Estimation of Height From Footlength : A Scientific Study in the Urban Population of Uttar Pradesh

Medical Science

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ABSTRACT
The present study was done on 150 medical students between the age group of 21 to 30 yrs to find out the correlation of footlength to height and to find whether there were any sexual differences in the urban population of Uttar Pradesh. Anthropometric measurements were taken by standard methods and the data was analysed by SPSS software. A good correlation was found between footlength and height in all individuals which was statistically significant . The regression formula was found to be different in both male and female indicating sexual differences . This knowledge can be practically applied to estimate not only the stature of an individual in the living for evaluation of growth but can also be used to determine the height and sex of the individual when partial body parts are found .

INTRODUCTION

It is common knowledge that taller individuals have larger feet and shorter individuals have smaller feet . But stature is actually anatomically complex that includes dimensions of legs , pelvis, vertebral column and skull and each of these parts contribute to the height of an individual . However knowledge of any particular body part having some correlation to the height is advantageous when partial body parts are found or when roughly estimating the height in living individuals when incomplete data is available for example foot prints or hand prints . Many studies have been done where estimation of height is done from long bones **(1,11)** but this method is not always feasible in living individuals and also may not be very accurate. It was Kulthanan et al, Rutishauser (1968), Ozden et al and Philip et al who studied that reliability of prediction of height from foot length was as high as that from long bones **(2,3,4,5)** .Stature may also be specific in different races and ethnic groups . Our study mainly focused on the urban population of Uttar Pradesh in both males and females to find out the correlation between height and foot length and to find out whether there were any differences in both sexes.

MATERIAL AND METHODS

The present study was carried out in the department of anatomy and physiology in a medical college in Uttar Pradesh . A total of 150 subjects (75 males and 75 females) were included in the study . All the subjects were healthy individuals with no ailment or deformity in the age group of 21 to 30 years . The age group was chosen such due to the fact that stature attains its maximum at 21 years of age and senile changes start after 30yrs of age. The subjects were asked to report early in the morning after having a light breakfast . All measurements were taken at the same time of the day and by the same individual so as to avoid diurnal variation in height . All measurements were done by standard procedures in a well lighted room

Measurement of height

Height was measured on a stadiometer **(fig1)**. Subjects were made to stand straight with their feet together against the wall in a well lighted room and the measurements were done to the nearest millimeter . All measurements were done at the same time of the day to avoid diurnal variation in height **(6) .**

fig1
Measurement of footlength
For the measurement of foot length nails were trimmed and measurements were taken on ruled paper in standing position . The outline was marked as it is done for a shoe print . Measurements were taken for the proximal and distal points on the foot outline as under :

Proximal point: point of maximum curvature on the outline of heel.

Distal point : point of maximum curvature on the outline of great toe.

Procedure was explained to the subjects and they were given practice .Plain blank paper was spread and the subject stood on the paper in the erect but relaxed position avoiding undue pressure on the foot . For the proximal point ,curve of the heel was marked by a pencil with good sharp tip holding it at right angles to the heel . The point of maximum convexity was marked as the proximal point . Distal point was considered on the great toe only not taking account of the other digits . Curve of the great toe was marked with pencil similar to the proximal point . Midpoint of the curve was taken as the distal point . Distance between the proximal and distal points was measured with a ruler **(fig2).** Ruler used for measurements was the same for all the measurements .
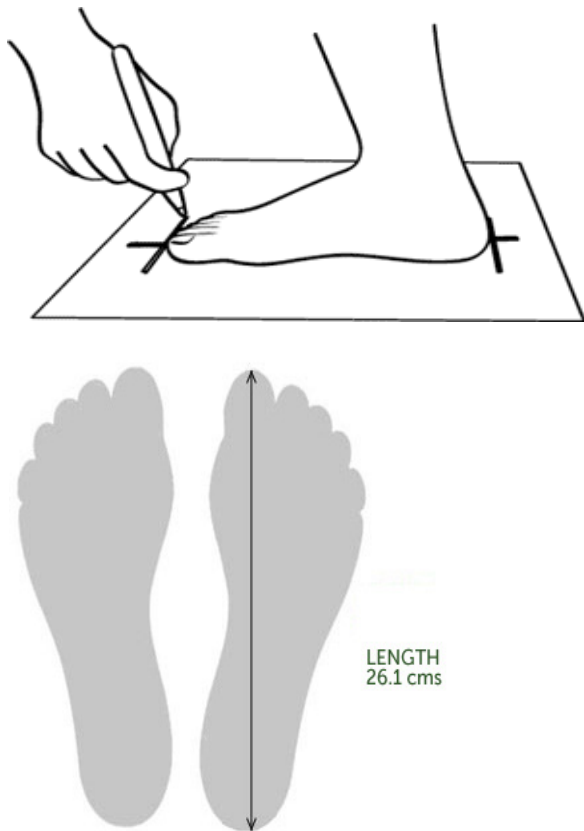
Fig 2

The data so obtained were analysed and subjected to statistical analysis using statistical package for social science (SPSS) software to know the correlation of the height from length of feet and simple linear regression formulae were derived for various combinations . The reliability of estimation of height was determined with the help of standard error of estimation (SEE). Sexual differences were evaluated using the "t" test.

OBSERVATIONS
The present study focused on the estimation of height from the foot length and to find whether there were any sexual differences . In order to measure the height of the individual , simple linear regression equation was derived . The SEE predicts the deviations of estimated height from the actual height .

Sexual differences in the studied parameters were assessed using the standard "t" test .

Table 1 shows that both the height and foot length were more in males in comparision to females which was found to be highly significant (p >0.001)

	Mean +/- SD		t-test	p value
	Male	Female		
Height	170.9365+/-8.43756	157.9351+/-6.617557	10.5	P = 0001
RFL	26.02267+/-1.645023	23.264+/-1.35164	11.221	P=0001
LFL	26.02+/-1.687794	23.30533+/-1.313742	10.992	P = 0001

Table 1 : Sexual differences in foot length

Table 2 illustrates the correlation coefficients between stature and dimensions of feet on left and right sides in

both the sexes. All the measurements exhibit statistically significant correlation with stature (p < 0.01). Correlation coefficients of the foot length measurements are higher in males bilaterally. The highest correlation is exhibited by left foot (r = 0.718). Tables 2 also list the regression coefficients for estimation of stature from measurements of feet of both sexes separately and together. The best correlation with stature is demonstrated by left foot length in all subjects.

	Male	Female	Both gender together
Total number	75	75	150
Height range(cm)	168.988-172.8851	156.4068-159.4633	161.5645-163.6899
Mean height(cm)	170.9365	157.9351	163.6899
S.D. of height	8.43756	6.617557	13.01548
Left foot length range(cm)	25.63022-26.40978	23.00194-23.60873	24.32567-24.98633
Mean left foot length(cm)	26.02	23.30533	24.656
S.D. of left foot length.	1.687794	1.313742	2.022839
Correlation coefficient(r) (foot left length and height)	0.868596**	0.718672**	0.73464**
Regression coefficient(b)	4.342254	3.620080615	4.726855
Value of constant(a)	57.95	73.594	47.141
Right foot length range(cm)	25.64277-26.40257	22.95185-23.57615	24.30777-24.97223
Mean right foot length(cm)	26.02267	23.264	24.64
S.D. of right foot length.	1.645023	1.35164	2.034468
Correlation coefficient(r) (foot right length and height)	0.876713**	0.700045**	0.746881**
Regression coefficient(b)	4.49677	3.427384	4.778163

** Correlation is significant at the .01 level (two-tailed) Table2

Table 3 exhibits standard error of estimate (SEE) along with linear regression equations for foot length in male and female subjects. It ranges from 0.97428 for males, 0.76413 for females. Estimation of height from foot length of female subjects' exhibits lower values of standard error of estimate than from foot length of male subjects. It means the reliability of estimation of stature from foot length of female subjects is more than male subjects.

Sr. No.	Sex	Regression equations	S.E.E	Value of r
1.	Male	y=170.93655+.173748* Mean of foot length	.97428	0.754
2.	Female	y=157.9351+.14267* Mean of foot length	.76413	0.691

Table 3: Estimation of Stature

DISCUSSION

Various studies have been conducted on the estimation of stature from the human skeleton. There are various methods to estimate stature from the bones but the easiest and the reliable method is by regression analysis [7, 8].

Studies using hands and feet measurement for stature estimation are scarce. These studies indicate that the bilateral variation was insignificant for all the measurements in both the sexes. Robbins who was one of the pioneers in this kind of study also did not find significant bilateral asymmetry in various measurements of the feet of a U.S. sample.

Similar views are expressed by Philip that either of the feet can be used for the estimation of stature as no significant asymmetry was observed by him while working on the footprints of a South Indian population [5]. The present study similarly did not find any bilateral asymmetry in measurements of foot length in an individual.

The present study shows sex differences to be highly significant for all the measurements (p < 0.001) which are in line with studies of Sharma et al [8]. In the present study, the significant differences in stature and foot measurements between males and females can be attributed to the fact that fusion of epiphyses of bones occurs earlier in girls in comparison to boys. In other words, boys have about two more years of bony growth than girls, which were expressed in male surpass of the somatometric measurements of the adult. [9].

The correlation coefficients between stature and all the measurements of feet were found to be positive and statistically significant and the right foot length in subjects of both the genders together exhibits the overall highest value of correlation (r =0.746) with stature followed by length of left foot in females. The correlation coefficients between stature and foot dimensions were found to be highly significant. Similar results were observed by Kanchan et al in North Indian endogamous group [9]. It was observed that the foot length in males and females show highest correlation with stature and minimum standard error in estimation of stature.

CONCLUSION

It is concluded that the foot length in males and females show highest correlation with stature and minimum standard error in estimation of stature. So the foot length provided the highest reliability and accuracy in estimating stature. The left foot length gives better prediction of stature than the right foot .The prediction of height is better in case of females in comparision to males .

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