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Original Research Article

Estimation of Stature from Footprint Length

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Abstract

Height and sex from different parts of the body help in solving crime mysteries related to human identity. Similarly, foot or shoe prints if present at the scene of crime may provide clue regarding the height and the sex of the person that helps in establishing partial identity of the suspect. In the present study, footprints of 100 subjects (50 males and 50 females), ageing 25-40 years. Maximum foot print length and the height of each subject was measured. Predictive equations using linear regression were then derived separately for males, females and for the combined data with the purpose of estimating the height when only the subject's foot print length is known. Thus, in the present study, correlation coefficient (r) of: 0.645666 of left and 0.500692 of right in males, 0.808102 of left and 0.68157 of right in females, And 0.802437992 of left and 0.713979 of right in the combined data was obtained between the height and foot print length of the subjects. The standard error of estimate was: 4.990062 of left and 5.656645 of right in males, 5.110548298 of left and 5.996358 of right in females, And 5.110548298 of left and 5.996359 of right in the combined data. The standard foot print length obtained was: 24.836 cm of left and 24.688 cm of right in male, 23.396 cm of left and 23.256 cm in females. The accuracy of sex determination by this method is reported to be 80%.

1. Introduction

Human height or stature is the distance from the bottom of the feet to the top of the head in a human body, standing erect. It is in centimetres when using the metric system or feet and inches when using the imperial system. Height of an two individuals may vary intra or inter-population. Height is important, because it is closely correlated with other health components, such as life expectancy. Studies show that there is a correlation between small stature and a longer life expectancy. The development of human height can serve as an indicator of two key welfare components, namely nutritional quality and health. The study of height is known as AUXOLOGY.

Ways in which the height of an individual can be measured are numerous, which can be broadly classified as direct or indirect. **Direct Methods:** 1) Using a metric tape 2) Against a graduated pole.

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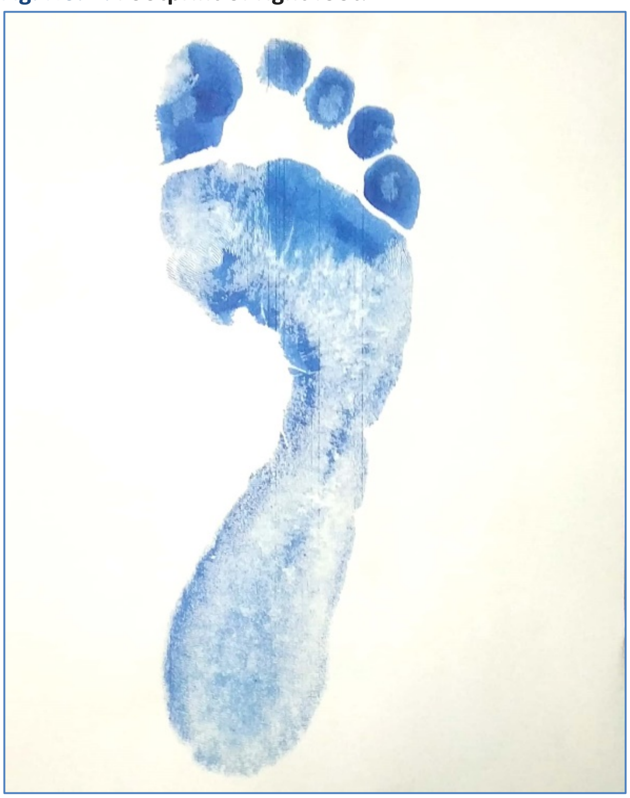
Indirect Methods:[3]

1) Distance between two middle fingers of hand with hand extended away from the flanks.
2) Length from vertex to symphysis X 2
3) Length of one forearm in cm (middle finger to acromion process X2) + 34 cm (clavicle 30 cm + breadth of manubrium 4cm)
4) Length from sternal notch to pubis X 3.3
5) Length from tip of olecranon process to the tip of middle finger X 3.1cm.

But here I have tried to determine the length of an individual from his or her footprint.

Footprints (**fig. 1**) are the impressions or images left behind by a person walking or running. Friction ridge skin present on the soles of the feet and toes (plantar surfaces) is as unique in its ridge detail as are the fingers and palms (palmar surfaces). Footprints have been preserved as fossils and provide evidence of prehistoric life. Known as "ichnites". [4,5]

Fig. No. 1: Footprint of right foot.



2. Materials and Methodology:

A descriptive cross-sectional study was conducted among 100 individuals (50 males and 50 females) ranging from age 25 to 40 years of family members of the patients and staff working at the DVVPF's hospital. This study was done using inkpad, blank sheets, scale and calculator. We conducted this study after Institutional Ethics Committee [IEC] Approval. Data was collected and analyzed using Microsoft excel and Epi info version 7.2.1. Participants who were willing to participate by giving written informed consent were included in the study. Participants having any congenital, acquired foot abnormalities were excluded from the study.

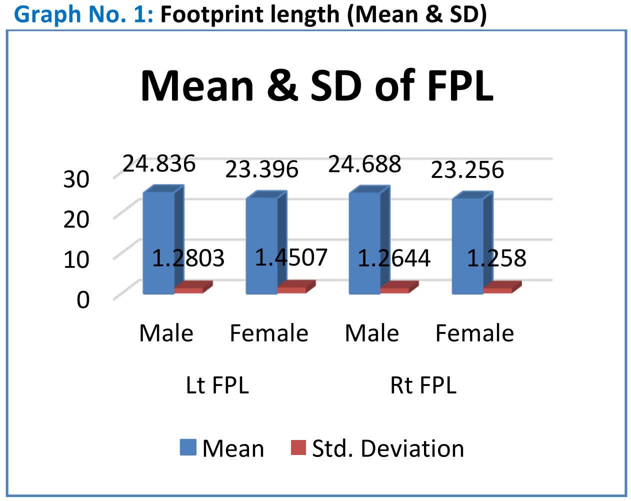
3. Results:

The observations of our study are shown in **table no. 1.** (Min-Minimum, Max-Maximum, SD- Standard Deviation).

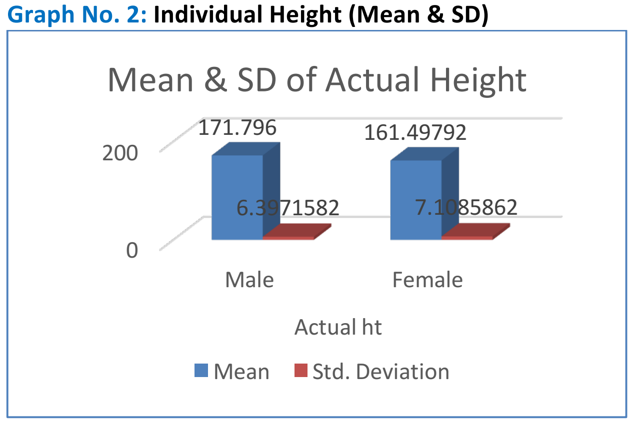
Table no. 1: Combined 50 pairs Foot Print Length

	N	Min	Max	Mean	SD
Lt FPL	50	20.0	27.6	24.116	1.5371
Rt FPL	50	20.0	27.1	23.972	1.4427
Actual height	50	148.50	184.25	166.64 6960	8.4763366

Graph No. 1: Footprint length (Mean & SD)

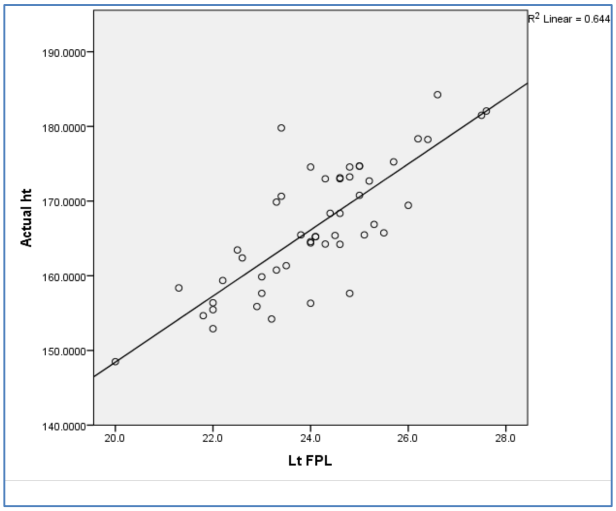


Graph No. 2: Individual Height (Mean & SD)



Mean left foot print length was 24.116 ± 1.5371 cm, range was 20.0 to 27.6 cm. Mean right foot print length was 23.972± 1.4427cm, range was 20.0 to 27.1 cm. Mean actual height was 166.64± 8.47cm, range was 148.5 to 184.2 cm.

Graph No. 3: Linear regression analysis for left footprint length (Lt FPL).



Graph No. 4: Linear regression analysis for Right footprint length (Rt FPL).

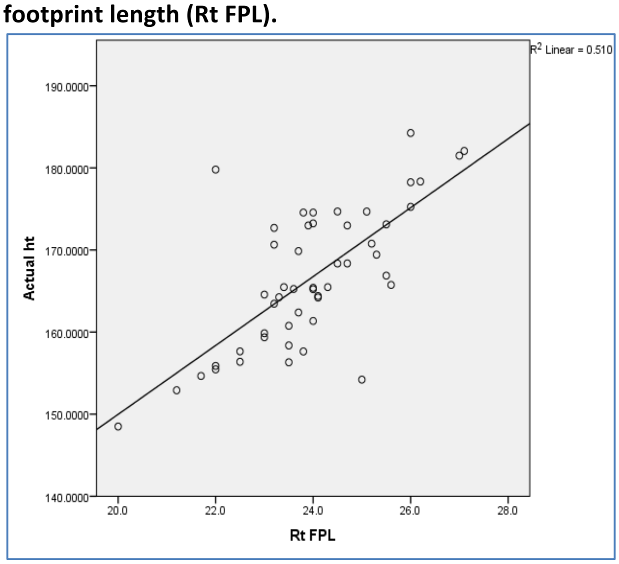


Table no. 2: Combined Left Regression Statistics

Multiple R	0.802437992
R Square	0.64390673
Adjusted R Square	0.636488121
Standard Error	5.110548298
Observations	50

$p < 0.001$; **Regression Formula: 59.93+4.425x**

The regression formula for left foot print from our study was **Regression Formula Left, Stature (Height) = 59.93+4.425xLeft foot length.**

Table no. 3: Combined Right Regression Statistics

Multiple R	0.713979
R Square	0.509766
Adjusted R Square	0.499552
Standard Error	5.996358
Observations	50

$p < 0.001$; **Regression Formula: 66.08+4.195x**

The regression formula for right foot print from our study was **Regression Formula Right, Stature (Height) = 66.08+4.195x Right foot length**

This was statistically significant ($p < 0.001$).

Table no. 4: Descriptive Statistics for males

	N	Min	Max	Mean	SD
Lt FPL	25	22.6	27.6	24.836	1.2803
Rt FPL	25	22.0	27.1	24.688	1.2644
Actual ht	25	162.3900	184.2500	171.796000	6.3971582
Valid N (listwise)	25				

Graph No. 5: Linear regression analysis for left footprint length (Lt FPL) of Male.

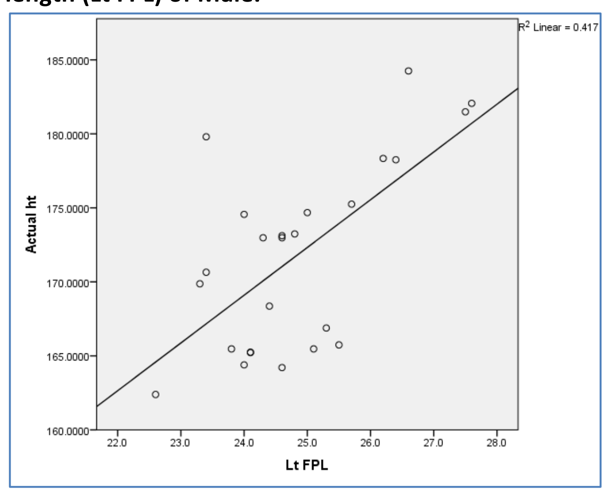


Table no. 5: Regression Statistics for males (Lt FPL)

Males Lt Regression Statistics	
Multiple R	0.645666
R Square	0.416885
Adjusted R Square	0.391532
Standard Error	4.990062
Observations	25

$P < 0.001$; **Regression Formula: 91.67+3.226x**

The regression formula in males for left foot print from our study was **Regression Formula Left, Stature (Height) =91.67+3.226xLeft foot length**

Graph No. 6: Linear regression analysis for Right footprint length (Rt FPL) of Male.

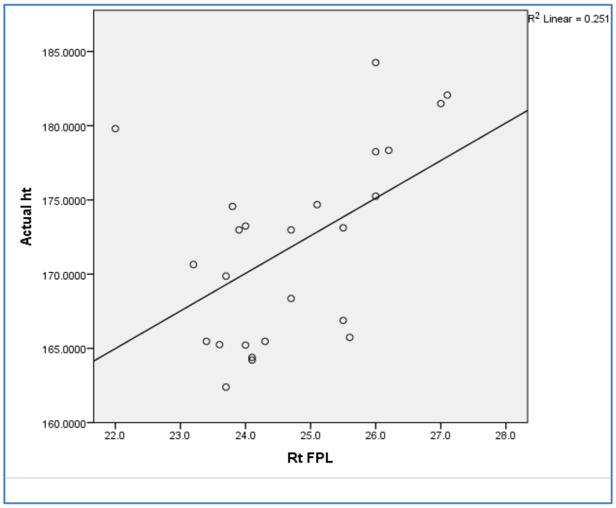


Table no. 6: Regression Statistics for males (Rt FPL)

Multiple R	0.500692
R Square	0.250692
Adjusted R Square	0.218113
Standard Error	5.656645
Observations	25

$P < 0.01$; **Regression Formula:109+2.53x**

The regression formula in males for right foot print from our study was **Regression Formula Right, Stature (Height) =109+2.53xRight foot length**

This was statistically significant ($p < 0.01$)

Table no.7: Descriptive Statistics for females

	N	Min	Max	Mean	SD
Left FPL	25	20.0	26.0	23.396	1.4507
Right FPL	25	20.0	25.3	23.256	1.2580
Actual ht	25	148.5000	174.6900	161.497920	7.1085862
Valid N (listwise)	25				

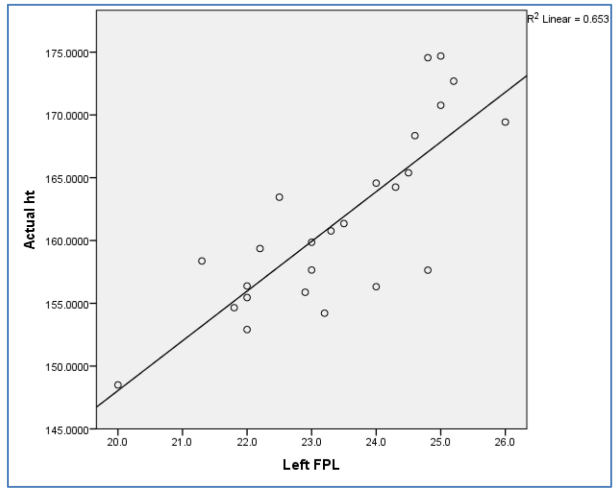
Table no. 7: Regression Statistics for females (Lt FPL)

Multiple R	0.808102
R Square	0.653029
Adjusted R Square	0.637944
Standard Error	4.277316
Observations	25

$p < 0.001$; **Regression Formula:68.85+3.959x**

The regression formula in females for left foot print from our study was **Regression Formula Left, Stature (Height) = 68.85+3.959xLeft foot length**

Graph No. 7: Linear regression analysis for left footprint length (Lt FPL) of Female.



Graph No. 8: Linear regression analysis for Right footprint length (Rt FPL) of Female.

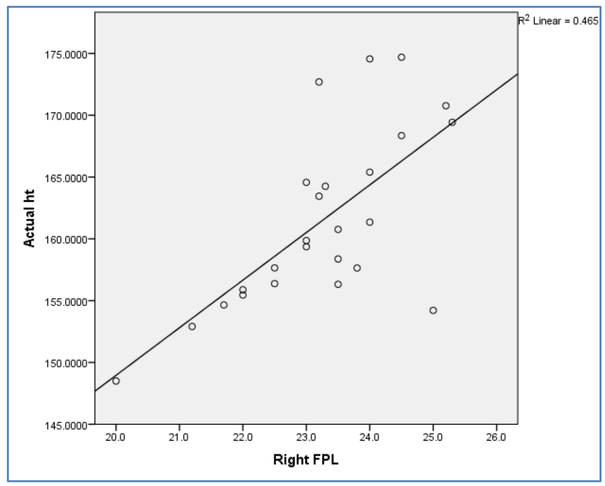


Table no. 8: Regression Statistics for females (Rt FPL)

Multiple R	0.68157
R Square	0.464538
Adjusted R Square	0.441257
Standard Error	5.313607
Observations	25

$p < 0.001$; **Regression Formula: 71.93+3.851x**

The regression formula in females for right foot print from our study was **Regression Formula Right, Stature (Height) = 71.93+3.851xRight foot length**

This was statistically significant ($p < 0.01$).

4. Discussion:

No two individuals are exactly alike in all their measurable traits, even genetically identical twins (monozygotic) differ in some respects. These traits tend to undergo change in varying degrees from birth to death, in health and disease, and since skeletal development is influenced by a number of factors producing differences in skeletal proportions between different regions.

Anthropometry constitutes that means, as it is the technique of expressing quantitatively the form of the human body. In other words, anthropometry means the measurement of human beings, whether living or dead or on skeletal material.[6, 7]

In the present study, males show higher mean values in each anthropometric dimension than among females. These statistically significant differences may be attributed to the early maturity of girls than boys; consequently, the boys have two more years of physical growth. In the present study height is estimated using simple and multiple linear regression models. Our study observes a statistically significant sex difference ($p < 0.001$) in the footprint length measurements between males and females in both right and left feet. A positive and strong correlation exists between various length measurements of the footprint and stature in both the sexes. Males show relatively higher values of correlation coefficients than females. Bilateral differences (right – left differences) were also observed in some of the footprint length measurements among males and females. Linear and multiple regression models are derived for estimation of stature from various footprint length measurements in males, females and for the pooled sample. Many previous studies have elaborated the stature estimation from foot print length and concluded similar findings as in our study.[6-9]

This study helps for easy determination of height through footprints in area of war or medicolegal cases.

5. Conclusion:

The results obtained are found to show less error in predicting stature as compared to other conventional methods used earlier. The percentage accuracy of establishing sex by the standard footprint by rational method is reported to be 80% which is quite significant for use. We advise multicentre study with large number of participants for further research.

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Conflict of Interest: None.

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