

Original Research**Correlation of Foot Length with Height in Population of Eastern Part of India**

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Abstract**Background:** Estimation of body height from its segments is very important both in anatomical and medico-legal purposes. Stature is very important criteria for personal identification.**Methods:** Present study was carried out for estimation of stature from the length of total 400 adults, out of which 200 were males and 200 were females in a campus of tertiary care teaching hospital at Kishanganj, Bihar. Standard measuring instruments were used for everyone. Their body height and foot lengths were measured. Foot length was defined as a straight distance from the most distal part of the great toe or second toe which one is longer. Data analysed and a good correlation was observed and it was statistically highly significant ($p < .001$).**Results:** Stature varied from 147 cm to 185 cm with SD of 9.47 cm in males. Mean of length in males were 163.1725 cm. In female varied from 140 cm to 169 cm with SD of 5.529. Mean value of stature in female participants was 151.08 cm. The difference in mean stature between males and females was extremely statistically significant ($p < 0.0001$). Mean foot length among males was 24.50 with SD of 1.297. Foot length in males was varied between 21.5cm to 27.7cm. In females ranges of foot length was from 18.7cm to 25.9cm.

Mean foot length in females was 22.08 with SD of 1.271. The difference in mean foot length between males and females was extremely statistically significant ($p < 0.0001$). There was no statistical difference in males and females of right and left foot. So right foot length was used in both subjects for further calculations.

Conclusion: Correlation Coefficient between body height, both right and left foot lengths in both the genders and combined data were found to be statistically significant ($p < 0.001$) and positive indicating a strong relationship between parameters.

It was concluded that estimation of stature among the population can be carried out using foot length. It will be helpful for Anatomists, Anthropologists and forensic experts to calculate stature based on foot length.

Keywords- Foot length, Body height, Correlation Coefficient, Anthropometry.

Introduction

Stature is the height of the person in the upright posture. It is an important measure of physical identity. Anthropometry as adopted by medical scientist is described as a technique of expressing the form of human body quantitatively as it is the systematic collection and correlation of measurement of the human body.¹

Anatomical parameter of human body such as stature and size of some part of it like foot length have been thoroughly studied in various purpose. Dimensional relationships between the body segments and the whole body have been of interest to artists, scientists, anatomists, anthropologists and medico-logistics for long time. Examination of skeletal remains recovered from a scene of crime, have often been used by the forensic anthropologists to extract relevant information about the victim. One such aspect pertains to reconstruction of living stature from such skeletal remains.^[2-7] Personal identification from foot and its segments becomes more important in cases of mass disasters. Assessing the height of an individual, from measurements of different parts, has always been of immense interest to the anatomists, anthropologists and forensic medicine experts.⁸

The rise of criminal activities in our societies is fact. The study can help the criminologists work, search for many lost persons and unidentified dead bodies. Length estimation becomes equally important along with other parameters like age, sex, race etc. According to the modern forensic studies basic anthropological dimension is not impressive. But simple foot length as criminological evidence can easing the measuring

the height of a person. Height of a person which itself is a sum of the length of certain bones and appendages of the body.⁹

Ossification and maturation of foot occurs earlier than the long bones and therefore during adolescences so height is variable as compared to adult. A tall person needs long foot to support of the body and balance. Height and foot size are based on many factors such as genetics, gender, health and environment. Foot size may be used in forensic study to measure the height of a person whose body is no longer intact.⁴

Various studies in past have been undertaken to study the relation between height of a person and various body parts but not much has been done to have it from the foot length. Therefore purpose of the present study is to study the anthropometric relationship between foot length and body height in normal young adults and its sexual dimorphism.

Material and Methods

Present study included total 400 asymmetric healthy peoples out of which 200 are males and 200 are females of between 20 to 70 years in Eastern part of India. Ethical clearance was obtained from the IEC [Institute Ethics Committee] before starting the study. Informed consent of participants was taken and socio-demographic indices like age and sex was noted. Each study subject was studied for the measurements of stature and foot length. The measurements were taken by using standard anthropometric instruments. Left foot length was selected for measurement as per recommendation of the international agreement for paired measurements at Geneva (1912).



Figure 1 a, b: Height measurement by using standard anthropometric instruments

Foot length was measured as a direct distance from the most prominent point of the back of the heel to the tip of the great toe or tip of the second toe which one is longer. Foot length for the both sides was measured as the distance from the most prominent part of the heel backward to the most distal part of the longest toe (2nd or 1st).

Instrument: Vernier caliper

Technique: The measurement was made on the standing subject, his right leg being slightly bent and drawn backward so that the body rested mainly on the left foot, which one was to be measured. The caliper was horizontally placed along the medial border of the foot. The fixed part of the outer jaw of the caliper was applied to the pternion and the mobile part of the outer jaw was approximated to the acropodian and measurements were taken. In the same way, the measurements were taken on the other side.

Height of the individual was measured in standing erect in anatomical position with standard height measuring instrument. The height of the individual was measured between the vertex and floor, with the person standing erect, in anatomical position and the head in the Frankfort plane, using a standing height measuring instrument.

Measurements were recorded in centimeters to the nearest millimeter using standard anthropometrical instrument. All measurements were recorded by the same person in order to avoid inter-

observer bias employed. Subjects having any disease, deformity, injury, fracture, amputation or record of any surgical procedures of either and or foot were disqualified from the study. The measurements were taken by only one observer in order to avoid inter-observer error. Measurements were taken at fixed time between 2 pm to 5 pm to avoid diurnal variations. The measurements were taken three times and their mean value was considered.

Results

Total 400 peoples were included in this study out of which 200 (50%) were males and 200 (50%) were females. Male: Female ratio of the population being 1:1. Ranges of age for study were from 20 to 70 years. Mean age of males 45.295 with standard deviation (SD) 14.365, whereas mean age of female was 43.67 with SD of 12.294. This difference in age was considered to be not statistically significant with $p=0.2249$.

Table 1: Distribution of subjects according to age group and gender

Age group	Male	Female
20-30	38	28
31-40	43	63
41-50	40	59
51-60	47	29
61-70	32	21

Stature varied from 147 cm to 185 cm with SD of 9.47 cm in males. Mean of length in males were 163.1725 cm. In female varied from 140 cm to

169 cm with SD of 5.529. Mean value of stature in female participants was 151.08 cm. The difference in mean stature between males and females was extremely statistically significant ($p < 0.0001$). Mean foot length among males was 24.50 with SD of 1.297. Foot length in males was varied between 21.5cm to 27.7cm. In females ranges of foot length was from 18.7cm to 25.9cm.

Mean foot length in females was 22.08 with SD of 1.271. The difference in mean foot length between males and females was extremely statistically significant ($p < 0.0001$). There was no statistical difference in males and females of right and left foot. So right foot length was used in both subjects for further calculations.

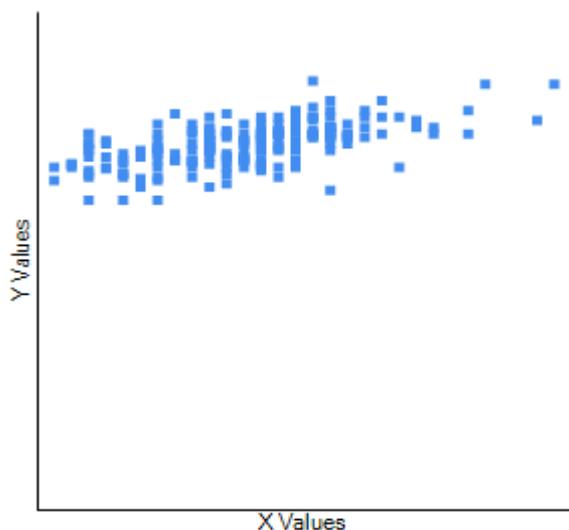
Table 2: Mean± Standard values of Body Height, Foot Length & Knee Height in both Males and Females

Variables	Male [mean ± SD]	Female [mean ± SD]	P value
Height [CMs]	163.1725±9.47	151.08±5.529	<0.0001
Rt foot length [CMs]	24.50±1.297	22.08 ±1.271	<0.0001
Lt foot length [CMs]	24.49±1.291*	22.09 ±1.272**	<0.0001

[* P=0.9384 when we compared length of foot on right and left leg among males and the difference is considered to be not statistically significant. **P=0.9374 when we compared length of foot on right and left leg among females and the difference is considered to be not statistically significant].

Correlation of height with foot length among females:

The value of R is 0.5921. This is a moderate positive correlation, which means there is a tendency for high X variable scores [height in cm] go with high Y variable scores [foot length in cm] (and vice versa).

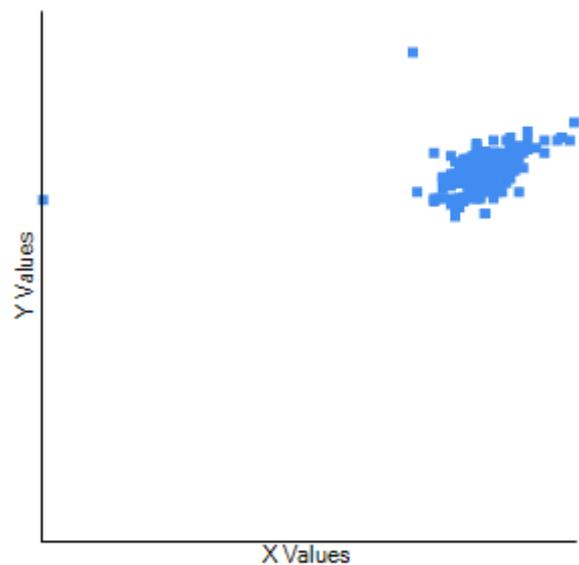


[Tendency for high X variable scores (height in cm) go with high Y variable scores (foot length in cm)]

Figure 2: Positive correlation among height and foot length in female participants

Correlation of height with foot length among males:

The value of R is 0.3549. Although technically a positive correlation, the relationship between your variables is weak (nb. the nearer the value is to zero, the weaker the relationship).



[X variable scores (height in cm) go with Y variable scores (foot length in cm)]

Figure 3: Positive weak correlation among height and foot length in male participants

Discussion

The conducted study is a cross sectional descriptive study and performed in the year 2013-14 in Department of Anatomy, MGM Medical College, Kishanganj as per the study design. Measurement by standard anthropometric

instruments of stature and foot length were taken of two hundred young and healthy subjects (200 males and 200 females), in the 20 to 70 years age group.

Estimation of stature from foot length is interest for forensic experts for identification. Data derived from all adult people cannot be used for all types of population. So we can used for height measurement among adult. In this study mean values of stature are greater in males than females with statistically significant difference. There was no significant bilateral difference for foot length in both subjects.

Correlation Coefficient between body height, both right and left foot lengths in both the genders and combined data were found to be statistically significant ($p < 0.001$) and positive indicating a strong relationship between parameters.

Study by Pandey N (2014)⁹ revealed that the mean stature of male was found to be 172.24 ± 5.87 cm and that among female was 158.09 ± 6.31 cm. The difference in stature between two genders was found to be statistically significant (p value < 0.001). Our findings were also same as the observations of Pandey N study. These findings are in line to the study conducted by H. Ozdan et al (2005) in Turkish population, Sanli et al (2005)¹⁰ and Krishan and Sharma (2007) amongst North Indian population (Rajputs), in which foot length and foot breadth on both sides were statistically significantly greater in males when compared to females. The difference in right and left foot length among males were found to be statistically insignificant.

Male stature was found to be significantly correlated with right foot length ($r=0.451$, $p<0.001$) and left foot length ($r=0.452$, $p<0.001$). Similar statistically significant correlation was seen between stature and right ($r=0.421$) and left ($r=0.506$) foot dimensions of females. Our finding replicates the finding of the study conducted by Krishan and Sharma (2007)¹¹ in the North Indian population (Rajputs) which found that bilateral hand and foot length in both male and females exhibit statistically significant correlation

coefficient with stature. Our finding also replicates the finding of study conducted above, in which the statistically significant correlation was found between stature of both sex and their foot length.

Qamra et al (1979)¹² studied on height and foot length in northwest Indian population and derived a regression equation concluding and strongly positive correlation with correlation coefficient of 0.69 for males and 0.70 for females.

Similar conclusion was drawn by Patel SM et al (2007)¹³ and Mansur DI et. al (2012)¹⁴ that if either of the measurement (foot length or total height) is known the other can be calculated and this fact may be of practical use in Medico-legal investigations and in Anthropometry. In our study correlation coefficient between height and foot length is 0.35 for male and 0.59 for female. It means there is a strong relation between height and foot length and foot length if either of the length is known the other can be calculated for anthropological and forensic study.

Study by Utsav Parekh (2014)¹⁵ revealed mean values of stature are greater for Males than Female with statistically significant difference. Mean values of foot length are greater for Males than Females with statistically significant difference. There was no statistically significant bilateral difference for foot length in both subjects.

There is a difference between correlation coefficient of males and females as in other previous studies, which sought for the need of gender specific regression equation. The correlation coefficient of the present study for both sexes is not in accordance with the correlation coefficient of the similar studies conducted in the other regions, which highlights the need for population specific regression equation.

Conclusion

Correlation Coefficient between body height, both right and left foot lengths in both the genders and combined data were found to be statistically significant ($p < 0.001$) and positive indicating a

strong relationship between parameters. This study found that foot measurements can be used to calculate stature with reasonable accuracy using statistical considerations and it is revealed that a single dimension can estimate the stature of a person with a great accuracy and small standard error. Sexual dimorphism with female consistently having smaller stature, lesser body weight and smaller foot length compared to their male counterparts was also found. Our findings suggest that the relationship between stature and foot length is of practical use for anatomists, medicolegal, anthropology, archaeological and other related studies.

It was concluded that the estimation of stature among the population can be carried out using foot length and there is positive correlation between stature and foot length in a particular population.

Thus, the present study suggests the height to be the best body height indicator for estimation of body height according to gender including age as a predictor variable in order to reduce the inherent problem of sample specificity and enhance accuracy confidence in the estimation.

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