

# Assessing Agreement Level between Actual Stature and Regression Estimates using Foot Length of Adults

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## ABSTRACT

**Introduction:** Stature can be determined using measurements of different body parts. Forensic anthropology uses regression equation for determining stature from body part. The aim of the present study is to assess the agreement level between actual and estimated stature using regression equation from right foot length (RFL) among both sexes in Chennai region.

**Material and methods:** In this cross sectional study, 619 subjects of both sexes with age ranging from 18 to 59 years were studied for determination of stature. Simple regression equations were formulated from RFL. They were applied for determination of stature of an individual of both sexes separately. Then they were assessed for their agreement between actual and estimated stature.

**Results:** The present study found a satisfactory agreement but not very good agreement between actual and estimated stature with regression equation from RFL in both sexes. According to the Bland-Altman plot, there was a bias as negative predicted higher than the actual stature values and few observations were found moving beyond lower and upper limits (95% confidence limit).

**Conclusion:** When actual stature cannot be determined, regression equation could be the most appropriate for prediction of stature using foot length in adults.

**Keywords:** Stature, Foot Length, Regression Equation, Forensic Anthropometry

## INTRODUCTION

Identification is necessary in living persons, recently dead, decomposed and mutilated bodies as well as skeleton. If the victim's identity is not known, it becomes difficult for the police to solve the crime.<sup>1</sup> The main part of corpus delicti (i.e. the body of the offence; the essence of crime) is the establishment of the identity of the dead body.<sup>1</sup> Identification of dead body and proof of corpus delicti is essential and integral part of any criminal and civil justice delivery system throughout the world. The stature prediction occupies relatively a central position both in the anthropological research and in the identification necessitated by the medical jurisprudence or by medico-legal experts.<sup>2</sup> The four primary characteristics of identification of a person are - age, sex, race and stature.<sup>3</sup> In forensic anthropology, stature is one of the most important elements in the identification of an individual.<sup>3</sup> Estimation of stature of an individual from the skeletal remains or from the mutilated or amputated limbs or parts of limbs has obvious significance in the field of forensic anthropology.<sup>4</sup>

In forensic anthropology anatomical and mathematical methods are used for determination of stature.<sup>5</sup> The anatomical

method consists simply in putting the bones together, in reproducing the curves of the spine, in making due allowance for the soft parts, and in measuring the height.<sup>6</sup> This method cannot be applied for stature reconstruction if complete skeleton is not provided. In this case, the mathematical method is mostly used for stature reconstruction<sup>7</sup>. The mathematical method includes regression equation and multiplication factor for determining stature from bone or body segment.<sup>8</sup> There are many regional and international studies involving regression equation using foot lengths for determination of stature.<sup>9-16</sup> The aim of the present study was to assess the agreement between actual and estimated stature using regression equation from right foot length (RFL) among both sexes in Chennai region.

## MATERIAL AND METHODS

The present study recruited 619 healthy subjects with 311 males and 308 females in the age group of 18 to 59 years. This age group was chosen as all centers of ossification in the foot and long bones get completely fused around 18 years. Subjects with age above 60 years were excluded from the study as stature and foot length significantly decline due to osteoporotic changes. All the measurements were taken in well lit room. The measurements were taken using standard anthropometric instruments in centimeter (cm.) to the nearest millimeter (mm.) accuracy according to the method given in the manual of biological anthropology.<sup>16</sup> The study was carried out in the Institute of Forensic Medicine, Madras Medical College and in the Institute of Internal Medicine, Government General Hospital, Chennai, from January to September in 2007. An ethical clearance was obtained from the Institutional Human Ethics Committee (IHEC) and an informed written consent in the regional language was taken from each subject.

The standing height method was adopted for measuring

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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 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. The mean stature for male adults was 167.5 cm. with SD of 7.23 and for female adults it was 154.1 cm. with a SD of 6.38. The average RFL for males was found to be 25.33 cm. with SD of 1.32 while for females it was 23.07 cm. with SD of 1.14. Out of 619 study subjects, 100 males and 100 females were randomly selected to formulate regression equations for determination of stature from RFL. The regression equation for determining stature from male RFL was  $68.471 + 3.94 (\text{RFL})$  while for female RFL was  $64.989 + 3.90 (\text{RFL})$ . Using regression equation, stature was estimated for remaining male and female subjects. Then it was compared with the actual stature values. Further the agreements were assessed between the two estimations separately for the male and female subjects.

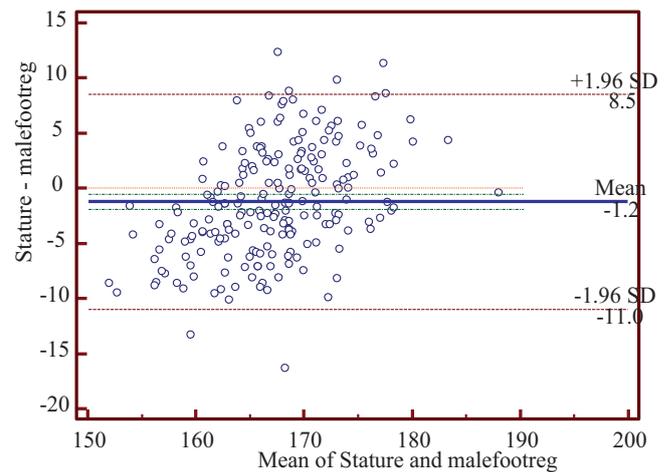
### STATISTICAL ANALYSIS

Data were expressed as mean  $\pm$  standard deviation (SD) and percentage. Bland-Altman analysis was used for finding the agreement level between actual with estimated stature using regression equation from RFL with 95% confidence interval.

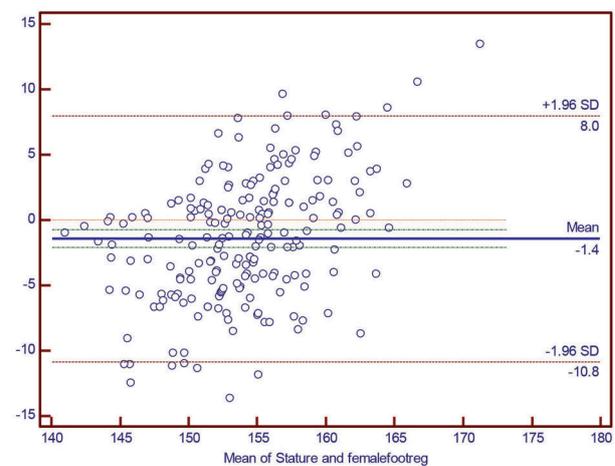
### RESULTS

Figure 1 shows the Bland-Altman plot between stature and regression estimation value of stature using RFL for the males. The mean line -1.2 revealed that the regression equation predicted the stature on the average 1.2 cm. higher than the actual stature. The 95% confidence of the mean difference value did not include the zero line. It caused the regression equation slightly over estimating the actual stature. The pattern of the distribution of the observations was random only, i.e. it did not follow any specific pattern. Further, it was observed that nearly 97.2% of the observations were within the range of lower and upper -1.96 SD and +1.96 SD limits (95% confidence). This showed an agreement between the actual stature and regression estimation. Since 2.8% of the observations were out of the 95% confidence range, this showed an agreement between the two but that was not a perfect agreement.

Figure 2 shows the Bland-Altman plot between stature and regression estimation value of stature using RFL for the females. The mean line -1.4 revealed that the regression equation predicted the stature on the average 1.4 cm. higher than the actual stature. The 95% confidence of the mean difference value did not include the zero line. It caused the regression equation slightly over estimating the actual stature. The pattern of the distribution of the observations was random only, i.e. it did not follow any specific pattern. Further, it was observed that nearly 95.7% of the observations were within the range of lower and upper -1.96 SD and +1.96



**Figure-1:** Bland-Altman plot showing agreement between actual and estimated stature with regression equation among males.



**Figure-2:** Bland-Altman plot showing agreement between actual and estimated stature with regression equation among females

SD limits (95% confidence). This showed an agreement between the actual stature and regression estimation. Since 4.3% of the observations were out of the 95% confidence range, it found an agreement between the two, but that was not a perfect agreement.

### DISCUSSION

By definition stature means body height or body length of a person. It is an important criterion for identification of a person. Identity of a person is incomplete without mentioning his / her height. No other identification procedure used by forensic anthropologists has undergone such a complicated course of development involving so many identifiable contributors as that concerned with the estimation of stature from detached parts of the skeleton. Prediction of the dimension of one body segment using another is common in forensic sciences based on the relationship between part of the body segment and the whole body.<sup>17</sup> When a full skeleton is available, then obviously direct measurement of the correctly assembled bones will give the original height within a few centimeters. On the other hand, stature can also be determined using measurements of different body parts. Mathematical method is the best choice in medico-

legal cases as it can be applied even when only part of the body is available.<sup>6</sup> For instance, linear regression equation can be used to predict the stature from body segments. The foot measurements are highly reliable for determination of stature as foot length possesses a biological correlation with stature and foot measurement gives better prediction about the stature of an individual.<sup>18,19,20</sup>

The present study found an agreement but not perfect agreement between actual and estimated stature with regression equation from RFL for determination of stature in males. According to the Bland-Altman plot, there was a bias as negative predicted higher than the actual stature values of 1.2 cm. based on the mean line. Few observations were found moving beyond lower and upper limits (95% confidence limit). Hence, it indicates that there is an agreement but it is not a perfect agreement. The findings were similar in case of females as well. The result shows that there is an agreement but not a perfect agreement between the actual and estimated stature with regression equation from RFL for the prediction of stature in adults of both sexes.

## CONCLUSION

The present study assessed the agreement level between actual and estimated stature with regression equation from RFL for determination of stature in both sexes. The present study indicates that the regression estimates has a good agreement. In conclusion, it is recommended to use regression estimates using foot length to predict the stature whenever the actual could not be determined.

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