2.00 to 4.30 pm.
- The data were subjected to statistical analysis using statistical package for social sciences (SPSS) and regression formulae were calculated for various combinations to reach the best estimate possible.

Measurements are taken as shown in Photo no. 1, 2, 3 stature, foot length, foot breadth respectively.

### Technique of height measurement

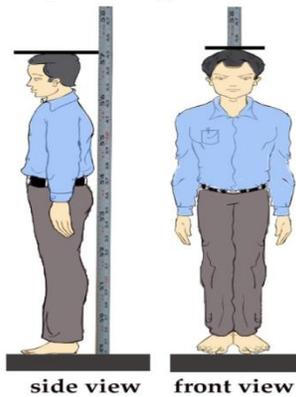


Photo no. 1. Height measurement.

**Stature:** It is the vertical distance between the point vertex and the floor.

**Technique:** The subject is made to stand in an erect posture and measurement is taken without any wear on head and foot. The subject should stand up against the wall, feet axis parallel or slightly divergent with head balanced on neck in F.H. (Frankfurt's horizontal) plane. Hands should hang down. If a wall is not available the subject should stand in an erect posture on a leveled floor.

Held the anthrop meter vertically in front of the subject exactly in mid-sagittal plane and by the right hand, movement of cross rod is controlled. No pressure should be exerted since this is a contact measurement. (Photo no.1)

**Foot Length:** Plantar aspect of the foot is called as sole so solar length which taken from the medial side of the foot as 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).(Photo no.2)

**Foot Breadth:** Plantar aspect of the foot is called as sole so solar breadth which taken from the dorsum of the foot as 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).(Photo no.3)



Photo No.2 Photo Showing the Technique Used For the Foot Length Measurement.



Photo No.3 Photo Showing the Technique used for the Foot Breadth Measurement.

## RESULTS AND DISCUSSION

Stature, foot length, foot breadth, of living male and female, cadaver of both sexes was measured. Parameters are analyzed using a standard computer programme and comparison was done as shown in (Table No. 1, 2, 3, 4). Linear regression equations were derived for the stature

estimation by foot length, foot breadth of male and female .It was compared with actual stature and estimated stature as shown in (Table No.5).There was difference in mean values of right and left foot length of male and female but there was no statistically significant difference. In females foot breadth of right and left foot showed statistically significant difference. (Table No.1)

**Table no. 1 -Male to male and female to female comparison.**

Sr. No	PARAMETER	MALE				FEMALE			
		FOOT LENGTH		FOOT BREADTH		FOOT LENGTH		FOOT BREADTH	
2	SIDE	Right	left	Right	left	Right	left	Right	left
3	SAMPLE SIZE	100	100	100	100	100	100	100	100
4	MINIMUM	22.2	22	8.5	8.2	20	19.5	7.3	7.2
5	MAXIMUM	28.4	28.3	10.7	10.7	24.5	24.4	10	10
6	MEAN	24.84	24.8	9.73	9.623	22.55	22.4	8.803	8.637
7	[SD]	1.256	1.271	0.510	0.522	1.001	1.066	0.573	0.556
8	(SEM)	0.126	0.127	0.051	0.052	0.100	0.107	0.057	0.056
9	DEGREE OF FREEDOM	198		198		198		198	
10	't' VALUE	0.403		1.467		0.985		2.081	
11	STATISTICALLY SIGNIFICANT OR NOT [YES OR NO]	NO		NO		NO		YES	
12	TWO TAILED P VALUE	0.6874		0.144		0.3258		0.0388	

As shown in Table No.2 there was a statistically highly significant difference in both the sexes between right and left foot length and breadth i.e. both the parameters showed clear cut sexual dimorphism. In our study we compared the parameters live male and female with male and female cadaver in (Table No .3) and (Table. No.4) respectively, but there was no statistically significant difference in foot length and foot breadth between right and left foot. It shows that we can consider either of the value in the medico legal cases for estimation of stature for identification of person in suspected cases.

**Table no. 2 - Male to female comparison.**

Sr. No	PARAMETER	FOOT LENGTH				FOOT BREADTH			
		Male	Female	Male	Female	Male	Female	Male	Female
2	SIDE	Right	Right	Left	Left	Right	Right	Left	Left
3	SAMPLE SIZE	100	100	100	100	100	100	100	100
4	MINIMUM	22.2	20	22	19.5	8.5	7.3	8.2	7.2
5	MAXIMUM	28.4	24.5	28.3	24.4	10.7	10	10.7	10
6	MEAN	24.84	22.55	24.76	22.41	9.73	8.8	9.623	8.637
7	[SD]	1.256	1.001	1.271	1.066	0.510	0.573	0.522	0.556
8	(SEM)	0.126	0.100	0.127	0.107	0.051	0.057	0.052	0.056
9	DEGREE OF FREEDOM	198		198		198		198	
10	't' VALUE	14.22		14.21		12.09		12.94	
11	STATISTICALLY SIGNIFICANT OR NOT [YES OR NO]	YES		YES		YES		YES	
12	TWO TAILED P VALUE	< 0.0001		< 0.0001		< 0.0001		< 0.0001	

As shown in (Table No.5).The correlation coefficient between stature and Left foot length was + 0.710 in male and + 0.670 in female which was most significant. It means there is a strong bond between stature and Left foot length and if either of the measurement (Left foot length or stature) is known, the other can be calculated and this would be useful for

Anthropologists and Forensic Medicine experts. Linear regression equations are given in (Table No.5).

**Table no. 3 -Male to male cadaver comparison.**

Sr. No		FOOT LENGTH				FOOT BREADTH			
		Male	Male Cadaver	Male	Male Cadaver	Male	Male Cadaver	Male	Male Cadaver
1	SEX	Male	Male Cadaver	Male	Male Cadaver	Male	Male Cadaver	Male	Male Cadaver
2	SIDE	Right	Right	Left	Left	Right	Right	Left	Left
3	SAMPLE SIZE	100	25	100	25	100	25	100	25
4	MINIMUM	22.2	22.4	22	22.6	8.5	8.6	8.2	8.5
5	MAXIMUM	28.4	26.4	28.3	26.2	10.7	10.5	10.7	10.3
6	MEAN	24.84	24.36	24.76	24.27	9.73	9.55	9.623	9.424
7	[SD]	1.256	0.940	1.271	0.884	0.510	0.543	0.522	0.514
8	(SEM)	0.126	0.188	0.127	0.177	0.051	0.109	0.052	0.103
9	DEGREE OF FREEDOM	123		123					
10	't' VALUE	1.773		1.826		1.541		1.711	
11	STATISTICALLY SIGNIFICANT OR NOT [YES OR NO]	NO		NO		NO		NO	
12	P VALUE	0.079		0.070		0.126		0.090	

**Table no. 4 -Female to female cadaver comparison.**

SR. NO		FOOT LENGTH				FOOT BREADTH			
		Female	Female Cadaver	Female	Female Cadaver	Female	Female Cadaver	Female	Female Cadaver
1	SEX	Female	Female Cadaver	Female	Female Cadaver	Female	Female Cadaver	Female	Female Cadaver
2	SIDE	Right	Right	Left	Left	Right	Right	Left	Left
3	SAMPLE SIZE	100	25	100	25	100	25	100	25
4	MINIMUM	20	20.4	19.5	20	7.3	7.9	7.2	7.9
5	MAXIMUM	24.5	24.5	24.4	24.4	10	10	10	10
6	MEAN	22.55	22.90	22.41	22.75	8.80	8.76	8.64	8.64
7	[SD]	1.001	0.969	1.066	0.994	0.573	0.565	0.556	0.558
8	(SEM)	0.100	0.194	0.107	0.199	0.057	0.113	0.056	0.112
9	DEGREE OF FREEDOM	123		123		123		123	
10	't' VALUE	1.583		1.462		0.305		0.024	
11	STATISTICALLY SIGNIFICANT OR NOT [YES OR NO]	NO		NO		NO		NO	
12	P' VALUE	0.116		0.146		0.761		0.981	

**Table no. 5 -Regression equation, actual stature and estimated stature comparison.**

Sr. No.	PARAMETRES	SEX	SIDE	REGRESSION EQUATION	SEE	CORREL-ATION COEFFICIENT	MEAN ACTUAL STATURE	ESTIMATED STATURE		
								MIN	MAX	MEAN
1	FOOT LENGTH	Male	Right	$S = 62.54 + 4.15 \text{ RFL}$	$\pm 5.30$	0.700	165.55	154.62	180.33	165.55
			left	$S = 62.44 + 4.16 \text{ LFL}$	$\pm 5.22$	0.710		154.04	180.27	165.55
		Female	Right	$S = 64.60 + 3.86 \text{ RFL}$	$\pm 4.44$	0.660	151.64	141.79	159.16	151.64
			left	$S = 69.29 + 3.68 \text{ LFL}$	$\pm 4.39$	0.670		140.95	158.96	151.64
2	FOOT BREADTH	Male	Right	$S = 94.08 + 7.35 \text{ RFB}$	$\pm 6.43$	0.510	165.55	156.51	172.68	165.55
			left	$S = 93.48 + 7.49 \text{ LFB}$	$\pm 6.33$	0.530		154.89	173.62	165.55
		Female	Right	$S = 119.50 + 3.65 \text{ RFB}$	$\pm 5.51$	0.360	151.64	146.15	156.01	151.64
			left	$S = 121.40 + 3.50 \text{ LFB}$	$\pm 5.56$	0.330		146.61	156.41	151.64

(RFL- right foot length, LFL- left foot length, RFB- right foot breadth, and LFB-left foot breadth)

It is also noticed that females of western part of Maharashtra exhibit a low

SEE ( $\pm 4 - 5.56$  cm.) and a relatively higher correlation coefficient between stature and

all the dimensions of foot than those observed in their male counterparts SEE(  $\pm$  5-6 cm.). It suggests that the accuracy in predicted stature would be greater among females than that of males.

Comparison of actual stature and stature estimated from measurements of foot using linear Regression equations. Minimum, maximum and mean values of the measurements were substituted in their respective regression equation and the estimated stature is calculated. Correlation coefficients of the length measurements are higher than that of breadth measurements in both the sexes.

Many other researches like Kewal Krishan, Tanuj Kanchan<sup>[7]</sup> among Gujjars, a North Indian study, worked on measurements of the foot length and foot breadth for the stature estimation, but in our study we considered cadavers of the both sexes for comparison. Values in our study correlates but differs from them may be due to variation in sample size, regional, racial variations.

## CONCLUSION AND RECOMMENDATIONS

The results of the present study show that the dimensions of feet can successfully be used for estimation of stature by law enforcement agencies and forensic scientists. The only precaution which must be taken into consideration is that these formulae are applicable to the population from which the data have been collected due to inherent population variations in these dimensions which may be attributed to genetic and environmental factors like climate, nutrition etc.

- Regression equation derived can be of help in artificial limb centers for construction of prosthesis required in cases of amputations following gangrene, trauma, frostbite etc.

- Regression equation derived for stature from other parameters can be utilized to calculate stature in patients suffering from spine disorders like kyphoscoliosis.
- The different formulae derived can be useful for corrective surgeries for leprosy patients.
- Regression equation derived for the stature of individuals can be applied to calculate stature and then body surface are in patients of burns.
- Correlation between various parameters can help in medico- legal cases for identification of body parts as well as for identification of in war casualties.
- This study is help to provide database for biometrics.
- The data collected can be utilized for future anthropological studies.
- Present study helpful for the sexual dimorphism in medico legal cases.

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