Original Article

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Stature Estimation from Foot Length of School Age Group Children

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Abstract

Background: Stature estimation of an individual from the skeletal material or the mutilated or parts of limbs has obvious significance in the forensic identification analysis. Estimation of stature is considered as one of the main parameters of personal identification. Establishing personal identity is one of the main concerns in forensic investigations. *Objective:* The current study dealt with developing a regression equation for stature estimation from foot length. *Study Design:* Cross Sectional study. *Place of Study:* Department of Forensic medicine, Gandhi Medical College, Secunderabad. *Methods:* The present study was carried out to establish the regression equation and correlation co-efficient between individual's height and foot length. It was conducted on the children of age group 9 years to 17 years. 239 subjects were selected irrespective of their caste, religion, dietary habits & socio-economic status. *Observation:* The mean (±SD) Stature of 239 students was 134.61 ± 21.05 cm. The right foot length showed a significant positive correlation (r= .017, p=0.0001s) with the stature. The left foot length also showed a significant positive correlation (r= .024, p= 0.0001s) with the stature. The constant and regression co-efficient value regarding right foot length was 143.97 and 0.123 respectively and left foot length was 144.93 and 0.172 respectively for estimating the stature. *Conclusion:* The present study has established definite correlation between stature and foot-length and also regression equations have been established. Foot measurements have a strong relationship with stature; hence, the stature of an individual can be successfully estimated from the foot length regression model derived in the study.

Keywords: Foot Length; Stature; Regression Equation.

Introduction

Stature estimation of an individual from the skeletal material or the mutilated or parts of limbs has obvious significance in the forensic identification analysis. Estimation of stature is considered as one of the main parameters of personal identification [1, 2]. It is well accepted that skeletal dimensions vary among different geographical regions, populations and ethnicities, and that standards for one population might not be appropriate for another population [3,4].

Sex determination from different bones [5,6] and stature reconstruction from femur, tibia, talus, calcaneus, metatarsal, skull, mandible, clavicle, radius, ulna, and sternum have all been previously reported [7,8]. Furthermore, stature estimation has also been calculated from hand and feet dimensions [9,10,11].

Forensic identification from the foot and its parts is important as there is an increased likelihood of the recovery of feet (often enclosed in shoes), separated from the body, in mass disasters such as high power explosions and bomb blasts, air plane crashes and other high impact transportation accidents [12]. The significance of the human foot and its bones, and foot prints in identification has been successfully reported in the past [13]. Published literature on estimation of sex from foot bones and foot dimensions [14-15], individualistic and unique features of the foot and footprints [15-16], and the

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use of radiographic comparisons of the foot [17-18] confirms the importance of the foot in identification.

Stature estimation is commonly reported in forensic case work pertaining to adult populations and less commonly in sub-adult cases. Even the earlier studies on estimation of stature from foot measurements were conducted on adult populations [19-20]. Studies to establish standards for stature estimation in a sub-adult population are essential as the formula derived for stature estimation in the adult population cannot be applied to sub-adults. In the case of growing individuals, it is probably more useful to estimate age than stature. Once the age is established, estimation of stature can reduce the pool of possible victim matches even further.

The reliability of prediction of stature from foot length is as high as that from long bones. Ossification of the bones of the foot occurs earlier than the long bones of the lower extremity. Therefore even during adolescence, stature can be predicted more accurately from the foot length than that from the long bones of the lower limb [21]. In this study, it was aimed to evaluate the predictive role of foot dimensions in stature estimation.

Aim and Objective

The present study is conducted on the children in the secondary school, who are aged between 09 and 17 years to establish the relation between the foot length and height and to get regression formula in this relation.

Material and Method

The study is made on the school going children's who are studying in Sixth standard to Tenth standard in the Govt. High Schools at Musheerabad, Secunderabad, Hyderabad. 239 subjects were selected irrespective of their caste, religion, dietary habits & socio-economic status. Sufficient permissions and consents are procured before the measurements of the children are taken and clearance from the Institutional Ethical committee is obtained in advance. Stature; using the stadio-meter, the subject was made to stand barefoot in the standard standing position on its baseboard. Both feet are in close contact with each other and head oriented in Frankfurt's plane. The height was then recorded in centimeter from the standing surface to the vertex in the weight bearing position of foot. The length of the foot was measured by a foot caliper. It was measured by making the subject sitting in a relaxed position with equal weight on both foot, ankle was perpendicular to the foot, after taking off the shoes and the stockings. The fixed jaw of the caliper was placed on pternion (most posterior and prominent point of the heel) and the sliding jaw was fixed on acropodion (tip of the most protruded first or second toe). Caliper was kept parallel to the long axis of the foot. Length of both right and left foot were measured. The measurement of height and foot length was carried out at a particular period of time 10am to 1pm to avoid diurnal variations.

In vernier caliper, Length = reading of the main scale + vernier coincidence x vernier constant + mechanical error. (Here vernier constant = 0.01 and mechanical error = 0) Calculation of stature using regression equation: Stature = value of constant + regression coefficient x foot length. Value of the constant and regression coefficient was calculated using SPSS Version 19 program.

Inclusion Criteria

All students, both boys and girls studying in sixth to tenth classes from the government high school Musheerabad were selected, irrespective of their socio-economic standards. The ages of these children are falling between 09 years and 17 years.

Exclusion Criteria

Children morphologically showing the congenital malformations, Dwarfism/ Achondroplasia, features of nutritional deficiencies and injuries to extremities are not included in the present study.

Data Analysis

Data thus collected was analyzed using SPSS version 19. The mean values and the standard deviations were calculated for stature and foot length. Correlation of the foot length with the stature was assessed. Regression co-efficient and constant was calculated for estimating stature through regression equation from foot length. The effectiveness of regression equation was tested by significance Z test.

Observation

Total 239 children were measured in various age groups starting from 09 years to 17 years who were school going children. Girls are 118 and Boys are 121 among them. Heights of individual are varying irrespective of age and sex.

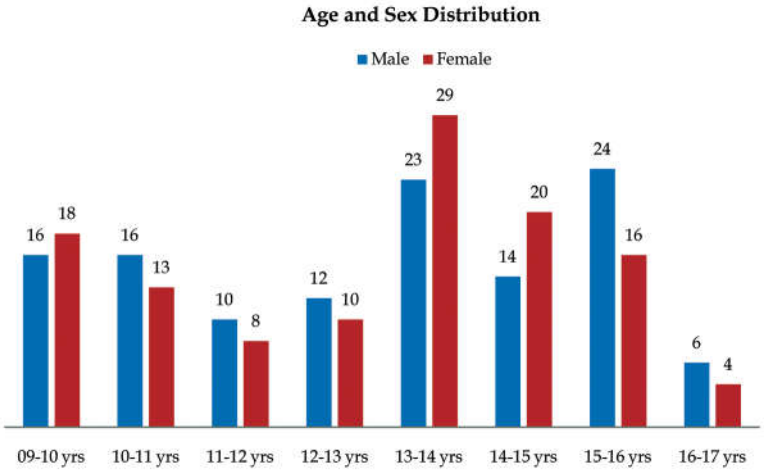

Fig. 1: Age and Sex Distribution of the Students

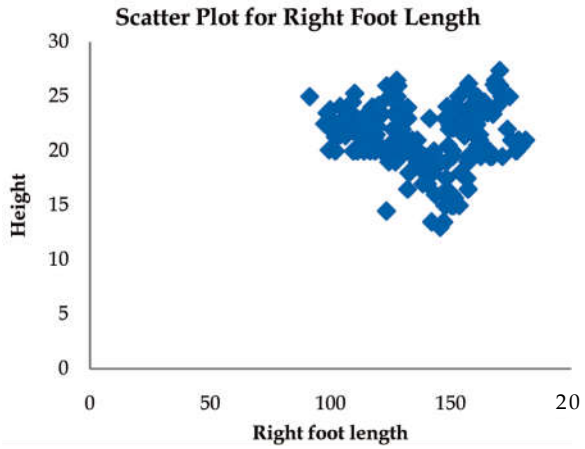

Fig. 2: Scatter diagram with regression analysis showing significant positive correlation between the stature and right foot length (r= 0.017 and p=0.0001s) stature (cm).

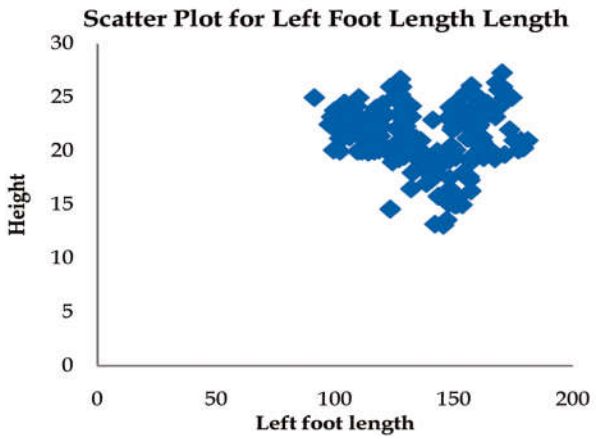

Fig. 3: Scatter diagram with regression analysis showing significant positive correlation between the stature and right foot length (r= 0.024 and p=0.0001s) stature (cm)

Table 1: Stature and length of the foot with corresponding constant and regression co-efficient

Variables	Measurement in cm		Constant	Regression Coefficient	Correlations with stature	
	Range	Mean ± SD			r	p-value
Stature	91.3 – 181.1	134.61 ± 21.05.5				
Right Foot Length	13- 27.4	21.56 ± 2.81	143.97	0.123	0.01798*	0.0001[s]
Left Foot Length	13.1 – 27.3	21.58 ± 2.82	144.93	0.172	0.02489*	0.0001[s]

*= Correlation is significant at the 0.01 level (2 tailed), S= Significant, r = Pearson's correlation stature (cm)

Table 2: Comparison between calculated stature and measured stature

Variables from which stature was estimated	Measured in cm		Estimated stature in cm		Significance of difference
	Range	Mean ±SD	Range	Mean +SD	
Stature	91.3 – 181.1	134.61 ± 21.05	100.86 – 173.18	133.59 ± 18.59	0.0006[NS]

The mean (±SD) Stature of 239 students was 134.61 ± 21.05.5 cm. The stature showed significant positive correlation with foot length as shown in Table No1. Table 1 shows the range and mean (±SD) of foot length, constant, regression co-efficient and r (Correlation co-efficient) value with level of significance. The length of the foot of the respondents of right side ranged between 13 and 27.4 cm where as the length of the left side ranged between 13.1 and 27.3 cm. The right foot length showed a significant positive correlation (r= .017, p=0.0001s) with the stature (Figure 2). The left foot length also showed a

significant positive correlation (r= .024, p= 0.0001s) with the stature (Figure 3). The constant and regression co-efficient value regarding right foot length was 143.97 and 0.123 respectively and left foot length was 144.93 and 0.172 respectively for estimating the stature. The regression equations for estimation of stature from right foot length (RFL) and left foot length (LFL) were 143.97+0.123 x RFL and 144.93 + 0.172 x LFL respectively.

Table II shows the range and mean of calculated stature (+SD) from foot length with the difference with the measured stature with level of significance. Significance of difference was tested using the two sample Z test at 5% level of significance (p=0.05). No significant difference was found between the measured and calculated stature from the foot length. The result indicated the effectiveness of the regression equation of estimating stature from foot length.

Discussion

Our study was conducted on a population group where students studying in Govt. High School at Musheerabad Hyderabad, belonging to various religious and regions were studied. We devised the linear regression equations as well as multiplication factors for estimation of stature from foot length in both the genders. In this study foot length is found to be good parameter for predicting stature in both the genders. The linear regression equation derived from foot length for estimation of stature showed a statistically significant relationship in both the genders.

Qamra et al [22] computed linear regression equations for estimating stature from either foot length or foot breadth of 1015 subjects between the ages of 17-32 years. After testing validity of equations, foot length was found to be more suitable. The variability in multiplication factors derived in our study could be due to the former study being conducted on a particular region whereas our study involved a diverse group.

Jasuja et al [23] derived multiplication factors for Punjabi Jat males for estimation of stature; 6.88 and 6.44 for right and left foot length respectively. In our study, they were 7.26 for right foot length and 7.23 for males for left foot length. The difference in multiplication factors between these two studies could be due to the former study being undertaken for a particular regional group whereas our study involves a diverse population group.

Giles et al [24] also suggested that foot length displays a biological correlation with height and the latter can be estimated from foot length. Nishat Ahmed Sheikh et.al [25] estimated stature from forearm length, the ratio fall between 3.49 and 3.88 for boys with a mean of 3.67 and SD + 0.090; and between 3.45 and 3.88 for girls with a mean of 3.68 and SD 0.093.

Grivas et al [26] evaluated the relationship between foot length and stature in a large sample of 5093 juveniles in Greece, average age being 11.47+/-2.71 years. It was suggested that foot length can estimate the stature and weight of a juvenile, especially after adjusting for age and sex.

Sanli et al [27] established the relationship between hand length, foot length and stature using multiple linear regression analyses. Their study sample included 155 adult (80 male, 75 female) Turks residing in Adana. They found multiple linear regression model for both genders together to be the best model with the highest values for the coefficients of determination R2 = 0.861 and R2 adjusted = 0.859, and multiple correlation coefficient R = 0.928.

The stature had been found to have significant positive correlation with the length of right and left foot. Whether the regression equation was effective in estimating stature from the foot length, the estimated values were compared with the measured values. No significant difference was found between the measured and estimated stature. From this result inference could be drawn that the stature of an individual can be estimated from the right and left foot length.

This method of stature estimation can be used by law enforcement agencies and forensic scientists. The only precaution which must be taken into consideration is that these formulae are applicable to the population from which the data have been collected due to inherent population variations in these dimensions, which may be attributed to genetic and environmental factors like climate, nutrition etc. The results obtained in our study correlates with the previous studies.

Conclusion

The present study has established definite correlation between stature and foot-length and also regression equations have been established. It will help in medico legal cases in establishing stature and identity of an individual when only some remains of the body are found as in mass disasters, bomb explosions, accidents etc. There are lot of variations in estimating stature from limb

measurements among people of different region & race. Hence there is a need to conduct more studies among people of different regions & ethnicity so that stature estimation becomes more reliable & identity of an individual is easily established. Obtained formulas are specific to that study populations therefore application of these by the other populations might cause incorrect results. Thus necessity in creation of specific equations peculiar to populations should be taken into account by researchers.

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