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Estimation of Stature, Age and Sex from Foot Dimensions in 18 To 20 Years of Age of Students in Maharashtra State, India.

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Keywords: Foot dimensions, foot length, foot width, foot girth, stature, correlation coefficient, regression equation, anthropology, sexual dimorphism.

ABSTRACT

The present study is based on measurement of foot length of 100 students of age group 18 to 20 years. Foot length (heel to tip of each digit), Foot width, foot girth at metatarsophalangeal joints and stature were the parameters. Collected data analyzed, standard deviation, co-relation coefficient, sexual dimorphism, regression formula and multiple regression equations were predicted. This would be useful for anthropologist and forensic, medicine, experts.

INTRODUCTION

Foot analysis have been done vigorously by various researchers mostly for the racial and ethnic variations in last half of 20th century. A number of studies have been reported until now for foot analysis technique.

Rutishauser [1] for the first time suggested that reliability of prediction of height from foot length was as high as that from long bone [2]. Foot dimensions deal with morphological features like size, shape, foot width, foot height and segmental length etc.

In modern science two aspects of human foot values drew attention for observation and analysis.

- Foot length and its proportion.
- Dermatoglyphic pattern.

MATERIALS AND METHODS

A total no. 100 subjects were considered for this study.

Sample, College Students between 18 to 20 years

Sample (a) 50 Females

Sample (b) 50 Males

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Informed consent was taken from the concerned authority and the children were briefed about the procedure for their co-operation. Those who had deformed foot and history of injury were eliminated from the study. The measurements were taken at a fixed time of the day to eliminate diurnal variations.

Foot length (HTL-heel to toe length) was measured by anatomical method. In this, subjects were asked to stand in anatomical position, on white paper. Edge of a metal ruler was placed at the tip of toes (touching the pulp and marked on the paper 2nd point was marked at the back of the heel on its most prominent point.

Foot length was measured by joining these two points at the level of each toe. Foot width (FW) was measured by taking the distance between most prominent point on the medial side (metatarsal tibialae) and the lateral side (metatarsal fibulae) using a vernier caliper[3] metatarsophalengeal joint girth (MPJG) of the foot was measured using a measuring tape [4].

Figure 1

Various Aspects of Foot Measurement.

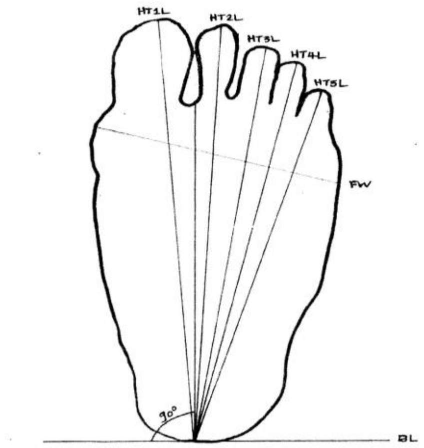
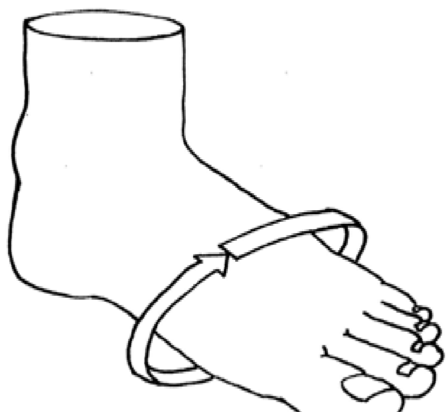


Figure 2

Metatarso phalangeal joint girth (MPJG).



Aims

To find out the relation between stature and foot dimensions in college students of Western Maharashtra.

Objectives

- Document the association between stature and foot measurements among 18 to 20 years.
- Formulate stature estimation equations from foot measurements in Western Maharashtra.

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- Find out sexual dimorphism in stature, foot measurements.
- Find out bilateral differences in foot measurements and its significance.
- Find out correlation between the variables.

Studying foot pattern and foot dimensions can reveal information regarding surgical and pathological conditions like talipes equinovarus, flat foot or varus metatarsal and other familiar or acquired anomalies [5]. Elaboration of such studies is found to be very useful to 'Criminologists'. [6]. It also plays a vital role in medical rehabilitation, sport sciences and foot wear design [7].

In this present study the mathematical method is utilized for stature estimation [8].

RESULTS

Table 1-A: Sample 1-a: Age group 18 to 20 years female.

Measurement	Mean		Standard deviation		Minimum		Maximum	
(in cm)	Left	Right	Left	Right	Left	Right	Left	Right
HT1L	23.724	23.915	0.9715	0.6638	21.9	21.8	25.7	25.2
HT2L	23.502	23.524	1.0559	0.7631	22.1	21.1	25.7	24.9
HT3L	22.844	22.652	0.8858	0.7877	20.0	19.8	24.5	23.9
HT4L	21.608	21.382	0.7912	1.0756	18.1	18.5	22.7	25
HT5L	20.428	19.712	0.9854	0.8932	16.6	16.6	22.2	21.3
FW	8.990	8.908	0.6238	0.6851	8.2	8.2	10.5	10.5
MPJG	22.526	22.126	1.5439	1.4473	20	20	25	25
STATURE	162.62		6.253		150		178	

Table 1-B: Sample 2-b: Age group 18 to 20 years male.

Measurement	Mean		Standard deviation		Minimum		Maximum	
(in cm)	Left	Right	Left	Right	Left	Right	Left	Right
HT1L	26.132	26.520	1.0352	1.1784	23.6	24.1	29	29
HT2L	25.850	25.842	1.1857	1.4786	22.9	23.2	28.5	29.4
HT3L	24.996	24.914	1.1199	1.3038	22.3	22.8	27.4	28.8
HT4L	23.670	23.310	0.9552	0.8872	21.4	21.5	25.6	24.9
HT5L	21.834	21.462	0.7233	0.7434	20.1	20.2	23.4	24.0
FW	9.840	9.866	0.4499	0.5659	8.5	8.6	10.7	10.9
MPJG	24.900	24.720	1.7985	1.6787	22	21	30	30
STATURE	173.38		6.385		159		188	

TABLE 2-A: Sample 1-a: Age group 18 to 20 years female.

Measurement (in cm)	Mean (Left-Right)	Standard deviation	't' value	Significance
HT1L	0.1880	0.6356	2.092	0.042*
HT2L	0.0220	0.7760	0.200	0.842
HT3L	-0.1920	0.5454	-2.489	0.016*
HT4L	-0.2260	0.9476	-1.686	0.098
HT5L	-0.7160	0.9239	-50480	0.000**
FW	0.021	0.810	-0.340	0.900
MPJG	-0.4000	0.8571	-3.300	0.002**

Table 2-B: Sample 2-b: Age group 18 to 20 years female.

Measurement (in cm)	Mean (Left-Right)	Standard deviation	't' value	Significance
HT1L	0.3880	0.6751	4.064	0.000**
HT2L	-0.0076	0.9948	-0.054	0.957
HT3L	-0.0820	0.8073	-0.718	0.476
HT4L	-0.3600	0.4920	-5.174	0.000**
HT5L	-0.3720	0.6363	-4.134	0.000**
FW	-0.0920	0.850	-1.542	0.135
MPJG	-0.1800	0.8254	-1.542	0.129

Females of 18 to 20 years age group showed significant bilateral differences in HTL of 3rd and 5th toes, left being longer. (Significancy level is 0.01). But I 1st toe, the right is longer and significancy level is 0.05. The MPJG is significantly more on left side. In males in the same age group bilateral differences are

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significant at the level of 0.01 in 1st, 4th and 5th toes. 1st is longer on right side while 4th and 5th are larger on left side.

Table 3-A: Sample 1-a: Age group 18 to 20 years female

Measurements (in cm)	Left foot/stature	Significance	Right foot / stature	Significance
HT1L	0.599	0.000**	0.679	0.000**
HT2L	0.561	0.000**	0.784	0.000**
HT3L	0.699	0.000**	0.642	0.000**
HT4L	0.496	0.000**	0.284	0.000**
HT5L	0.568	0.000**	0.489	0.000**
FW	0.523	0.000**	0.561	0.000**
MPJG	0.315	0.026*	0.477	0.000**

Table 3-B: Sample 2-b: Age group 18 to 20 years male

Measurements (in cm)	Left foot/stature	Significance	Right foot / stature	Significance
HT1L	0.837	0.000**	0.789	0.000**
HT2L	0.783	0.000**	0.622	0.000**
HT3L	0.824	0.000**	0.713	0.000**
HT4L	0.776	0.000**	0.725	0.000**
HT5L	0.784	0.000**	0.650	0.000**
FW	0.622	0.000**	0.671	0.000**
MPJG	0.529	0.026*	0.349	0.013**

In females of 18 to 20 years group correlation coefficients of all foot measurements and stature are statistically significant on both sides at the level of 0.01. Only MPJG on left side is significant at the level of 0.05.

In males of 18 to 20 years group correlation coefficients of all foot measurements and stature are statistically significant on both at the level of 0.01. Only MPJG on right side is significant at the level of 0.05.

Table 4-A: Sample 1-a: Age group 18 to 20 years female

Measurements (in cm)	Regression equation for left foot	Mean error	Regression equation for right foot	Mean error
HT1L	71.237+(3.852x HT1L)	5.061**	9.767+(6.392xHT1L)	4.640**
HT2L	84.565+(3.321xHT2L)	5.230**	11.525+(6.423xHT2L)	3.923**
HT3L	64.076+(4.314xHT3L)	5.001**	47.226+(5.094xHT3L)	4.845**
HT4L	77.988+(3.917xHT4L)	5.487**	127.372+(1.648xHT4L)	6.058**
HT5L	88.933+(3.607xHT5L)	5.198**	95.089+(3.426xHT5L)	5.509**
FW	115.461+(5.246 FWL)	1.233	116.969+(5.125xFWR)	1.090**
MPJG	133.865+(1.277xMPJG)	5.996*	117.027+(2.061xMPJG)	5.553**

Table 4-B: Sample 2-b: Age group 18 to 20 years male

Measurements (in cm)	Regression equation for left foot	Mean error	Regression equation for right foot	Mean error
HT1L	38.516+(5.161x HT1L)	3.533**	60.066+(4.273xHT1L)	3.968**
HT2L	64.347+(4.218xHT2L)	4.011**	103.974+(2.686xHT2L)	5.052**
HT3L	55.973+(4.697xHT3L)	3.657**	86.365+(3.493xHT3L)	4.522**
HT4L	50.665+(5.184xHT4L)	4.073**	51.822+(5.215xHT4L)	4.446**
HT5L	22.221+(6.923xHT5L)	4.003**	53.600+(5.581xHT5L)	4.904**
FW	86.546+(8.825 FWL)	1.604	98.722+(7.567 FWR)	1.208
MPJG	126.581+(1.879xMPJG)	5.473**	140.561+(1.328xMPJG)	6.046*

In, age group 18 to 20 years estimation of stature from FL and MPJG are highly significant in both the sexes.

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Table 5-A: Sample 1-a: Age group 18 to 20 years female

M equation:
1) Multiple regression equation for right foot:
Y = (15.189) + (1.311)x Foot width Rt + (0.193)x MPJGRF + (-0.131)x HT1LRF + (8.468)x HT2LRF + (-0.005)x HT3LRF +(-1.048)x HT4LRF + (-2.134)XHT5LRF
2(Multiple regression equation for left foot
Y=(52.374) + (2.193)x Foot width Lt + (1.063)x MPJGLF + (-4.191) xHT1LLF + (7.613) xHT2LL + (-2.677)xHT3LLF + (-3.676)x HT4LLF + (6.250) xHT5LLF

Table 5-B: Sample 2-b: Age group 18 to 20 years male

M equation:
1) Multiple regression equation for right foot:
Y = (29.427) + (2.860)x Foot width Rt + (0.068)x MPJGRF + (2.507)x HT1LRF + (0.773)x HT2LRF + (0.228)x HT3LRF +(-0.259)x HT4LRF + (1.459)xHT5LRF
2) Multiple regression equation for left foot
Y=(-14.511) + (4.797)x Foot width Lt + (0.190)x MPJGLF + (5.349) xHT1LLF + (-4.325) xHT2LL + (3.926)xHT3LLF + (-3.849)x HT4LLF + (4.623) xHT5LLF

In age group of 18 to 20 years female using right foot measurement percentage of dependency of these factor on estimated stature is 78%.

In age group of 18 to 20 years female using left foot measurements percentage of dependency of these factor on estimated stature is 62 %.

In age group of 18 to 20 years male using left foot measurements percentage of dependency of this factor on estimated stature is 86%.

In age group of 18 to 20 years male using left foot measurements percentage of dependency of this factor on estimated stature is 86%.

DISCUSSION

The estimation of stature from various long bones, head length and hand length has been attempted by many workers. However, foot dimensions have not frequently been used for this.

The present study uses mathematical method (division factors and regression analysis) in determination of stature from foot dimensions. The regression analysis gives better reliability of estimate in prediction of stature than the division factor method.

Given study deals with the correlation of total standing height with different foot measurements in students of western Maharashtra in 18 to 20 years of age group.

As seen in table no. 2-a & b in females HTL of 1st toe is statistically more significant on right side. While HTL of left 3rd and 5th toes and MPJG is more significant. In males HTL of right 1st toe is significant, while on left side the HTL of 4th and 5th toes is statistically more significant.

All dimensions are significantly more in males, indicating the presence of sexual dimorphism in these measurements. The significancy level being 0.001.

Correlation coefficient between stature and various foot dimensions are highly significant for all the parameters (table no.3-A & 3-B).

The regression equations for estimation of stature using different parameters are highly significant in this age group in both males and females. The significancy level being 0.001 for all the parameters(table no. 4-A & 4-B).

Multiple regression equations for estimation of stature using all parameters were derived. In (age for 18-20), the dependency of this equation in maximum. Again it is maximum in males of 18 to 20 years with left foot measurement (86%) (table no. 5-A & 5-B).

The mean estimated stature was calculated using regression equation. The mean actual stature is known. The difference was calculated as mean error (table no. 2-A & 2-B) The same is shown in tabulated form.

CONCLUSION

It is worthwhile to mention here that the present study is a pioneering study in forensic anthropology. The study has successfully reported the highly significant correlation between stature and foot dimensions in 18 to 20 years age group. Sexual dimorphisms as well as bilateral differences in various foot measurements are also seen. The present study has also observed that differences between male and female individuals with regards to foot dimensions are more pronounced than the differences within sexes.

There is a strong bond between height and foot dimensions particularly foot length and if either of the measurement (foot length or total height (is known), the other can be calculated. This would be useful for anthropologists and forensic experts.

ABBREVIATION

1. Height (H)
2. Weight (W)
3. Body mass index (BMI)
4. Foot width right (FWR)
5. Foot width left (FWL)
6. Metatarsophalangeal joint girth Right Foot (MPJGRF)
7. Metatarsophalangeal joint girth Left Foot (MPJGLF)
8. Heel to Great Toe Length of Right Foot (HT1LRF)
9. Heel to Second Toe Length of Right Foot (HT2LRF)
10. Heel to Third Toe Length of Right Foot (HT3LRF)
11. Heel to Fourth Toe Length of Right Foot (HT4LRF)
12. Heel to Fifth Toe Length of Right Foot (HT5LRF)
13. Heel to Great Toe Length of Right Foot (HT1LRF)
14. Heel to Second Toe Length of Right Foot (HT2LRF)
15. Heel to Third Toe Length of Right Foot (HT3LRF)
16. Heel to Fourth Toe Length of Right Foot (HT4LRF)
17. Heel to Fifth Toe Length of Right Foot (HT5LRF)

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