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PERSONAL RECOGNITION OF SEX AND STATURE BASED ON PODOGRAM

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ABSTRACT

Background: Height and sex derived 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, an attempt has been made to derive regression formulae to determine height from foot print length in both sexes individually as well as for the combined data (males and females). An attempt was also made to determine the sex using the statistically derived standard foot print length as a benchmark. **Material & Methods:** Foot prints of 200 subjects (100 males and 100 females), from among the college going students of NKP Salve Institute of Medical sciences & Research Centre & Lata Mangeshkar Hospital, Nagpur, Maharashtra., India were studied. Maximum footprint 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. The standard foot print length (obtained from the statistically derived standard foot print length formula) was used as a benchmark to estimate the sex of the individual. **Results**: Thus, in the present study, correlation coefficient (r) of 0.698 in males, 0.738 in females and 0.848 in the combined data was obtained between the height and foot print length of the subjects. The standard error of estimate was 4.66 in males, 4.528 in females and 4.778 in the combined data. The standard foot print length obtained was 23.55 cm. The accuracy of sex determination by this method is reported to be 80%. **Conclusion:** The study has revealed a highly significant degree of correlation between the measurements of footprint lengths and stature from footprints of 200 subjects of both sexes between the ages of 18-26 years. The percentage accuracy of establishing sex by the standard foot print ration method is reported to be 80%, which is quite significant for use.

KEYWORDS: Anthropology, Stature, Sex, Regression formulae, Standard foot print length.

INTRODUCTION

Every part of the human body is unique in itself. It is amazing to discover that every part of the body is different in its own way from a similar part in another body. There is also a relationship between each part of the body and the whole body. Nothing exemplifies this truth more than the relationship that various parts of the body have to the stature and sex identity of an individual.[1,2] Many authors have studied the relationship between various parts of the body with the stature and sex.[3-10] Stature estimation from dismembered body parts can be done based on the ratio of the body part concerned, in relation to the entire body.[3] The relationship between humerus, radius, ulna, femur, tibia and clavicle with the stature have been topics of research interest for decades.[1,3-7] Morphology of human feet is greatly influenced by the combined effects of heredity and living style of man that determines the size and shape of the foot or footprints and thereby makes them unique data to establish human identity.[2,3,8]

Clinicians, anthropologists, anatomists and forensic scientists have studied the various aspects of foot, over a long period of time.[1] Researchers have studied the relationship between footprints and stature, using various methods. This study was undertaken with an objective of assessing the reliability and applicability of estimating stature and sex identity by deriving linear regression equations and a standard foot print formula respectively thus providing additional evidence to the foot print study in determining stature and sex.

MATERIALS AND METHODS

The present study was a cross-sectional study conducted at NKP Salve Institute of Medical sciences & Research Centre & Lata Mangeshkar Hospital, Nagpur from May-16 to June-16 which was scrutinized & permitted by

Institutional Ethics Committee. The study subjects comprised of participants who were 18-26 years old college going students of NKP Salve Institute of Medical sciences & Research Centre & Lata Mangeshkar Hospital, Nagpur, India. Only those students with healthy and normal feet were included in this study. Footprints were obtained from 100 male and 100 female participants.

Kores duplicating ink was uniformly spread on a glass slab using a roller and the subject was first asked to place his/her feet on the slab and then on a plain white sheet of paper. The footprints thus obtained were numbered and filed. After taking the footprints, the sole of the feet were cleaned with cotton wool soaked in acetone. The subjects were advised to wash it again with soap and water. The footprints obtained from the right foot of the subjects were selected for the study (the 0.95-0.99 length correlation between the right and the left footprints, as stated by Robbins'[9] makes it apparent that either foot can be used for estimating stature). Maximum foot print length was measured as a straight distance between the highest points on the first or the second toe (whichever was higher) and the lowest point on the margin of the heel.[4,9]

Stature of each individual was measured as a vertical distance from the floor to the vertex. The subject was asked to stand bare foot and with the head in the Frankfurt plane.[9]

Figure 1: Measurement of maximum foot print length.

The data collected was then analyzed using the computer software SPSS version 10.0 and linear regression equations were derived to determine the stature from maximum foot print length. The results obtained were compared with the actual stature of the subjects. This was followed by determination of sex wherein the following formulae was derived to determine the sex from footprint length by calculating the statistical mean as shown below.

$$\text{Standard footprint length} = \frac{(\text{male mean FPL-SD}) + (\text{female mean FPL +SD})}{2}$$

All the foot print lengths less than or equal to this standard foot print length were presumed to be belonging to females, while all the foot print lengths greater than the standard foot print length were presumed to be belonging to males. On applying the sensitivity and the specificity tests on the results obtained, the accuracy of predicting sex by this method was determined.

RESULTS

The mean height and the footprint length of the males were greater than that of the females (Table 1). There was a partial positive correlation between the footprint length and the height of a person for males, females and for the combined data, with correlation coefficient (r) = 0.7 for males, (Fig 2), 0.74 for females (Fig 3) and 0.85 for the combined study population (Fig 4).

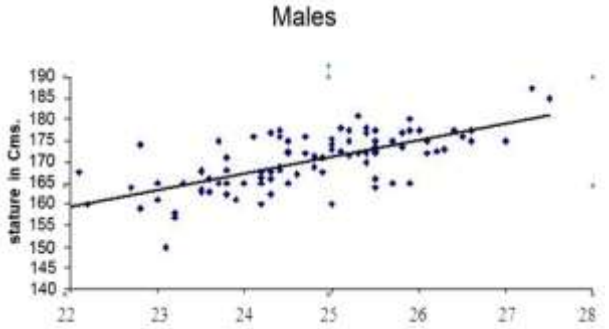

Figure 2: The graph plotted between the footprint length and the height for the male study population.

The regression formulae derived (Table 2) in the present study, and the results obtained were compared with the actual stature of the subjects. It is evident from the present study that 79% of the stature values predicted by the respective regression formulae in males, 89% in females and 92.5% in the combined population fell within one standard deviation of estimate range of predicted stature.

Table 1: Mean and standard deviation (SD) values of height and foot print length for the study data.

Mean & S.D	Male	Female	Combined
Height (Measured) Mean (Cms)	170.04	157.84	163.94
(S.D)	6.47	6.76	9.0
Foot – Print Length Mean (Cms)	24.67	22.43	23.55
(S. D.)	1.15	1.17	1.61

Table 2: Regression formulae to estimate height from foot print length, along with the standard error (S.E) of estimate for males, females and the combined population.

Male /Female/Combined	Regression Formula	Standard Error
Male	Y =72.997+3.933x	4.6609
Female	Y = 59.12+4.367x	4.5825
Combined	Y=48.132+4.903x	4.7708

X =foot print length, Y=height

The Standard Foot Print length as obtained from the respective formula is equal to 23.55 cm. An attempt was made to determine the sex of the subjects using this value.

All the foot print lengths less than or equal to this value were presumed to be belonging to females while all the values greater than this were presumed to be belonging to males. On applying the sensitivity and the specificity tests, the accuracy of sex prediction by this method was found to be 80%. In figure 5, the left side (the lower range of foot print length between 20 to 22.9 cm) is predominated by females while the right side (the high range of foot print length, that is, >24.6 cm) is predominated by males. A small range of foot print length, in the centre of the graph, shows almost equal number of males and females, which may justify the 20% error obtained in predicting sex by this method.

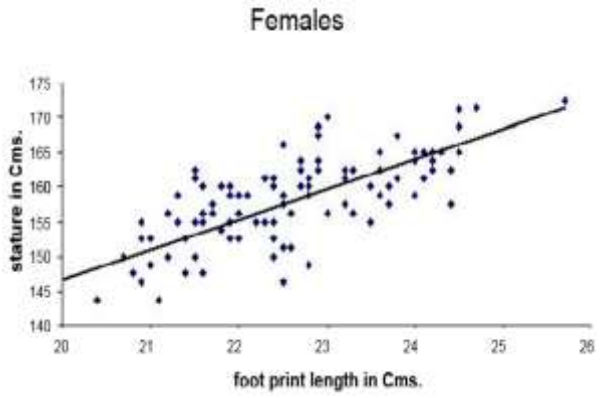

Figure 3: The graph plotted between the foot print length and the height for the female study population

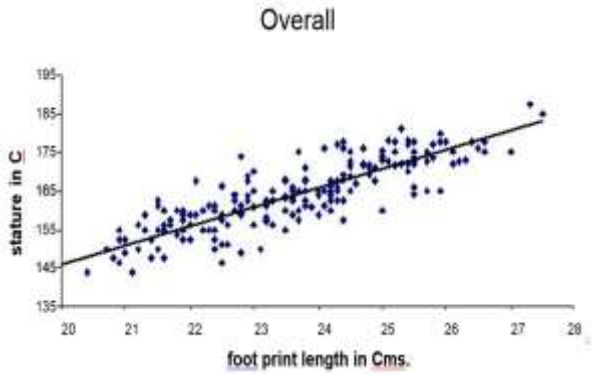

Figure 4: The graph plotted between the foot print length and the height in the combined study population.

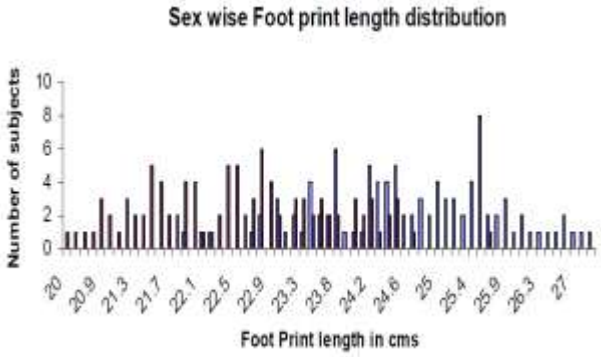

Figure 5: The graph plotted between the foot print length and the number of subjects.

The lower range of foot print length (i.e.between 20 to 22.9 cm) is predominated by females while the high range of foot print length, (i.e. >24.6) is predominated by males. A small range of foot print length, in the centre of the graph, shows almost equal number of males and females, which may justify the 20% error obtained in predicting sex by this method.

DISCUSSION

It was observed that in most of the samples of footprints, there was a difference in the length of right and left

footprints. Since the right foot was the dominant foot in the majority of the subjects, it was selected in the present study.

The measurement of the maximum foot print length of the right foot was used for predicting stature, which was then compared with the actual stature of the subject. The results thus obtained were found to obey the normal distribution rule in which 68% of the values are expected to fall within one SD of estimate range.[1]

In the past Anthropologists like Topinard, Martin and Robbins developed a 15% foot length to stature ratio and a 14% foot print length to stature ratio.[9] Stature ratio method and multiplication factor method were used by related studies in India.[10] However, when these methods were applied in our study, the data showed larger error and thus lesser accuracy in predicting stature from footprints. In a hope to minimize these errors and enhance the accuracy of predicting stature, regression formulae were developed and applied in this study.

Determination of sex in the same study offers us an opportunity to apply the respective regression formulae to the male and female footprints that may lead us towards identification that is more accurate.

CONCLUSION

The study has revealed a highly significant degree of correlation between the measurements of footprint lengths and stature from footprints of 200 subjects of both sexes between the ages of 18-26 years.

Regression formulae have been developed to predict stature separately for males, females and the combined data along with the standard error of estimate. The results obtained are found to show less error in predicting stature as compared to other conventional methods used earlier. Moreover, in an aircraft accident it is the feet, which are recovered more intact than other parts of the body, as they are often shoe clad. Hence, feet can be excellent clue regarding personal identity.

The percentage accuracy of establishing sex by the standard foot print ration method is reported to be 80%, which is quite significant for use.

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