Prediction of Stature with Regression Equation and Multiplication Factor using Foot Length in Adults: A Comparative Study

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ABSTRACT

Introduction: Stature estimation is important in medicolegal investigations and anthropological studies. Regression equation and multiplication factor are used for estimation of stature from body segment. The objective of this study is to find out any significant difference exists between the regression equation and multiplication factor estimates using right foot length in predicting the stature.

Material and methods: A total of 619 study subjects that included both males and females with age ranged from 18 to 59 years were selected for estimation of stature. Simple regression equation and multiplication factor were formulated from RFL. They were used for estimation of stature of both male and female study subjects separately. Then both the methods were analyzed for their accuracy and to find out any difference between them.

Results: It was statistically significant for multiplication factor when compared with regression equation for determining stature from RFL in males (p=0.018) and females (p=0.002).

Conclusion: The present study found that multiplication factor was better than regression equation in determining stature from RFL in both sexes among population in Chennai region.

Keywords: Stature, Foot Length, Regression Equation, Multiplication Factor, Forensic Anthropometry

INTRODUCTION

The stature estimation is considered to be an important assessment in the identification of an individual in forensic sciences.[1] It is an important parameter in medico-legal investigations and in identification of unknown human skeletal remains in forensic examination.[2-4] For instance, establishing the identity of dead person is required in cases of suicide, homicide, riots, explosion, accidents, earthquakes, tsunami and floods. In disaster either natural or artificial where only fragments of the body are found, the identification becomes difficult.[5,6] Therefore, the determination of stature of an individual from skeletal material or from the mutilated or from amputated limbs or from parts of limbs, has obvious significance in the personal identification in the events of murders, accidents or natural disasters as required in forensic identification analysis.[7,8]

Determination of the one body part using another is common in modern sciences as there is a relationship between part of the body and the whole body.[8,9] Anatomical and mathematical methods are generally employed for determining the stature.[10] The anatomical method deduces stature by simply putting the bones together with due allowance for the soft part.[5] The anatomical method cannot be used for stature reconstruction if complete skeleton is not available. In this case, they have to employ the mathematical method which is relatively less precise as compared to the anatomical method.[11] The mathematical method comprised of regression equation and multiplication factor for reconstruction stature from body segments.[12] There are lot of earlier studies reported on stature estimation using either regression equation or multiplication factor.[9,13-18] Nevertheless, a very few studies compared these methods for their reliability and accuracy. Hence, the objective of this study is to find out any significant difference exists between the regression equation and multiplication factor estimates using right foot length in predicting the stature.

MATERIAL AND METHODS

The present cross-sectional study was carried out in 2007 between January and September. The entire study was done in the Institute of Forensic Medicine, Madras Medical College and in the Institute of Internal Medicine, Government General Hospital, Chennai. A total of 619 healthy subjects consisted of 311 males and 308 females. The age ranged from 18 to 59 years. This age group was taken as all the centers of ossification in the long bones get completely fused around 18 years. Subjects with age above 60 years were excluded as stature and foot length significantly decrease due to osteoporotic changes. The measurements were taken in well-lighted room. The measurements were taken according to the technique given in the manual of biological anthropology.[19] The standing height method was selected for measuring stature of each subject. Stature is the vertical distance between the highest point on the vertex and platform of stadiometer. Foot length is the straight distance directly from pternion to acropodian. It was measured using specially designed instrument more or less like an osteometric board

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of a miniature size. It consisted of a horizontal rectangular wooden platform with a fixed metal scale with calibration from 0 – 30 cm. to the nearest mm. accuracy. From the total study subject of 619, 100 males and equal number of females were randomly selected to formulate regression equations and to derive multiplication factor from RFL. The regression equation for male RFL was 68.471 + 3.94 (RFL) while for female RFL, it was 64.989 + 3.90 (RFL). The multiplication factor was obtained from average ratio of the stature to the RFL. The multiplication factor for male RFL was 6.70 while for female RFL, it was 6.63. By applying these methods, stature was determined for rest of the study subjects. Then it was compared to the actual stature. The differences were used for comparing between the two estimations separately for the male and female subjects.

STATISTICAL ANALYSIS

Data were presented as mean ± standard deviation (SD) and percentage. Paired t-test was applied to determine statistical significance of differences in regression equation and multiplication factor for determining stature with RFL.The results were considered significant if p - value of less than 0.05.

RESULTS

Table 1 shows the mean, standard deviation, minimum and maximum of actual stature and RFL of study subjects by gender wise. The mean stature value for male adults was found to be 167.5 cm. The minimum and maximum stature values were found to be 146.1 cm. and 190.0 cm. respectively. Similarly, the female mean stature value was found to be

Selected variables in cm.	Male				Female			
	Mean	SD	Range		Mean	SD	Range	
			Min.	Max.			Min.	Max.
Stature	167.455	7.213	146.1	190.0	154.106	6.389	139.6	178.0
RFL	25.33	1.32	21.3	30.4	23.07	1.14	19.6	26.3

Table-1: Mean and SD of the stature, RFL of the study subjects

Variables	Prediction range	Number	Percentage
Regression equation	Within ± 3 cm	82	38.9
	Less than -3 cm	82	38.9
	More than +3 cm	47	22.3
Multiplication factor	Within ± 3 cm	78	37.0
	Less than -3 cm	72	34.1
	More than +3 cm	61	28.9
(n=211)			

Table-2: Distribution of the male subjects based on the difference between the actual and estimated stature for the regression equation and multiplication factor using RFL

Variables	Prediction range	Number	Percentage
Regression equation	Within ± 3 cm	94	45.2
	Less than -3 cm	81	38.9
	More than +3 cm	33	15.9
Multiplication factor	Within ± 3 cm	70	33.7
	Less than -3 cm	77	37.0
	More than +3 cm	61	29.3
(n=208)			

Table-3: Distribution of the female subjects based on the difference between the actual and estimated stature for the regression equation and multiplication factor using RFL

Variables	Number	Mean	SD	t value	p Value
Regression equation	211	-1.23	4.97	-2.39	0.018
Multiplication factor		-0.639	6.06		(S)
S: Significant					

Table-4: Comparison of regression equation with multiplication factor in males

Variables	Number	Mean	SD	t value	p Value
Regression equation	208	-1.42	4.80	3.173	0.002
Multiplication factor		-0.707	5.92		(S)
S: Significant					

Table-5: Comparison of regression equation with multiplication factor in females

154.1 cm. with a range of 139.6 cm. to 178.0 cm. The mean RFL for males was found to be 25.33 cm. and for females it was 23.07 cm. Table 2 shows the difference between the actual and estimated stature for regression equation and multiplication factor methods of the male subjects. In 38.9% of male subjects, the regression equation prediction was higher than 3.0cm. than the actual stature value. In 22.2% of the male subjects, the prediction was less than 3.0cm. than the actual stature value. The remaining male subjects were predicted within the range of ± 3.0cm. The prediction level of the multiplication factor for the male subjects was also shown in the same table.

Table 3 shows the difference between the actual and estimated stature for regression equation and multiplication factor methods of the female subjects. In 38.9% of female subjects, the regression equation prediction was higher than 3.0cm. than the actual stature value. In 15.9% of the female subjects, the prediction was less than 3.0cm. than the actual stature value. The remaining female subjects were predicted within the range of ± 3.0cm. The prediction level of the multiplication factor for female subjects was also shown in table 3.

Table 4 shows the mean difference between the estimated and actual stature value of the two methods among male subjects. The mean difference between the actual stature value and regression estimation was found to be -1.23. The mean difference between the actual stature value and multiplication factor estimation was found to be -0.639. The above two means were compared by paired 't' test. The significant p-value (p=0.018) reveals that multiplication factor estimation has been better than the regression equation estimation for the male subjects using foot length.

Table 5 shows the mean difference between the estimated and actual stature value of the two methods among female subjects. The mean difference between the actual stature value and regression estimation was found to be -1.42. The mean difference between the actual stature value and multiplication factor estimation was found to be -0.707. The above two means were compared by paired't' test. The significant p-value (p=0.002) reveals that multiplication factor estimation has been better than the regression equation estimation for the female subjects using foot length.

DISCUSSION

Stature can be determined using measurements of different body parts. It is directly proportional to different body parts and shows a definite biological and genetic association with each other. Mathematical method finds its utility in forensic analysis as it can be used even when only part of the body is available.[5] For instance, linear regression equation can be used to establish height from body segments. Similarly, the stature can also be established with multiplication factor. The foot measurements are highly reliable for determination of stature as foot length possesses a biological correlation with stature and foot measurement provides better predictive information about the stature of an individual.[20] Ossification and maturation occur in the foot earlier than the long bones and therefore stature could be more accurately determined especially in adolescence age from foot measurement as compared to that of from long bones.[21,22]

The present study found a significant difference between regression equation and multiplication factor when applied for stature determination in males from RFL. It indicates that the multiplication factor is better than the regression equation for determination of stature using RFL. The findings were similar in females as well. Many earlier studies investigated with regression equation.[8,18,22,23] and multiplication factor[24] for stature determination from foot length.

However, a very few study compared these methods for stature determination especially with foot length.[10,28] They reported that prediction of stature with regression analysis was better than multiplication factor in the respective population. However, the present study which shows that multiplication factor is better than regression equation for the prediction of stature. This is because of variations in body dimensions are natural among population due to various factors like genetic, nutritional and environmental factors.[7,25-27] The study has strength of deriving both regression equation and multiplication factor from a smaller group and tested against a larger group.

CONCLUSION

The present study assessed regression equation and multiplication factor derived from RFL for determination of stature in both male and female subjects. The result shows that the multiplication factor is better than the regression equation for the prediction of stature in both sexes using RFL.

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