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Original Research Article

ESTABLISHING THE CORRELATION BETWEEN FOOT LENGTH AND HEIGHT – REGRESSION ANALYSIS STUDY IN PUNE REGION

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ABSTRACT

Introduction: Evaluation of height from multiple long bones is done by several researchers with variable degree of success. Limited literature exists on establishing the correlation between foot length (FL) and height (Ht). The present study was implemented to find out percentage ratio of FL to Ht and to assess the relationship between foot length and height through regression analysis method.

Materials and Methods: An observational anthropometric study was done on healthy 500 male and female students with age bracket of 18 to 23 years. Foot length and height measurements were done by appropriate instruments and same expert to avoid observer bias. SPSS (Version 12) software was used for data analysis and correlation coefficients. Multiple regression correlation analysis methods were used to evaluate statistical differences.

Results: The mean FL was significantly higher in all age groups of males than that of females ($p < 0.001$). The correlation coefficient 'r' was statistically significant for majority of age groups ($p < 0.01$). There was positive correlation between foot length and height and in the study reliable regressive equation was derived.

Conclusions: The study reported statistically significant correlation between foot length and height of individuals. The regression equation derived in the study can be utilized effectively for estimation of height in a diverse population group and it would be very useful for personal identification in forensic medicine field and anthropology.

KEY WORDS: Correlation, Foot Length, Height, Regression Analysis.

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INTRODUCTION

Growth is an essential process which is estimated by the height of an individual. It embodies the sum of the length of specific bones and appendages of the body, representing certain relationship with form of proportions to the total stature [1].

Such relationship is crucial to evaluate the racial differences, especially in forensic field. Assessment of height from several long bones

has been done by various experts with variable degree of success. Numerous challenges to take precise measurements of long bones have been perceived by many researchers. One of the anthropometric studies showed that correct dimensions of length of femur could not be taken due to variable position on angle of neck with shaft of femur [2]. Ashizawa attempted to establish the association between foot length and general body size [3]. In one of the morphometric studies, authors estimated height from different metacarpals among study participants and observed significant correlation in both gender [4].

However, there is limited published data on use of foot dimensions for similar purpose. Very few studies have been conducted so far which proved high reliability of foot length in prediction of height compared to long bones [5].

Ossification as well as maturation in the foot ensues earlier than the long bones and therefore, during adolescence age, height could be more accurately predicted from foot measurements as compared to that of long bones [1].

The current study was undertaken to establish relationship between foot length and height through regression analysis method. An attempt was also made to estimate the percentage ratio of foot length to height. The emerging results would create anthropometric database which can be utilized in forensic medicine and other relevant areas.

MATERIALS AND METHODS

Study population and sampling procedure: This was an observational study in which 500 students belonging to age group 18-23 years were included as study subjects. Both genders were taken as subjects. They were free from history of major trauma or illness. The study was approved by local institutional ethics committee and all procedures were conducted as per ethical standards. A written informed consent was obtained from the study subjects after explaining the purpose of the study.

Measurements: Foot length (FL) was measured by 'first segment of Anthropometer Rod'. FL was the distance between acropodian and pternion of the same foot. Acropodian was the most distally placed point on the toecap of first or second toe whichever is longer. Pternion was taken as the hindmost point on the heel. Both the lengths of right and left foot were measured. Standard height measuring instrument was used to estimate the height (Ht) of subject. The subject was in erect posture without shoes with back and hips touching the wall. Examiner stood on the left side of the subject. The height of subject was the vertical distance between vertex to floor. All measurements were taken by same examiner to avoid observer variations. All subjects were examined between 2-30 p.m. and 4-30 p.m. to avoid diurnal variations.

Statistical analysis

The data evaluation was performed using SPSS Version 12.0 (SPSS Inc. USA). Mean and Standard deviation (SD) of all observations were calculated. P value less than 0.05 was considered to be statistically significant. The significant differences were determined by correlation coefficients, multiple regression correlation analysis methods.

RESULTS

Table 1 delineates the mean foot length (FL) of male and female subjects. It was clearly seen that mean FL was significantly higher in all age groups of males than that of females ($p < 0.001$).

In the current study, the percentage ratio of foot-length to height was also significantly higher in males of age group 21-22 than that of females of the same age group. However, in other age groups (18 to 20 and 22-23) the difference between ratios was not significant statistically (Table 2).

Correlation regression analysis revealed that, in males and females both, the correlation coefficient 'r' was statistically significant for majority of age groups ($p < 0.01$). This indicated that there was positive correlation between foot length and height (Figure 1). So, linear regression coefficients were found out, which again were statistically highly significant ($p < 0.01$). However, In the age group of 20-21 of males and 22- 23 of males & females; the correlation coefficient and regression coefficient were not statistically significant. So, the regression equation could not be given a good fit for these age groups.

Table 1: Distribution of Mean Foot-Length in Study Subjects (n=500).

Age Group	Males			Females			't' value	'p' value
	Number	Mean	SD	Number	Mean	SD		
18 - 19	43	26.84	1.586	113	24.299	1.771	8.232	0
19 - 20	68	26.819	1.888	55	24.42	1.866	7.941	0
20 - 21	84	26.525	1.89	55	24.231	1.844	7.008	0
21 - 22	43	27.241	1.628	17	23.311	2.019	7.862	0
22 - 23	6	26.725	1.679	16	24.437	1.023	3.913	0.001

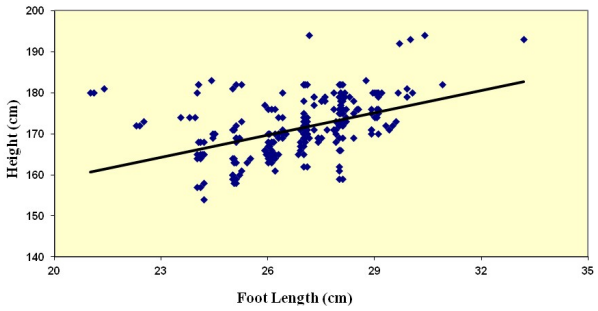
SD – Standard Deviation, p< 0.05 was considered as statistically significant

Table 2: Percentage Ratio of Foot-Length to Height in Study Subjects (n=500).

Age Group	Percentage Ratio			
	Males	Females	't' value	'p' value
18 - 19	15.6852	15.3474	1.961	0.052
19 - 20	15.5874	15.4285	0.886	0.377
20 - 21	16.2901	15.333	0.91	0.364
21 - 22	15.8319	14.9713	3.195	0.002
22 - 23	15.9774	15.5079	1.375	0.184

P < 0.05 was considered as statistically significant

Fig. 1: Correlation Between Foot Length and Height in Male Subject.



It was concluded that the foot length can be estimated from height. It could be estimated by formula FL = b X Ht + constant, for adult males: FL = 0.044 X Height + 19.286 and for adult females FL = 0.149 X Height + 0.765.

DISCUSSION

The present study reported observations on correlation of foot length (FL) with total standing height (Ht) in male and female students of Pune. There was significant relationship between FL and Ht which was reflected through positive correlation coefficient (Figure 1). This finding was in agreement with multiple studies. Charnalia VM revealed positive correlation between FL and Ht. [6] in another study conducted in Mumbai, the significant association was also observed between these two variables. [2]

Use of regression models have been proved to be very useful in forensic investigations. An assessment of height is one of the basic domains in investigation procedure, particularly, in case of unknown and co-mingled human remains [7]. Regression equations are found to be beneficial to establish the relationship between stature and foot dimensions. This could help to ensure the personal identity of person. Limited studies have been implemented to generate such regression models across India.

In this study, an attempt was made to devise new regression formula which could assist in estimation of height from foot length. In this study, the correlation coefficient between Ht and FL was 0.358 and 0.185 (18-19 years), 0.103 and 0.403 (19-20 years) and 0.238 and 0.236 (21- 22 years) in male and female subjects respectively. It can be concluded that, there was a strong correlation between Ht and FL and if one of the dimensions is known, the other can be easily estimated and this could be effectively utilized by forensic professionals and anthropologists. However, for other age groups (20-21 and 22-23), correlation coefficient and regression coefficient were statistically not significant. Qamra et al. also obtained a regression equation between FL and Ht in North West India population [8]. In another anthropometric study, 3000 English criminals were investigated and regression formulae were derived for evaluation of stature from foot length [166.457 + 4.031 (foot 25.688) ± 2.9 cms] [9]. To the best of our knowledge, no study has been conducted so far in Pune which deals with the findings on correlation of height with foot length.

In this study, the mean foot length was significantly higher in all age groups in male subjects as compared to females (Table 1). Similar pattern of sexual dimorphism was also seen in studies of Khan M et al [10]. and Numan et al [11]. Some experts speculated that low height in females comparing to males, due to

oestrogen influence can affect the proliferative capacity of chondrocytes [12].

Ciliary neurotrophic factor (CNTF) is a substance which hinders bone formation and plays a sex specific role in bone growth and remodelling. In males, CNTF enhances both limb height and torso height whereas in females, it decreases the number of trabeculae and affect torso height. So various responses to CNTF could explain height differences between two genders [12]. The height variation between males and females could be attributed to genetic and environmental factors.

In the present study, even though, the percentage ratio of FL to Ht was reported to be more in males as compared to females; no statistical association was observed between them except for the age group 21-22 which revealed statistically significant correlation ($P<0.05$) (Table 2).

The present study had many strengths. First, very scarce published data is available on this research, especially in Pune region of Maharashtra State. Second, all interviews and measurements were carried out by single examiner, which provided uniformity in data gathering. However, the restricted sample size was the major limitation of this study. This was a pilot study and final results can be retrieved only after complete study including significant number of subjects in the study.

CONCLUSION

The current study revealed statistically significant correlation between foot length and height of individuals. The regression equation derived in the study can be utilized effectively for estimation of height in a diverse population group and it is of immense value in the field of personal identification particularly for mutilated bodies as well as fragmentary remains.

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Conflicts of Interests: **None**

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