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Original Research Article

Estimation of Height from Footprint Length in MGM Warangal

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Abstract

Background: The human foot is studied for various reasons in forensic sciences. It is of value in the crime scene in establishing the personal identity and can be a useful link for the perpetrators of crimes. The present study aimed to estimate the height of an individual based on their footprint lengths.

Methods: This cross-sectional study was conducted in the Department of Forensic Medicine, Kakatiya Medical College, and MGM Hospital, Warangal, Telangana State. A total of n= 50 male and n=50 female students were included for the study aged from 18 to 23 years. Glass plate of (2 X 2 Feet) cleaned and smeared uniformly with painter ink will be kept on the floor. Students with dry feet will be asked to stand on the smeared glass plate first and then, on two separate white sheets so that prints of the right foot and left foot will be transferred on these white sheets separately. Height is measured with a stadiometer.

Results: The average footprint length of the right foot was slightly larger than the left foot in males. A relevant correlation (r) value was found to be positive for the right footprint (+ 0.560). In females, the average footprint length of the right was also slightly larger as compared to the left footprint length. The correlation coefficient (r) values were however strongly positive for left foot + 0.712 versus right foot + 0.614. The relevant regression equations have been developed and depicted in tables 3 and 4.

Conclusion: it can be concluded that the footprint length in males, as well as females, shows a good correlation with body height. Therefore, footprint length can provide better reliability and accuracy in the estimation of body height. In males, the right footprint gives a better correlation and in females, both right and left footprints are equally reliable.

Keywords: Height, Footprint length, Stature, Male, Female

Introduction

The human foot is studied for various reasons in forensic anthropology because time is a critical factor in crime scene investigation, so rapid identification of the suspect is very important. Though several parameters help in identifying a person, the stature of the individual is most important. Evidence that a person leaves at the crime scene is likely to include footprint or shoe print. [1] If a body has been dismembered or mutilated where the only foot is available, the approximate stature may be determined by foot length. The stature estimation is rather an easy task if there is a

complete dead body, but it is very difficult in cases where only some parts of the body are available. Its usefulness in various aspects of murder, natural mass disasters, railway and road accidents, bomb blasts, etc., Footprint can be collected almost from every kind of crime scene. [2] Examination of the footprint is important in developing countries as people go barefoot due to socio-economic status and climatic conditions in rural places. Forensic pathologists are requested to handle the identification of unknown dead, mutilated, dismembered human remains many times. [3] As there is a link between the foot length and the stature of a person as in cases of other parts of the body and stature, it is necessary to develop the method to determine stature from the footprint length, as it varies by geography, climate, genetics, nutrition and diet, race, religion, and socioeconomic state of the local population. [4] The footprint is one such important piece of evidence we find in the crime scenes. The statistical linear regression method is prescribed to determine and bring a common formula for estimating stature from various body parts like the length of upper and lower limbs, lip prints, etc. A fine correlation coefficient is noted between the footprint length and the stature of a person. The long bones of the lower limbs usually ossify late while the bones of the feet ossify in an earlier stage of life. Determination of age from the bones of the feet is much more reliable than that of the long bones during the adolescent age. [5] And that is why the foot length is important in archeological studies, anthropology, and the practical aspects of medico-legal issues. With this background, we in the current study tried to estimate the height of a person based on his/her footprint in our group of population.

Material and Methods

This cross-sectional study was conducted in the Department of Forensic Medicine and Toxicology, Kakatiya Medical College, and MGM Hospital, Warangal. Institutional Ethical Committee clearance was obtained for the study. Consent was obtained from all the participants of the study and only those voluntarily willing to participate were included in the study. The method of sampling used was convenient sampling

Inclusion criteria

1. Male and Female Medical students of Kakatiya Medical College
2. Aged between 18 to 23 years
3. Voluntarily willing to participate in the study

Exclusion criteria

1. Abnormalities of lower limb/ foot
2. Spinal/skeletal abnormalities
3. History of endocrinal disorders
4. H/O Fracture of the foot with surgical treatment

Based on the inclusion and exclusion criteria n=50 male students and n=50 female students were included in the study. Material such as black ink, non-breakable glass plate, white sheets, roller, pencils, scales, tape, a calculator was kept ready. A 2 X 2 feet glass plate smeared with painter ink was kept on a flat floor. The students were asked to wash and dry their feet followed by standing on the smeared glass plate with one foot and the same print was collected on the white sheet kept aside the pate. Both right and left footprints were transferred to the white sheets in this way. All the footprints were recorded in this manner and the footprint length was measured from heel to tip of extension of the longest toe. The height was measured with a stadiometer without foot ware and the measurement was recorded. All the collected data were entered in MS Excel spreadsheet analysis of data using descriptive statistics such as percentage and standard deviation and linear regression equation for each group was calculated by using SPSS version 20 on windows format.

Results

N=16(32%) of the males were having the average Right Footprint Length (RFPL) between 24.1 to 25 cm and mean height was 173.5 cm similarly, for the left foot n=19(38%) subjects were having an

average length between 24.1 to 25 cm and mean height was 172.6 cm. The other descriptive division of the right and left footprint length and mean height have been depicted in table 1.

Table 1: Right Footprint and left footprint Length and Height in Male Students

RFPL (cm)	*(n)*	*Min Ht (cm)*	*Max Ht (cm)*	*Mean Ht (cm)*	*S.D (cm)*	*LFPL (cm)*	*(n)*	*Min Ht (cm)*	*Max Ht (cm)*	*Mean Ht (cm)*	*S.D (cm)*
22 – 23	05	159.5	170.5	165.9	5.3	22 – 23	05	165.5	171.5	168.7	2.0
23.1 – 24	10	163.5	176.5	170.2	4.2	23.1 – 24	06	164.5	174.5	169.4	4.4
24.1 – 25	16	156	175.5	173.5	5.2	24.1 – 25	19	156	186	172.6	5.6
25.1 – 26	13	168	186	186	5.4	25.1 – 26	14	166	181	174.3	4.5
26.1 – 27	04	175	183	183	4.5	26.1 – 27	04	169.5	183	175.8	4.8
27.1 – 28	02	179	196	196	8.5	27.1 – 28	02	180.0	183.5	181.75	3.5

The measurement of right footprint length (RFPL) in females found n=18(36%) subjects between the length 21.1 – 22 cm with a mean height of 153.2 cms. Similarly, for the left footprint measurement n=19(38%) of cases were with length 21.1– 22 cm the mean height was 152.6 cms. The smallest foot measured for the right side was 19.8 cm in one subject and similarly, for the left side, there were n=2 subjects with 19.8 cms measurement. A detailed description is given in table 2.

Table 2: Right Footprint and left footprint Length and Height in Female Students

RFPL (cm)	*(n)*	*Min Ht (cm)*	*Max Ht (cm)*	*Mean Ht (cm)*	*S.D (cm)*	*LFPL (cm)*	*(n)*	*Min Ht (cm)*	*Max Ht (cm)*	*Mean Ht (cm)*	*S.D (cm)*
19.8 – 21	06	150.5	154.5	152.5	2.3	19.8 – 21	07	144	156	151.2	3.9
21.1 – 22	18	144 .1	160	153.2	3.4	21.1 – 22	19	151	160	152.6	6.0
22.1 – 23	15	154.3	169	161.2	4.9	22.1 – 23	14	15	169	159.6	5.8
23.1 – 24	08	160.1	170	164.1	3.6	23.1 – 24	05	161	170	164.8	3.7
24.1 – 25	03	156.7	171	164.8	6.6	24.1 – 25	05	156	172	164.8	6.6
> 25.1	00	00	000	000.0	0.0	> 25.1	00	00	000	000.0	0.0

The average footprint length of the right foot was slightly larger than the left foot in males. A relevant correlation (r) value was found to be positive for the right footprint (+ 0.560). The left footprint length was smaller and there was a weak positive correlation of left footprint length because the (r) values were (+0.161) the differences were statistically insignificant. The regression formula to calculate the height based on the right footprint length was 85.75 + 3.56 (RFPL). Similarly, for calculation of height from left footprint length was 89.33 + 3.25 (LFPL) the other details depicted in table 3.

Table 3: Regression equation of Right Footprint Length, Left Footprint Length, and height in Male Students

Variable	*Mean ± SD*	*Range*	*r-value*	*Reg. Coeff. b-value*	*Reg. Equation (height)*
RFPL	23.5±1.15	22.0–27.9	+ 0.560	3.56	85.75+ 3.56 (RFPL)
Height	172.3 ± 6.64	157 – 195			
LFPL	24.4±1.21	21.5–28.7	+ 0.161	3.25	89.33 + 3.25 (LFPL)
Height	172.3±6.64	157 – 195			

In the females, out of n=50 subjects, the average footprint length of the right was also slightly larger as compared to the left footprint length. The correlation coefficient (r) values were however strongly positive for left foot + 0.712 versus right foot + 0.614 the differences were although not statistically considered as significant. Based on the right footprint the regression to estimate the height of females was 58.66 + 4.41 (RFPL) and for the left foot it was calculated as 58.90 + 4.42 (LFPL) the details have been given in table 4.

Table 4: Regression equation of Right Footprint Length, Left Footprint Length, and height in female Students

Variable	*Mean ± SD*	*Range*	*r-value*	*Reg. Coeff. b-value*	*Reg. Equation (height)*
RFPL	22.5± 2.05	19.8–24.9	+ 0.614	4.12	58.66 + 4.41 (RFPL)
Height	157.55 ± 5.89	144.3-171.5			
LFPL	22.10 ± 2.60	19.8 – 24.5	+ 0.712	4.22	58.90 + 4.42 (LFPL)
Height	157.55 ± 5.89	144.3-171.5			

Discussion

The footprint is an important identifying factor having many applications right from identification of newborn babies in hospitals to avoid swapping to a criminal person who might have a missing toe, flat foot, or any other deformity of the foot. Nowadays, the footprint is also an important identifying factor. This becomes a piece of strong evidence to identify the culprit excluding all other suspects. During the eighteenth century, a mathematical formula was formulated by Topinard to estimate a person's height: maximum foot length divided by 0.15 reveals the stature of most individuals. [6] However, this formula may not be applicable in all the different races where there may be genetic variations. Therefore, the quest for the formula to be applied in our group of the population lead to this research being conducted. The results of our study found that the mean height of a male is taller as compared to females which is a very common observation in other studies. [6] However, A study by Ilayperuma et al., [7] found the height of females in the Czech Republic is slightly greater than that of males. The variation in the height between males and females is mainly due to sex chromosome inbuilt properties. In this study, the footprint length of the male was greater than females which are in concordance with the observations made in other similar studies in this field. [8, 9] In the current study it was observed that the footprint of the right foot was slightly greater than the left foot both in males and the differences were insignificant. In the case of females, the right footprint was also found to be greater, but the differences were insignificant. An interesting observation by Vidya CS et al., [10] in the South Indian population found both in males and females the left footprint was lengthier as compared to the right footprint. Janarthanan R et al., [11] in a similar study done in Bengaluru found the right footprint was larger as compared to the left footprint which is in agreement with the observations of the

current study. In this study, we included subjects aged below 25 years because the bone mass peaks around this age and then gradually tends to decline in both men and women. Firooznia et al., [12] have shown that bone loss with age is a natural phenomenon and tends to decline after the age of 25-30 years. In the current study, we developed a separate regression equation for each foot in both male and female subjects depicted in Tables 3 and 4 respectively. Similar regression equations have been developed by the other studies in this field by various authors. [13,14] However, the important limitation is the sample size in these studies. In this study, we used n=50 male subjects and n=50 female subjects but to get an accurate regression equation the sample size should be more.

Conclusion

Within the limitations of this study, it can be concluded that the footprint length in males, as well as females, shows a good correlation with body height. Therefore, footprint length can provide better reliability and accuracy in the estimation of body height. In males, the right footprint gives a better correlation and in females, both right and left footprints are equally reliable. The regression formula developed in this study may be utilized by anthropologists, anatomists, and forensic experts for estimation of stature.

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