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REGRESSION EQUATIONS FOR STATURE ESTIMATION AMONG MEDICAL STUDENTS OF GHAZIABAD

Rakhee Verma[1], Syed Esam Mahmood[2]

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Author's Affiliation:
[1]Associate Professor, Community Medicine, Rama Medical College & Hospital, Ghaziabad; [2]Associate Professor, Community Medicine, Mahamaya Rajkiya Allopathic Medical College, Ambedkarnagar

Correspondence:
Dr Syed Esam Mahmood
Email: semahmood@gmail.com

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ABSTRACT

Introduction: Ossification and maturation in the foot occurs earlier than the long bones and therefore, during adolescence height could be more accurately predicted from foot measurement as compared to that from long bones. This study was undertaken to find out the correlation between foot length and height of an individual and to derive regression formulae to estimate the height from the foot length in the study population.

Materials & Method: This cross sectional study was conducted at Ghaziabad among 150 healthy medical students aged between between 17 – 25 years. Foot length and height was measured. Statistical analysis was performed using SPSS software. Karl Pearson's correlation coefficient and Linear Regression analysis was applied.

Results: The mean height and mean foot length was 164.44 cm and 24.65 cm respectively. A strong positive correlation between height and foot length of individuals was found. The regression equation for height and foot length was found to be Y(height) = 4.399 X(mean foot length) + 55.988.

Conclusion: Foot length is a useful parameter in stature estimation. Further detailed study for stature estimation using other parameters like hand and toe length should be conducted to establish regression equations.

Key words: Foot length, height, regression equations, medical students

INTRODUCTION

Stature is the height of the person in the upright posture. It is an important measure of physical identity. Establishing the identity of an individual from mutilated, decomposed and amputed body fragments has become an important necessity in recent times due to natural and man-made disasters. It is important both for legal and humanitarian reasons. "Stature" is one of the most important elements in the identification of an individual.[1]

Dimensional relationships between the body segments and the whole body have been of interest to artists, scientists, anatomists, anthropologists and medicolegistics for long time.[2] 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.[3]

In medico-legal autopsies, establishing personal identity of the victims is often required. Estimation of stature from extremities and their parts plays an important role in identifying the dead body in forensic examinations.[4]

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.[5-8]

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. The aim of the present study was to find out the correlation between foot length and height of an individual and to derive regression formulae to estimate the height from the foot length in the study population.

MATERIAL METHODS

The present cross sectional study was conducted at Department of Community Medicine, Rama Medical College & Hospital, Hapur road, Ghaziabad. Sample size was taken as 150 (75 males and 75 females) asymptomatic, healthy medical students of the age group ranging between 17 – 25 years. The subject having any disease or deformity was not included in this study.

Foot length was measured as a direct distance from the most prominent point of the back of the heel to the tip of the hallux or to the tip of second toe when the second toe was longer than hallux by spreading caliper in centimeter. Height of the individual was measured in standing erect anatomical position with standing height measuring instrument in centimeter.

Data entry and statistical analysis were performed using the Microsoft Excel and SPSS windows version 14.0 software. Karl Pearson's correlation coefficient was used to determine the strength of relationship between foot length and stature. Linear Regression analysis was used to estimate the stature both for male and female. The goodness of fitted model was tested by R^2. A p value < 0.05 was considered as statistically significant.

RESULTS

Notations:

HT : Height, RFL : Right foot length, LFL : Left foot length, MFL : Mean foot length, SD : Standard deviation, SE : Standard error

Table 1: Gender wise distribution of respondents according to height and foot length

Gender	HT	RFL	LFL	MFL
Male				
N	75	75	75	75
Mean	170.94	26.02	26.02	26.02
SD	8.44	1.65	1.69	1.66
Female				
N	75	75	75	75
Mean	157.94	23.26	23.31	23.28
SD	6.62	1.35	1.31	1.32
Total				
N	150	150	150	150
Mean	164.44	24.64	24.66	24.65
SD	9.98	2.04	2.03	2.03

Table 2: Correlations of foot lengths with height

Correlation with Height	RFL	LFL	MFL
Male			
N	75	75	75
Pearson's Correlation (r)	0.877	0.869	0.874
p-value	<0.0001	<0.0001	<0.0001
Female			
N	75	75	75
Pearson's Correlation (r)	0.700	0.719	0.715
p-value	<0.0001	<0.0001	<0.0001
Total			
N	150	150	150
Pearson's Correlation (r)	0.892	0.991	0.998
p-value	<.0001	<.0001	<.0001

Table 3: Regression Equation of Height (Ht) with Foot lengths and its goodness of fit (R^2)/standard error

Category	Regression Equation	R^2 (goodness of fit)	SE of estimate
Overall	Ht = 56.910 + 4.363×RFL	0.796	4.523
Overall	Ht = 56.088 + 4.393×LFL	0.799	4.488
Overall	Ht = 55.988 + 4.399×MFL	0.801	4.463
Overall	Ht = 55.922 + 1.730×RFL + 2.672×LFL	0.802	4.477
Male	Ht = 53.918 + 4.497×RFL	0.769	4.086
Male	Ht = 57.951 + 4.342×LFL	0.754	4.210
Male	Ht = 55.470 + 4.437×MFL	0.765	4.121
Male	Ht = 53.846 + 4.661×RFL -.162×LFL	0.769	4.114
Female	Ht = 78.200 + 3.427×RFL	0.490	4.758
Female	Ht = 73.568 + 3.620×LFL	0.516	4.633
Female	Ht = 74.693 + 3.575×MFL	0.511	4.661
Female	Ht = 73.568 + .233×RFL + 3.367×LFL	0.517	4.664

The mean height and mean foot length of males was 170.94 cm and 26.02 cm respectively while the mean height and mean foot length of females was 157.4 cm and 23.8 cm respectively.(Table 1)

There was a significant correlation coefficient between height and right foot length(r = 0.877, p <

0.0001 for male and r = 0.700, p< 0.0001 for female), height and left foot length (r = 0.869, p < 0.0001 for male and r = 0.719, p < 0.0001 for female) and height of entire subjects and mean foot length (r = 0.998, p < 0.0001). A strong positive correlation between height and foot length of individuals was found. (Table 2)

Scatterplots showing correlation between foot length and height

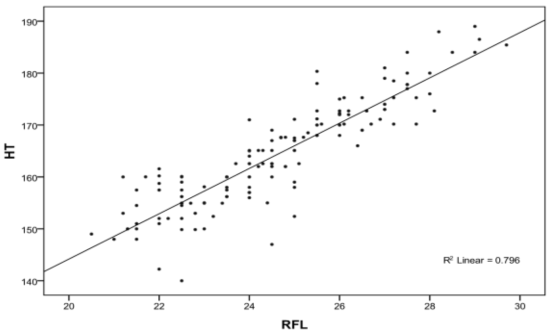

Figure 1 (a): Scatterplot between height and right foot length of all individuals

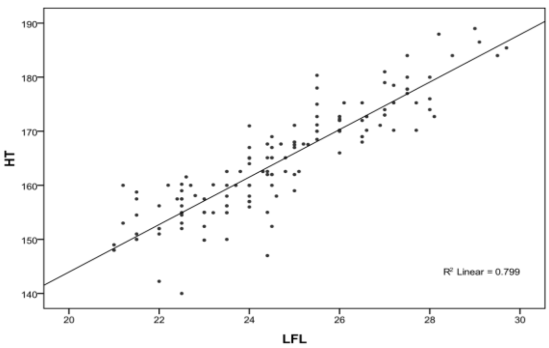

Figure 1 (b): Scatterplot between height and left foot length of all individuals

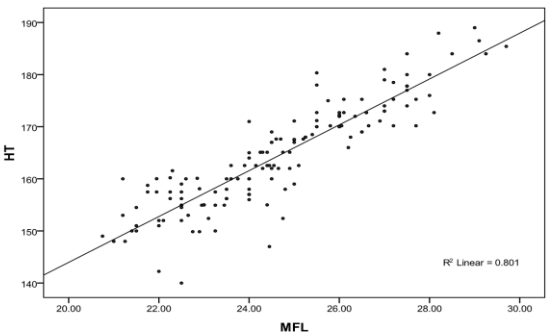

Figure 1 (c): Scatterplot between height and median foot length of all individuals

The regression equation for height and foot length was found to be y= 24.342 x+ 57.951 (for left foot of male), y = 4.497 x + 53.918 (for right foot of male), y = 3.620 x + 73.568 (for left foot of female), y = 3.427 x + 78.200 (for right foot of female), Y = 4.399 X + 55.988(for mean foot length for both males and females), where X is the foot length and Y is the height.(Table 3) A strong significant relationship between foot length and body stature of all subjects is evident from the above figures (1 a, b and c).

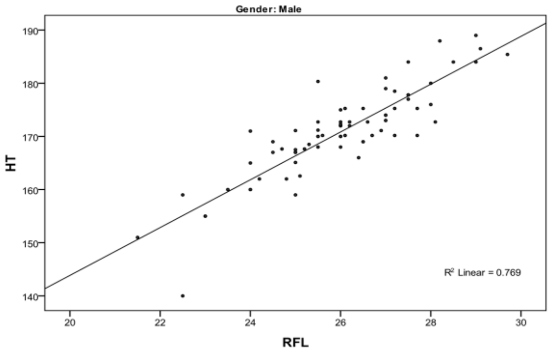

Figure 2 (a): Scatterplot between height and right foot length of males

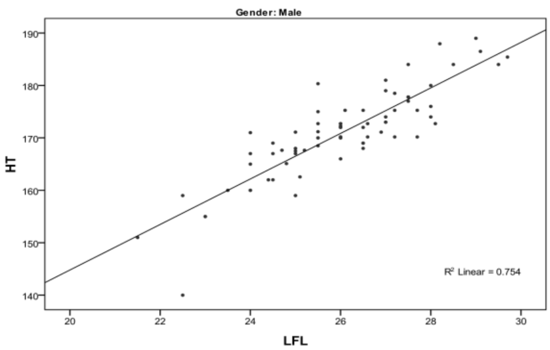

Figure 2 (b): Scatterplot between height and left foot length of males

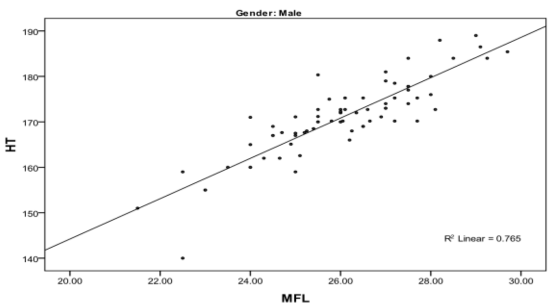

Figure 2 (c): Scatterplot between height and median foot length of males

A strong significant relationship between foot length and body stature of males is evident from the above figures (2 a, b and c).

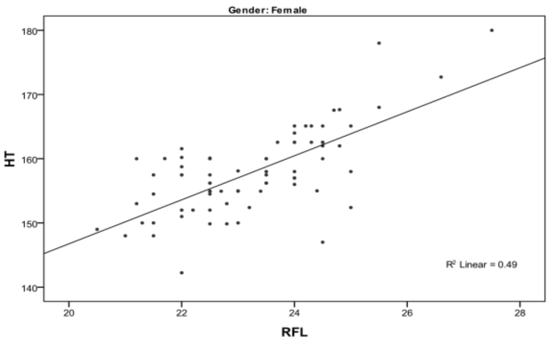

Figure 3 (a): Scatterplot between height and right foot length of females

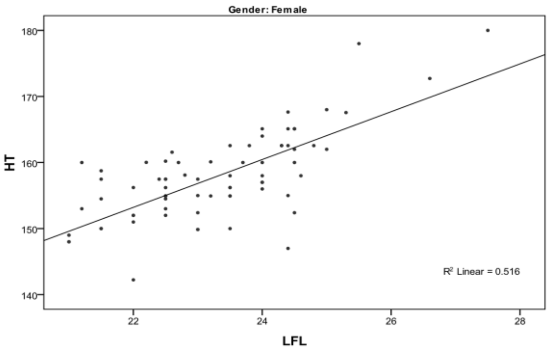

Figure 3 (b): Scatterplot between height and left foot length of females

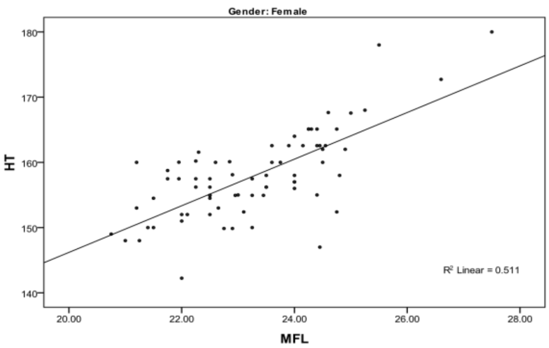

Figure 3 (c): Scatterplot between height and median foot length of females

A strong significant relationship between foot length and body stature of females is evident from the above figures (3 a, b and c).

DISCUSSION

Estimation of stature from anthropometric measurements is an area of interest for forensic experts for the purpose of identification especially the in cases where death(s) occurs due to terrorism such as bomb blasts and calamities like earth quakes, floods and air crashes where only parts of bodies are available.

Various studies have been conducted worldwide on the estimation of stature from the human skeleton. There are different methods to estimate the stature from the bones but the easiest and reliable method is by regression analysis. Patel *et al* (2007) [9] in their study on 502 medical students (278 male and 224 female) between 17 to 22 years of age belonging to various regions of Gujarat, India reported a regression formula between foot length and height of an individual. Tharmar et al [10] carried a study among 107 randomly selected subjects in Malaysia and developed a regression equation for stature estimation from foot length obtained from foot impression.

Our study revealed a significant correlation coefficient between foot length and height of entire subjects. The regression equation for height and foot length was found to be Y = 4.399 X + 55.988 (for both male and female and mean foot length), where X is the foot length and Y is the height. Our findings are comparable to the study by Malik et al who reported a regression equation of body stature on foot length to be Y(body stature)=58.101+4.261(Foot length).[11] Sanli et al in 2012 [12] conducted a study among medical students of Pune, India and reported regression equation: H=90.0+3.2 r=0.645 in males and H=72.8+3.7 r= 0.702 in females. Karaddi et al (2013) in their study among medical students in Gulbarga from analysis revealed that there was a significant positive correlation between right foot length with stature (r=+0.82) and left foot length with stature (r=+0.80).[13] Recent studies carried out on medical students have also shown a positive correlation between the foot length and stature ranging from 0.719 to 0.724.[14,15] The correlation coefficient between height and foot length was + 0.658 in male and + 0.567 in female among first year south Indian medical students.[16] This shows that foot length is a useful parameter in stature estimation. The value of correlation co-efficient obtained in the present study is inconsistent with several research studies. The difference may be attributed to obvious genetic and possible environmental factors. Sen & Ghosh in 2008 [17], recommended that it would be unwise to use same equations for stature estimation in different population groups.

Further detailed study for estimation of stature including other parameters like hand length, cranial sutures, toe length etc. should be conducted to establish regression equations.

CONCLUSION

It is concluded that foot length has good predictive value in estimation of stature. The correlation coefficient was positive between stature and foot length of both males and females indicating its reliability and accuracy in estimating stature in males and females respectively.

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