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Correlation of Handprints and Footprints with respect to Stature: Study on Maharashtrians of Mumbai

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Abstract. Identification of an individual is an important aspect in forensic investigations. Stature estimation is of interest to forensic scientists for its importance in human identification. The present study was an attempt to deduce the stature from footprints as well as the hand prints and hence to determine whether there is any correlation between the stature and the respective prints/ length. Footprint is valuable physical evidence that can be found at scene of crime and its identification can facilitate elimination of the suspects and establishing the identity of the criminal. Also handprints to some extent can help in estimation of stature. The study aimed to estimate the stature in a sample of 1000 bilateral footprints and handprints collected from 500 adult Indian male Maharashtrians and 500 adult Indian female Maharashtrians from Mumbai who consented to volunteer in the study and ranged in the age-group of 18 to 25 years. Samples were collected and data was entered in Microsoft Excel 2007 and statistically analyzed using linear regression analysis. In case of both males and females all footprint lengths exhibit a statistically positive significant correlation with stature. Similarly, handprint lengths exhibit a statistically positive significant correlation with stature. The values of correlation co-efficient shows that the footprint length is more significantly correlated with stature compare to handprint lengths.

Keywords: Anthropometry; Handprints; Footprints; Stature; Correlation.

1. Introdução

Anthropometry is a field of science which includes measurement of human body, its component parts and relative dimensions for various purposes. These

measurements include length of various measurable body parts such as the length of limbic bones, pelvic bone, skull, body weight, height etc. Anthropometry is presently considered as an important branch of Forensic Science. It has many applications in forensic medicine and forensic science. The various branches of Anthropometry include Somatometry, Craniometry, Cephalometry and Osteometry.

One of the important parameter in anthropometry is human stature. Stature is the height of the person in upright position. Height varies greatly between individuals and across populations for a variety of environmental, genetic and biological factors. Once we estimate the possible height of the victim or the suspect using his footprints or handprints, then the suspect pool is reduced thus taking us closer to the possible individual which will also help us in identification of the same. In medico-legal autopsies, establishing personal identity of the victims is often required. Estimation of stature from extremities and their parts plays an important role in identifying the dead body in forensic examinations.

Cephalo-facial dimensions in a North Indian population have been used for determination of stature¹. Estimation of stature from footprint and foot outline dimensions in Gujjar tribe of North India has also been reported². Skeletal height reconstruction from measurements of the skull in indigenous South Africans has also been reported³. A study on stature estimation determination of stature from foot and its segments in a north Indian population has also been reported⁴. Sex Determination from hand dimensions of North and South Indians has also been reported⁵. Anthropometric relationships within and between hand and foot dimension have been shown useful for personal identification in mass disasters⁶. Estimation of stature from the anthropometric measurement of hand length has also been reported⁷. Static and dynamic footprints have also been used for stature estimation⁸. A study on estimation of stature from upper limb length been carried out on Sudanese adults⁹. Estimation of stature from foot prints of Indian Tamils has also been reported¹⁰.

Many researchers also studied that the reliability of prediction of height from foot length was as high as that from long bones. We can deduce stature of an individual if we find the footprint / handprint / foot length / hand length of the individual. Also Ossification and maturation in the foot occurs earlier than the long bones and therefore, during adolescence age, height could be more accurately predicted from foot measurement as compared to that from long bones.

The aim of the present study was to find out the correlation between foot length and hand length with respect to height of an individual using regression formulae in the sample population. In this work, correlation between stature and footprint and, stature and handprint is achieved after devising linear and multiple regression equations that will help in estimating stature whenever the mutilated remains or fragments of feet are recovered.

2. Materials and methods

This study was carried out on 1000 individuals. 2000 samples of bilateral footprints and handprints were collected from 500 adult Indian male Maharashtrians and 500 adult Indian female Maharashtrians from Mumbai who consented to participate in the study and ranged in age from 18 to 25 years. For this study anthropometric measurements were taken. Height was measured to the nearest 0.1cm with a Stadiometer (Seca).

Foot measurement for each subject was taken by firmly placing the foot on the sheet of paper and drawing an outline all the way around the foot. The length and width of the foot was marked using the topmost and the bottom points and the length was thus measured to the nearest 0.1cm with a ruler (Camlin).

Similarly, hand measurements for each subject was taken by firmly placing the hands on the sheet of paper and an outline was drawn all the way around and highest and the lowest points were used to measure the hand length. The length and width of the hand was marked using the topmost and the bottom points and the length was thus measured to the nearest 0.1cm with a ruler (Camlin).

3. Results

Foot length and hand length displays a 95% biological correlation with respect to height that suggests that height might be estimated from foot or shoeprints and hand prints. From the collected data, statistics and regression analysis are applied, and multiplication factors are deduced to form simple equations:

$$\text{Maximum/mean foot length} \times \text{correlated factor (x)} = \text{height.} \quad (1)$$

$$\text{Maximum/mean handprint/hand length} \times \text{correlated factor (y)} = \text{height.} \quad (2)$$

- In the present study, the height varied from **159 cm to 186 cm for males** and from **149 cm to 170 cm for the females**.
- The length of footprint varied from **20.7 cm to 24.8 cm**. Thus the value of mean value is **22.94 cm** (standard deviation, SD = 1.13 for females and SD = 1.27 for males).
- The length of handprint varied from **15.7cm to 19.5cm**. Thus the value of mean average is 17.03cm. (SD = 0.77 for females and SD = 0.82 for males).
- Multiplication factor was deduced for both hand prints and footprints and is denoted by (x) for footprints and (y) for handprints (see Table 1).

Table 1. Multiplication factor for both genders.

Multiplication Factor	Male	Female
X	$x_m = 6.79$	$x_f = 6.88$
Y	$y_m = 9.13$	$y_f = 9.26$

x_m – multiplication factor for footprints in case of males; x_f – multiplication factor for footprints in case of females; y_m – multiplication factor for handprints in case of males; y_f – multiplication factor for handprints in case of females.

Table 2 shows the correlation coefficient calculated for different measures for both genders. This coefficient is calculated according Eq. 3:

$$r = \frac{\sum d_x d_y}{\sqrt{(\sum d_x^2 \sum d_y^2)}} \quad (3)$$

Table 2. Correlation coefficients.

	Male		Female	
	Footprint w.r.t. Stature	Handprint w.r.t. Stature	Footprint w.r.t. Stature	Handprint w.r.t. Stature
Correlation Coefficient r	$r_{mf} = 0.83$	$r_{mh} = 0.76$	$r_{ff} = 0.54$	$r_{fh} = 0.66$
Calculated r	$r_{mf} (hx) = 5.84$	$r_{mh} (hy) = 5.34$	$r_{ff} (hx) = 3.88$	$r_{fh} (hy) = 4.62$

h – height; r_{mf} – correlation factor for two variable: stature and footprints in case of a male;

r_{mh} – correlation factor for two variables: stature and handprints in case of a male; r_{ff} – correlation factor for two variables: stature and footprints in case of a female; r_{fh} – correlation factor for two variables: stature and handprints in case of a female; $r_{mf} (hx)$ – calculated

correlation factor for two variables: stature and footprints in case of a male; r_{mh} (**hy**) – calculated correlation factor for two variables: stature and handprints in case of a male. r_{ff} (**hx**) – calculated correlation factor for two variables: stature and footprints in case of a female; r_{fh} (**hy**) – calculated correlation factor for two variables: stature and handprints in case of a female.

For the values to be statistically significant, the value of calculated r should be greater than the tabulated value for r . We observed that:

- The tabulated r for this particular calculation is 0.29.
- Since the values of calculated r (i.e., r_{mf} , r_{mh} , r_{ff} and r_{fh}) for foot prints and handprints are greater than the tabulated value; so both the variables show a positive correlation.
- Also the value of correlation factor should never exceed than one. The closer the value comes near one, the more significant that particular measurement is.
- Hence, with this condition we derive that in males, the footprints are more significant and will give more precise information about the stature as compared to handprints. But in case of females, handprints tend to give more precise information about the stature than footprints.

4. Conclusions

The present study provides baseline information for the Maharashtrian population from Mumbai. It could lead to the development of a standard for such data on various groups of the population. The present study concludes that footprint length measurements have a strong relationship with the stature of adult male Maharashtrian compared to the female. From the present study we found some multiplication factors which were helpful for estimation of stature from respective foot lengths and hand lengths. Also we compared that whether footprints are more accurate or handprints to estimate the stature of an individual. The results showed that footprints tend to give us more accurate measurements with respect to height in case of a male. But it is vice-versa in case of a female.

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