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Stature Estimation from the Dimensions of Foot in Females

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Introduction

Stature reconstruction is important as it provides a forensic anthropological estimate of the height of a person in the living state – playing a vital role in identification of individual. Height estimation by measurement of various long bones has been attempted by several workers with variable degree of success. Each worker has derived his own formula for calculating the stature from long bones. However, foot measurement has not frequently been used for this.

Studies on the estimation of stature from the skeletal remains or from the mutilated limbs, mostly of the long bones have been reported as indicated by the published work of the Pearson (1899), Trotter and Glesser (1952). The Indian perspective of the problem of stature estimation has been studied by the Athwale et al (1963), Patel et al (1964), Joshi et al (1964,65), Lal and Lala (1972), Kalte and Bansal (1974), Thakur and Rai (1987), Saxena (1984), Bhatnagar et al (1984), Jasuja (1987). Also there are few studies in which stature is estimated from inferior extremity length and foot length. (Agnihotri A.K. et al(2007), Ozden H et al(2005), Sangli S.G. et al (2005), Oommen A. et al (2005), Krishnan K.(2007), Patel et al (2007).

It were 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(Kulthanan T et.al2004.Rutihauser IH. 1968. Ozden H, et. al2005. Philip TA. 1989). Ossification and maturation in the foot occurs earlier than the long bones and therefore, during adolescence age, height could be more accurately predicted from foot measurement as compared to that from long bones. Present study was, therefore, conducted to find out correlation between foot length and body height and evaluate the reliability of estimation of height from foot length.

Material and Methods

The study subjects comprised of 250 females in the age group 18-23 years selected from various visitors to Lady Hardinge Medical College and Asst. Hospital, New Delhi since the maximum height of an individual is attained by this age. Cases having any significant disease, orthopaedic deformity, metabolic or developmental disorders which could have affected the general or bony growth were not included in this study. All the measurements were recorded to the nearest centimetre using standardized anthropometric measuring equipment; Stadiometer and Sliding Calipers. The data was tabulated, analyzed and subjected to statistical calculations using Spss.

Stature: Using the Stadiometer, the subject was made to stand barefoot in the standard standing position on its baseboard.

Foot Length: From tip of toe to heel on the medial side using a standard Sliding Callipers (Position: Standing).

Foot Width: From base of 1st to 5th metatarsal using standard Sliding Callipers (Position: Standing)

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Results

In females, stature varied from 150.0 cm to 183.5 cm with mean values of 156.48 cm and standard deviation of 5.38 cm and standard error is 0.340. Variation in dimensions of foot length and foot breadth in females is given in Tables 1.

Table 2 illustrates the correlation coefficients between stature and foot dimensions of feet on left and right sides in females. All the measurements exhibit statistically significant correlation with stature ($p < 0.01$). Correlation coefficients of the foot length measurements are higher in comparison to foot breath in females. Table 3. Illustrate the Simple and multiple regression equations to estimate stature from foot length and foot breadth.

Discussion

The present study was conducted in 250 female volunteers, in the age group 18-23 years for the prediction of stature from foot measurements. The prediction can be of special importance in conditions where whole body is not available for identification. No significant difference was found in either left or right side measurements. The values of mean and standard deviation of height in female subjects (in cm) were 156.48+/- 5.38. When we compare our study of females to that of Ozaslan's, we find the mean height and SD to be lesser by 5.4 cm +/- 0.2 cm, mean foot length and SD more by 0.7cm +/- 0.2 cm, mean Foot Breadth more by 0.1cm, SD of Foot Breadth lesser by 0.2 cm. Such a difference was not seen in other measurements ($p > 0.05$). When we compare study of Kanchan and Moudgil (2008) with our study, we find that the effect of bilateral variation on stature was insignificant and sex differences were found to be highly significant for all the measurements, a finding common in both the studies. The study done by Jitender et.al (2010) had shown that the reliability of stature estimation from foot length in female subjects is more than male subjects, whereas in our study reliability for stature estimation from foot length is lesser for female subjects. In both studies a good correlation of height with foot length was observed. (41) The lesser SD in our study in female height was possibly due to the reason that most of the females belong to Northern part of country. No study was available on Indian females to compare our result. The lesser height in females may be due to the fact that fusion of bones occurred earlier as compared to males who have more time for bone growth. Works of Giles et al., Robbins and Quamra et al. has been conducted in the area of making height estimations from foot and shoe measurements by means of a statistical method (Giles,E et al, 1991, Robbins L.M 1986, Quamra S R, et .al 1986). Singh and Phookan saw differences in their studies on the connection between foot measurement and height in relation to ethnic group, with the correlation coefficient between foot length and height in different groups being 0.63 and 0.92, the connection between foot width and height 0.51 and 0.65, proving height estimation by foot length measurement gives better results than height estimation by foot width measurement This study, the connection between height and foot width in female, the right side as ($r = 0.101$, $p > 0.05$), and left side ($r = 0.086$, $p > 0.05$). In Tokyo, in a study using a total of 533 males and 567 females from three different ethnic groups of the same height, body weight and width were measured, and a linear regression balance was found for different groups and sex measurement averages, differences are pronounced. Female and male from the different ethnic groups, but having the same height, showed a difference in foot lengths. According to the results found by the researchers, morph metric works should be made with attention to the society (Ashizawa. k et al, 1997). Jasuja and Manjula studied height estimations from print averages made with and without shoes (Jasuja O P, Manjula, 1993). For the estimation of height when length measurement were used rather than width measurements, bare foot measurements gave better results than shoe measurements, and less standard deviation extremes were asserted in the given approximations (Jasuja, et.al 1991). In our study, better results were achieved in height estimation in terms of foot length measurements than in foot width measurements. The correlations coefficient between female foot length with height was seen to be closer to Singh and Phookan's correlation coefficient finding, with the differences and 0.500 with 0.490 for female (Singh et,al, 1993). Gordon and Buikstra, for the development of their linear model for height estimation from foot and shoe measurement, showed a strong relationship between the calculation model with foot length and height (Gordon & Buikstra, 1992). In our study, for females beside left and right foot lengths, other factors of importance may be determined. The same definition can be made for other parameters. With the help of the models gained, it was noticed that determination of one's sex could be done with an 86–98% accuracy ratio (Smith, 1997). Because there may be differences between different societies in order to height and people's feet size, and especially in winter both male and female may wear the same kind of footwear. It was supposed that if any kind of foot prints were found on the spot, this study would lead the determination of sex

Conclusion

Footprint dimensions are strongly correlated with stature and thus give better prediction of stature than the other measurements. It is further concluded that the reliability and prediction of stature by the regression method is better than that of the division factor method. There are lot of variations in estimating stature from limb measurements among people of different region & race. It is, therefore, studies are required to collect the data from the different part of globe as the stature is the inherent characteristic of the individual, though influenced environmentally, therefore regional, simple and multiple regression equations can be of great value.

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Table-1

Descriptive statistics for stature and dimensions (cm) of foot in females

	Mean	**SD**	**SE**
Stature (cm) x1	156.48	5.38	0.340
Foot Length x2	23.60	1.06	0.067
Foot Breadth x3	8.74	0.49	0.030

Table. 2

Correlation Coefficient of Stature and Foot Measurements in Adult females along with their 't' and p values :

	r	**'t'**	**p value**
Foot Length	0.583	435.90	< 0.001
Foot Breadth	0.379	447.97	< 0.001

Table 3.

Simple and multiple regression equations to estimate stature (x1) (cm) from foot length (x2) in females

Simple regression equations	
Foot length (x2)	x1 = 2.967 x2 + 88.235
Foot breadth (x3)	x1 = 4.138 x3 + 120.316
Multiple regression equation	
Foot length (x2) and foot breadth (x3)	x1 = 85.778+2.793x2+0.880x3

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