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RESEARCH ARTICLE

ESTIMATION OF STATURE FROM FOOT LENGTH OF SCHOOL AGE GROUP CHILDREN IN TELANGANA STATE

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ABSTRACT

Background: Bio-archaeological research reveals the importance of accurate stature estimation. Establishing personal identity is one of the main concerns in forensic investigations. Estimation of stature forms a basic domain of the investigation process in unknown and co-mingled human remains in forensic anthropology case work.
Objective: The current study dealt with developing a regression equation for stature estimation from foot length.
Study Design: Descriptive study.
Place of study: Department of Forensic medicine Kamineni Institute of Medical Sciences, Narketpally.
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 who are studying in Sixth standard to Tenth standard in the Local schools at Narketpally. 170 subjects were selected irrespective of their caste, religion, dietary habits & socio-economic status.
Observation: The mean (±SD) Stature of 170 students was 141.3 (± 20.5) cm. The right foot length showed a significant positive correlation (r= .018, p=0.0001s) with the stature. The left foot length also showed a significant positive correlation (r= .025, p= 0.0001s) with the stature. The constant and regression co-efficient value regarding right foot length was 144.01 and 0.126 respectively and left foot length was 145.07 and 0.176 respectively for estimating the stature.
Conclusion: 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.

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. These let us know and discuss about many accidents (airplanes, trains etc.) mass disasters and murder cases (Jasuja and Singh, 2004; Ozaslan *et al.,* 2003; Ozaslan *et al.,* 2011). Also, in aspect of forensics; it is crucial in description of suspects from palms and foot prints in crime scenes (Krishan, 2008; Kanchan *et al.,* 2008; Krishan and Sharma, 2007). Not only in forensic sciences but also in many other study disciplines such as anatomy, podiatry, medicine and anthropology. Bio-archaeological research reveals the importance of accurate stature estimation. It provides relevant information on life conditions of past populations. Stature is a god indicator of health, sexual dimorphism and evolutionary trends in overall body size and proportions.

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In addition, accurate stature estimation is necessary for reconstructing living body mass, skeletal rigidity and activity levels (Vercellotti *et al.,* 2009). 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 (DiMaggio and Vernon, 2011). The significance of the human foot and its bones, and foot prints in identification has been successfully reported in the past (Krishan, 2008). Published literature on estimation of sex from foot bones and foot dimensions (Case and Ross, 2007; Krishan *et al.,* 2010; Abdel-Moneim *et al.,* 2008; Sen *et al.,* 2011; Robbins, 1978), individualistic and unique features of the foot and footprints (Robbins, 1978; Owsley and Mann, 1989), and the use of radiographic comparisons of the foot (Owsley and Mann, 1989; Rich *et al.,* 2003; Rich *et al.,* 2002; Dean *et al.,* 2005; Ozden *et al.,* 2005; Sanli *et al.,* 2005; Krishan *et al.,* 2007) 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 (Sen and Ghosh, 2008; Zeybek *et al.,* 2008; Kanchan *et al.,* 2008; Jasuja *et al.,* 1991; Saxena, 1984; Qamra *et al.,* 1986; Gorden *et al.,* 1989; Kewal Krishan, 2007; Macdonnel, 1901). 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. In this study, it was aimed to evaluate the predictive role of foot dimensions in stature estimation.

Aims and objectives

The present study is conducted on the children in the secondary school, who are aged between 11 and 16 years to establish the relation between the foot length and height and to get regression formula in this relation.

MATERIALS AND METHODS

Present study is made on the children who are studying in Sixth standard to Tenth standard in the Local schools at Narketpally. 170 subjects were selected irrespective of their caste, religion, dietary habits and 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) (Kanchan *et al.,* 2008) and the sliding jaw was fixed on acropodion (tip of the most protruded first or second toe) (Kanchan *et al.,* 2008). Caliper was kept parallel to the long axis of the foot10. 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 children, both boys and girls studying in sixth to tenth classes from the local government schools are selected, irrespective of their socio-economic standards. The ages of these children are falling between 11 years and 16 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 170 children are measured in various age groups starting from 11 years to 16 years who are school going children. Girls are 88 and Boys are 82 among them. Heights of individual are varying irrespective of age and sex.

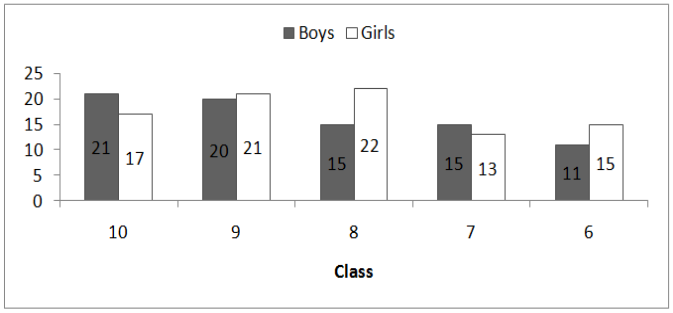

Fig. 1. Class wise Strength of Students

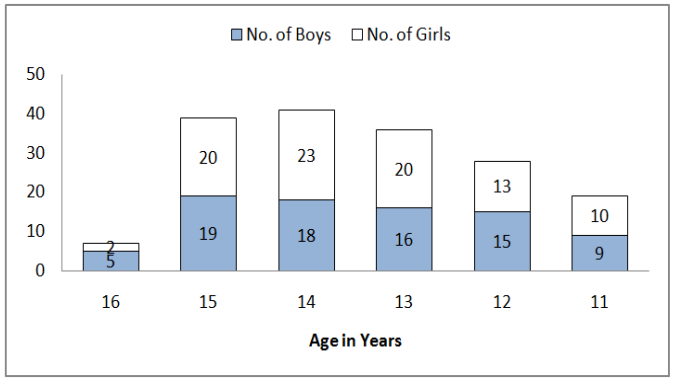

Fig. 2. Age and Sex Distribution of the Students

The mean (±SD) Stature of 170 students was 141.3 (± 20.5) cm. The stature showed significant positive correlation with foot length as shown in Table 1. 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.

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	141.3 ± 20.5				
Right Foot Length	13- 27.4	21.1 ± 2.95	144.01	0.126	0.018*	0.0001[s]
Left Foot Length	13.1 – 27.3	21.1 ± 2.96	145.07	0.176	0.025*	0.0001[s]

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

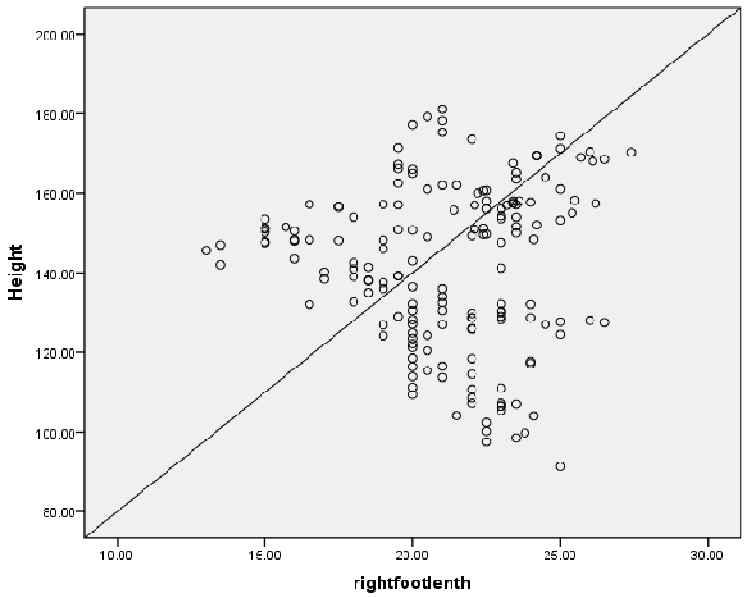

Fig. 3. Scatter diagram with regression analysis showing significant positive correlation between the stature and right foot length (r= 0.018 and p=0.0001s) stature (cm)

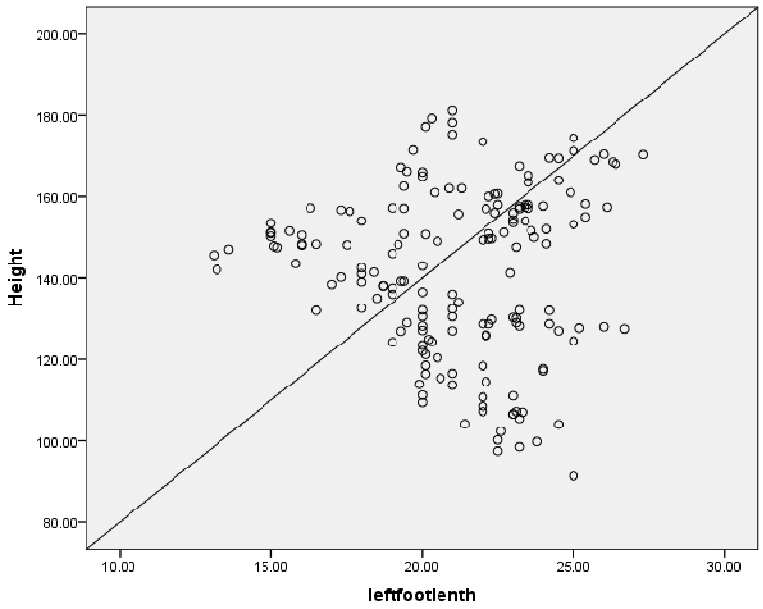

Fig. 4. Scatter diagram with regression analysis showing significant positive correlation between the stature and right foot length (r= 0.025 and p=0.0001s) stature (cm)

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	
Right Foot Length	91.3 – 181.1	141.3±20.5	116.6 – 141.3	122.9±3.27	0.0006[NS]
Left Foot Length	91.3 – 181.1	141.3±20.5	117.7- 131.9	123.9±2.96	0.0006[NS]

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= .018, p=0.0001s) with the stature (Fig 3). The left foot length also showed a significant positive correlation (r= .025, p= 0.0001s) with the stature (Fig 4). The constant and regression co-efficient value regarding right foot length was 144.01 and 0.126 respectively and left foot length was 145.07 and 0.176 respectively for estimating the stature. The regression equations for estimation of stature from right foot length (RFL) and left foot length (LFL) were 144.01+0.126 x RFL and 145.07 + 0.176 x LFL respectively.

Table 2 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 the schools of Narketpally, District Nalgonda state Telangana 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.

Macdonnel (1901) studied 3000 English criminals and derived regression formulae for estimation of stature from foot length, 166.457 + 4.031 (foot-25.688) +/- 2.9 cms. However, sex and side was not been given due consideration in this study. Krishnan (2007) (Kewal Krishan, 2007) concluded that the dimensions of hands and feet can provide good reliability in estimation of stature. Qamra *et al.* (1986) suggested that a true relationship existed only between foot length and stature, and the relationship in other combination of variables was affected to a great extent by foot length alone. Kanchan *et al*. (2008) examined the relationship between stature and foot dimensions among 200 (100 males and 100 females) Gujjars (North Indian community). They devised linear and multiple regression equations for estimating stature using foot dimensions.

Zeybek *et al*. (2008) developed formulae for estimation of the stature and gender through foot measurements. They derived multiple regression formulae for stature estimation and logistic regression analysis for gender estimation using foot measurements. Gordon *et al*. (1992) estimated stature from foot dimensions and models containing both foot length and foot breadth were found to be significantly better than those containing only foot length. Nishat Ahmed Sheikh *et al.* (2014) 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. 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 concludes that 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. It is highlighted here that the findings of the present research apply to a very specific population and hence, should not be generalized. Researchers are encouraged to conduct similar studies in different population groups to look into the generation of additional standards which can further be used in the identification of individuals from human remains.

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Ethical Approval

Ethical approval taken from the Institutional ethics committee.

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Conflicts of Interest: Nil

Author Disclosures

Authors have no conflict of interest. This study was a part of departmental research activities of Forensic Medicine at Kamineni Institute of Medical Sciences, Narketpally.

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