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Technical Note

Prediction of Stature from Hand Length and Foot Length

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Abstract: Identifying the remains of an unknown individual is an important part of forensic investigation, however, identification can become difficult when a complete body is not available. The present study was carried out to investigate the determination of an individual's stature using hand length and foot length. In this study, 100 students from the J. J. M. Medical College in Davangere, Karnataka, were randomly selected. The height of each student, the length of each hand (right and left), and the length of each foot (right and left) of each student were measured. These data were subjected to statistical analysis. Correlation coefficients were derived and regression equations were developed that led to the conclusion that hands and feet can be used in the population under study for the estimation of stature. In females, the hand length gave a better prediction of stature when compared to foot length.

Introduction

Identifying the remains of an unknown individual is an important part of forensic investigation. Identification can become difficult when a complete body is not available. The determination of stature, along with sex, age, and ethnicity, is an important part of the identification process [1].

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The relationship between specific body dimensions and stature can be used to help identify an individual. For example, it has been demonstrated that stature can be estimated from imprints of the hand, foot, or footprints, or from a shoe left at the scene of a crime [2]. Similarly, the stature of a victim can be estimated when a part of body, such as a long bone, or hand, is all that remains [3].

Earlier studies have shown that various measurements of the body tend to differ in various ethnic groups [4]. Consequently, the formulae designed to estimate stature from various anatomical dimensions in one population do not apply to another [5, 6]. There is a need for population-specific stature estimation formulae. A regression equation can be used to predict dependent variables from independent inputs within the range of the scatterplot values. Because the regression equation for stature estimation is population specific, there is a need to develop a separate regression formula for stature estimation from various parameters for a particular population. Furthermore, the need for alternative formulae for the genders is also proved because the rate of skeletal maturity in males and females varies during the course of development [5].

Other studies have previously developed regression equations for the estimation of stature from a single parameter [7–12]. This study has developed regression equations for stature estimation from two parameters: hand length and foot length.

Materials and Methods

The present study was carried out in J. J. M. Medical College (Davangere, Karnataka). Students belonging to the Davangere region (50 males and 50 females) were randomly selected. Students with hypochondriasis, achondriosis, congenital anomalies of bone, fractures of lower limbs, or fractures of upper limbs were excluded from the study. The height of the student, the lengths of the right and left hand, and the lengths of the right and left foot of each student were measured by the same observer, with the same instrument, on the same day.

Hand length was defined as the direct linear distance between the distal wrist crease and the distal end of the most anterior projecting point (i.e., tip of the middle finger). The students were asked to place their hands flat on a flat, hard, horizontal surface with fingers extended and adducted, following which the hand length was measured. Care was taken to see that there was no abduction or adduction at the wrist joint (i.e., the forearm was directly in line with the middle finger).

Foot length was defined as the direct distance from the most prominent point of the back of the heel to the tip of the big toe or to the tip of the second toe when the second toe was longer than the big toe. Using a calliper, foot lengths were taken independently on the left and right side of each foot.

Stature was measured as the vertical distance between the point vertex and the heel touching the floor (ground surface). Technique: The student stood with erect posture against a wall with the feet axis parallel or slightly divergent and the head balanced on the neck. The measurement was taken without anything worn on the head or foot, using an anthropometric rod.

The collected data was subjected to statistical analysis. The mean, standard deviation, and range for height, right hand length, left hand length, right foot length, and left foot length were calculated separately for males and females.

Correlation of height with right and left hand length and correlation of height with right and left foot length were calculated separately for males and females. Regression equations were developed for stature estimation from hand length and foot length. The regression equation is given by $y = \alpha + \beta x$ where $\beta = \sum xy - n\bar{x}\bar{y}/\sum x^2 - n\bar{x}^2$ and $\alpha = \bar{y} - \beta\bar{x}$.

Results

The statistical data that were extracted from the calculations are tabulated in Table 1, Table 2, and Table 3. Figures 1 through 8 are scatter diagrams showing the correlation between height and the parameters (i.e., hand and foot lengths in both males and females).

Table 2 shows the correlation coefficient of height with the right hand length and the left hand length for males and females and the correlation coefficient of height with the right foot length and the left foot length for males and females. For males, the correlation coefficients of the height with the right hand length and the left hand length are 0.514 and 0.529, respectively, which shows moderate positive correlation. Similarly for females, the correlation coefficients of the height with the right hand length and the left hand length are 0.770 and 0.762, respectively, which shows strong positive correlation. For males, the correlation coefficients of the height with the right foot length and the left foot length are 0.573 and 0.495, respectively, which shows moderate positive correlation. Similarly for females, the correlation coefficients of the height with the right foot length

and the left foot length are 0.269 and 0.221, respectively, which shows weak positive correlation.

The regression formulae developed for stature estimation is shown in Table 3.

All in Centimeters	Range		Mean		Standard Deviation	
	Male	Female	Male	Female	Male	Female
Height	139–179	146–171	167.94	155.33	7.57	5.321
Right Hand Length	17.2–19.7	15–18.7	18.598	17.05	0.641	0.891
Left Hand Length	17–20	15.5–18.7	18.682	17.23	0.768	0.770
Right Foot Length	23–28	21–26	25.05	23.56	1.07	1.05
Left Foot Length	23–28	21–26	24.86	23.47	1.02	0.96

Table 1

Measurement range, mean, and standard deviation for height, right hand length, left hand length, right foot length, and left foot length for both males and females.

	Male	Female
Correlation of height with right hand length	0.514	0.770
Correlation of height with left hand length	0.529	0.762
Correlation of height with right foot length	0.573	0.269
Correlation of height with left foot length	0.495	0.221

Table 2

Correlation of height with right and left hand length and correlation of height with right and left foot length for both males and females.

	Regression Formulae	
	Male	Female
Right Hand Length	**Y1** = 55.24 + 6.06**X1**	**Y3** = 77.24 + 4.58**X3**
Left Hand Length	**Y2** = 70.55 + 5.21**X2**	**Y4** = 65.49 + 5.21**X4**
Right Foot Length	**Y5** = 65.54 + 3.91**X5**	**Y7** = 68.79 + 3.72**X7**
Left Foot Length	**Y6** =75.54 + 3.23**X6**	**Y8** = 68.89 + 3.50**X8**
X1 & X3 - Right hand length of male and female, respectively X2 & X4 - Left hand length of male and female, respectively Y1 & Y3 - Height from right hand length of male and female, respectively Y2 & Y4 - Height from left hand length of male and female, respectively X5 & X7 - Right foot length of male and female, respectively X6 & X8 - Left foot length of male and female, respectively Y5 & Y7 - Height from right foot length of male and female, respectively Y6 & Y8 - Height from left foot length of male and female, respectively		

Table 3

Regression formulae developed for stature estimation from right and left hand length and regression formulae for stature estimation from right and left foot length for males and females.

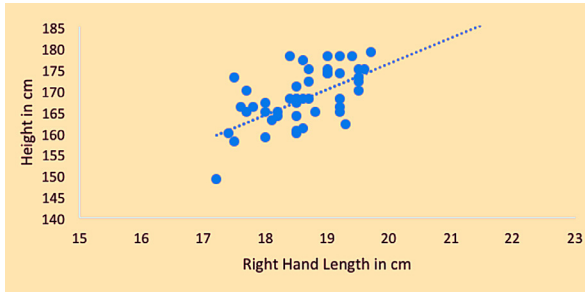

Figure 1

Scatter diagram showing correlation of height with right hand length in males.

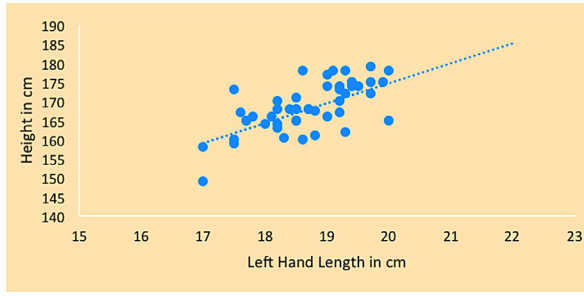

Figure 2

Scatter diagram showing correlation of height with left hand length in males.

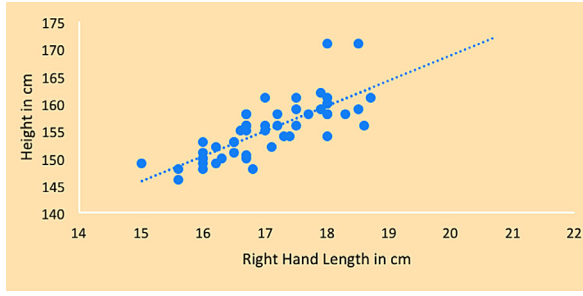

Figure 3

Scatter diagram showing correlation of height with right hand length in females.

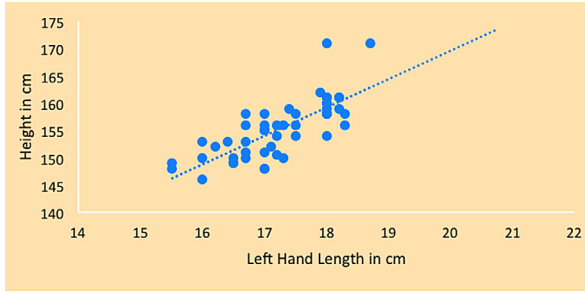

Figure 4

Scatter diagram showing correlation of height with left hand length in females.

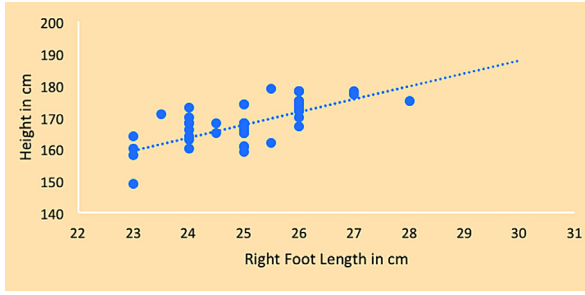

Figure 5

Scatter diagram showing correlation of height with right foot length in males.

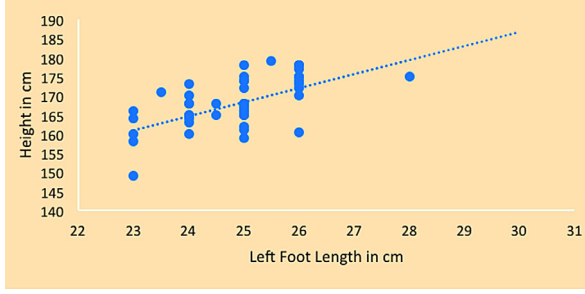

Figure 6

Scatter diagram showing correlation of height with left foot length in males.

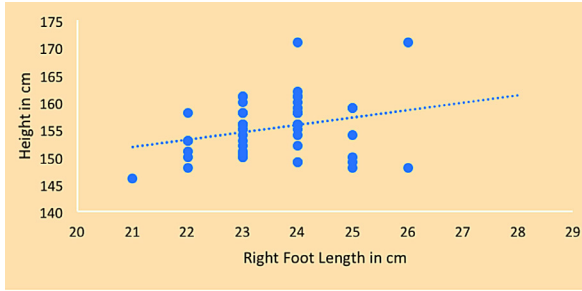

Figure 7

Scatter diagram showing correlation of height with right foot length in females.

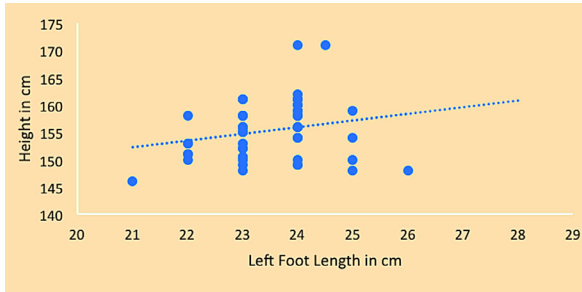

Figure 8

Scatter diagram showing correlation of height with left foot length in females.

Discussion

The results of the present study demonstrate that hand length, as opposed to foot length, gives a better prediction of height in females, whereas in males, both hand length and foot length can give the same prediction for height. The correlation of height with the right and left hand length for males is 0.514 and 0.529, respectively, which shows moderate correlation; the correlation of height with the right and left foot length for males is 0.573 and 0.495, respectively, which also shows moderate correlation. But for females, the correlation of height with the right and left hand length is 0.770 and 0.762, which shows strong correlation, whereas, correlation of height with the right and left foot length is 0.269 and 0.22,1 which shows weak correlation. According to a study done by Isurani Ilayperuma et. al, the correlation

co-efficients (r) of height with a hand length for a male and a hand length for a female were 0.58 and 0.59, respectively, demonstrating that there was moderate correlation between height and hand length, which was essentially the same in both sexes [13]. A study conducted by Ilayperuma et. al [14] shows a correlation coefficient of height with foot length is +0.724 for males and +0.719 for females. According to Krishan and Sharma, the correlation coefficients of height for males and females in the population they studied was 0.609 and 0.677 [15]. A correlation coefficient between height and foot length in the Gujarat population was shown to be + 0.69 for males and + 0.70 for females [16]. According to Jitender et. al, correlation coefficients between stature and all the measurements of hands were found to be positive and statistically significant, with the left hand length in both the sexes together exhibiting the overall highest value of correlation (r = 0.768) with stature [17].

Conclusion

In this study, we derived separate regression equations for the right and left hand and foot lengths for males and females to estimate the accurate stature of individuals. The results indicate that both hand and foot lengths can be efficiently used for the estimation of stature. In females, hand length gives a better prediction of stature when compared to foot length. But in males, both hand length and foot length give the same prediction of stature. However, it should be remembered that the correlation coefficients between foot hand length, stature, and the estimates of stature based on these regression formulae are population specific.

In addition to ethnic differences, secular trends [18] and environmental factors (e.g., socioeconomic and nutritional status) can influence body proportions [19].

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