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FOOT ARCH PATTERN AND STATURE ESTIMATION FROM FOOTPRINT USING STUDENTS OF THE UNIVERSITY OF PORT HARCOURT.

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ABSTRACT

Stature or body height is one of the most important and useful anthropometric parameter that determine the physical identity of an individual. Identification of an individual is the mainstay in forensic investigations. Foot lengths have been used for the determination of sex, age and stature of an individual. The present study examined the foot arch pattern and the relationship between stature and foot length among students at the University of Port Harcourt. Stature and foot prints of 250 subjects comprising 125 males and 125 females falling within the age range of 18-30 years were measured; stature was measured from the vertex of the head to the floor maintaining the anatomical position and Frankfurt plane, foot length was obtained from the foot print by measuring the distance between acropodion and the pternion. Foot arch patterns were obtained by comparing the arch patterns from the foot print with the standard foot arch patterns. Statistical analyses using with respect to sexual dimorphism was highly significant ($p<0.05$); while there was no statistically difference with respect to bilateral differences between the left and the right foot in all measurement ($p>0.05$). The regression formulae for males are (H for left foot = 4.55(LFL) + 56.0. H for right foot = 4.45(RFL) + 56.3).While females are (H = 3.80(LFL) + 72.7. H = 3.78(RFL) + 73.61). The correlation coefficients between stature and foot length were found to be positive and statistically significant ($p<0.05$) as it tends towards one (0.83 in males and 0.74 in females). This high correlation coefficient observed between stature and foot length in males and female indicates that foot length provides a very high reliability and accuracy in estimating stature of an unidentified male or female.

INTRODUCTION

For many years the relationship that exists between different parts of the body and height has been of great interest to anthropologist (Trotter and Glaser 1952). This is because of the increase in the number of catastrophic events causing mass death, for example: plane crash, mass suicide, tsunami, forest fire, earthquakes etc, which requires the identification of victims from dismembered human remains.

Many investigators have studied the relationship between heights of human and the length of various long bones (Dupertius and Hadden, 1951, Trotter and Glasser

1952, Zorab *et al.*, 1993). They found out that foot prints are of immense value in establishing personal identity such as stature.

It has been established previously that that dimensions of the lower extremities show greater association with body height than those of the upper extremities (Ozaslan *et al.*, 2003; Fessler,2005). Footprints are of immense value in establishing personal identity of a criminal in forensic examination, as they are found to be a kind of evidence at the crime site that link the crime to the proprietor. The partial or complete foot can be found on the rain covered surfaces, newly waxed floors, freshly cemented surfaces, moistened surfaces, in dust, mud, sand, oil, paints and blood at murder scenes (Qamra *et.al.*, 1980). The morphology of human foot shows variation due to the combined effect of hereditary, lifestyle and climate factors (Krishan, 2007; *Robbins, 1978),* therefore, this study will be concerned with investigating and deriving population-specific equations for stature estimation based on foot print using students of the University of Port Harcourt, Nigeria. In addition, this study will be concerned with determining the correlation between foot print/foot length and height of students between the age range of 18 – 30 years of the University of Port Harcourt; derive a linear regression formulae that will help in estimating stature from length; sexual dimorphism in foot length as well as comparing and analyzing the foot arch pattern of the students.

MATERIALS AND METHODS

Two hundred and fifty (250) students (125 males and 125 females) aged between 18-30 years, were used for the study since the maximum height of an individual is attained by this age (Ozaslan *et.al, 2006).* These were students with normal gait and motion activity from the University of Port-Harcourt, Rivers State, Nigeria.

Measurement and analysis of foot print

A total of 500 foot prints were obtained from left and right feet of 250 (125 males and 125 females) subjects. The sole of the foot was first cleaned with a piece of cotton wool moistened with surgical spirit to avoid dirt and other particles from interfering with the ink and print. Thereafter, the foot of the subject was placed on a large ink pad with the foot and the toes fully extended. The foot print was obtained by placing the foot on a white paper with sufficient pressure applied to ensure good contact between the sole of the foot and the paper. The foot prints obtained were measured later at leisure so as to obtain the foot length. Foot length was obtained by measuring the maximum distance of the foot print from the acropodion (A) anterioly to the pternion (B) posteriorly, which is the backward projecting point on the heel in nearest centimeter (Fig.1).

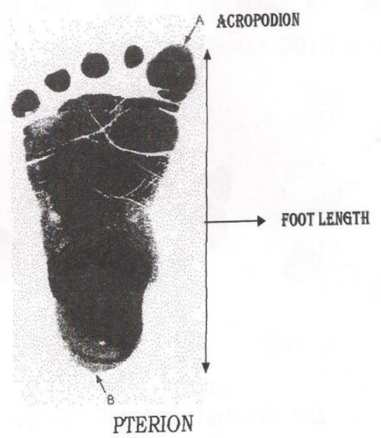

FIG. 1: SHOWING MEASUREMENT OF FOOT LENGTH FROM FOOT PRINT

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Stature Measurement

Stature of each subject was measured according to the standard procedure recommended by Weiner and Lourie (Weiner and Lourie 1981) as follow: the subjects were asked to remove clothing and foot wear to expose their feet, the height of the individual was measured between the vertex of the head and the floor after placing the subject in anatomical position and the head in Frankfurt plane using a standing height measuring instrument. The height was then recorded in the nearest centimeter from the standing surface to the vertex of the head.

Determination of foot arch pattern

The foot prints obtained were compared and matched with the standard foot arch pattern gotten from Saddler (2011) and Anderson (2011)(Fig. 2 and 3)

Fig 2:Standard foot arch pattern adopted from Ian Saddler 2011

Fig 3: the foot print that is been compared with the standard

STATISTICAL ANALYSIS

The obtained values were statistically analyzed using statistical package for social sciences (SPSS) version 17.0 for windows. Sexual dimorphism and bilateral differences was tested by applying a paired t-Test analysis. The Pearson correlation analysis was used to determine the association between stature and foot length measurement. The equations for stature estimation using foot length were calculated by linear regression analysis.

RESULTS

Table 1 presents the descriptive statistics of all the measured parameters in both gender, all measured values were higher in males than in females and these sex differences were found to be statistically significant (p<0.001). Table 2 shows an independent sample test comparing left and right foot length in the same individual in males and females; from the table it was observed that the bilateral differences are not statistically significant as P tends towards one (p>0.05). Important parameters are summarized in table 3; for males, the correlation coefficient between heights, left and right foot prints were positive: 0.82 and 0.84 respectively. The correlation coefficient in the females was 0.73 and 0.76 respectively. The right foot has stronger correlation than the left foot since it tends towards one. Also represented in table 3 are the regression coefficient and the value of Constance of both feet in gender. Table 4 presents a frequency table of the foot arch pattern in males and females.

Table 1 Descriptive statistics in males and females

Parameters	Males(cm)	Females(cm)	T-value	P. values	Inference
Mean of Height ± SD	174.16±8.47	163.08±6.59	11.54	0.000	Significant
Mean of Left foot length±SD	25.94±1.53	23.77±1.29	12.17	0.000	Significant
Mean of Right foot length±SD	25.96±1.56	23.79±132	12.37	0.000	Significant

P<0.001 : Significant

Table 2: Samples Test Comparing Left and Right Foot Length in Males and Females

Sex	Mean Diff. of Left and right foot length	T-Val7uue	P-Values	Inference
Males	-0.13±0.19	-0.07	0.88	Not Significant
Females	0.08±0.17	0.47	0.85	Not Significant

P>0.05 : Not Significant

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Table 3: Showing the Correlation Coefficient, Regression Coefficient and Value of Constant in Males and Famales

Gender	Males	Females
Total Number	125	125
Mean of Height ±SD (cm)	174.16±8.47	163.08±6.59
Mean of left foot length ±SD (cm)	25.94±1.53	23.77±1.29
Mean of Right foot length ±SD (cm)	25.96±1.56	23.79±1.32
Correlation coefficient in left foot	0.82	0.73
Correlation coefficient in right foot	0.84	0.76
Regression coefficient in left foot	4.55	3.80
Regression coefficient in right foot	4.54	3.78
Value of constant in left foot	56.01	72.68
Value of constant in right foot	56.29	73.61

Regression equation: Male - H = 4.55(LFT) + 56.00; H = 4.54 (RFL) + 56.29
Females - H = 3.80(LFT) + 72.67; H = 3.78(RFL) + 72.61.00
Where H is the height.

Table 4: Frequency Table of Foot Arch Pattern in Gender

	Males		**Females**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Neutral Pronators	53.0	42.4	65.0	52.0
Over Pronators	47.0	37.6	39.0	31.2
Supinators	25.0	20.0	21.0	16.8
Total	125	100	125	100

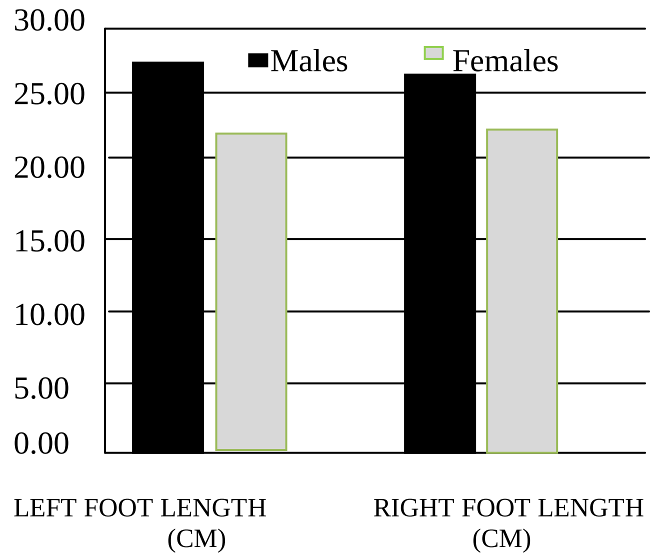

CHART 1: MEAN FOOT LENGTH IN GENDER

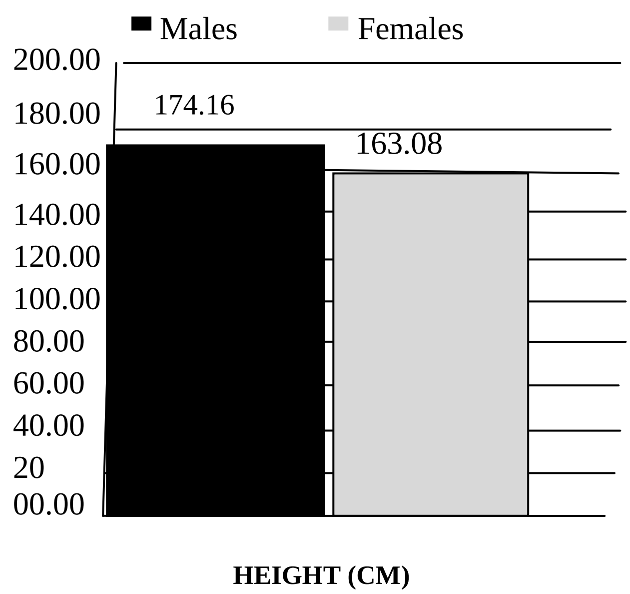

CHART 2: MEAN HEIGHT IN GENDER

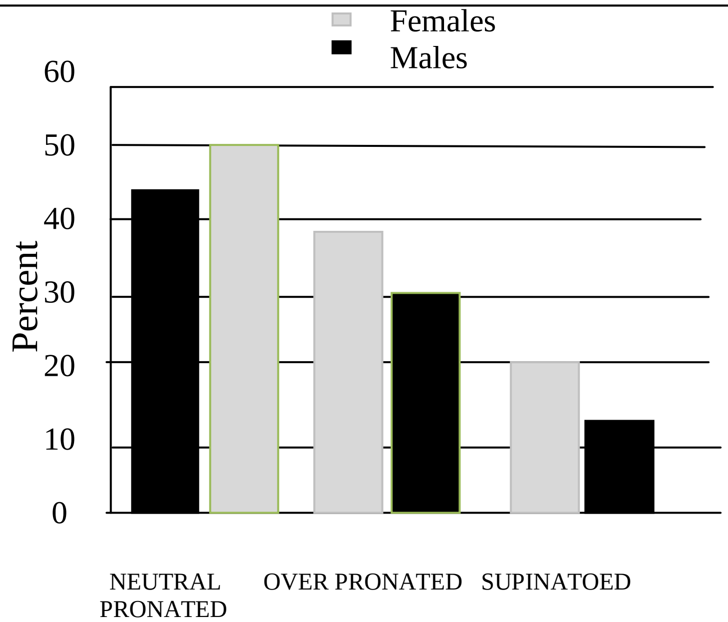

CHART 3: PERCENTAGE FOOT ARCH PATTERN IN GENDER

DISCUSSION

The result of the present study shows that foot print can be used as a predictive value for the estimation of stature in forensic and medical investigations. However, one has to be careful because these results and the regression equations in particular can only be applied to the population from which the data have been obtained due to racial differences. An age range of 18 to 30 years (average being 24.47 years) was used for this study since the average adult foot

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length is attained by the age of 16 years in males (Anderson *et al.,* 1956).

The present study shows that there is statistical significant difference in gender with respect to height and foot length, because males showed higher mean values in all measurements. Sexual dimorphism has also been reported by other studies (Fessler, (2005); Ozden *et al.,* (2005); Agnihotri *et al.,* (2007); Sen and Ghosh,(2008); Zeybek *et al.,* (2005); Kanchan *et al*, (2008).

This study also observed Non significant bilateral differences in gender, these findings were in agreement with the results obtained by some other studies (Ozden *et al.,* (2005); krishan and Sharma (2007); Zeybek *et al.,* (2008)]. However, Agnihotri *et al.,* (2007) and Sen and Ghosh,(2008) presented significant bilateral differences in foot length in their study. The differences may be attributed to environmental and genetic factors.

In this work all footprint measurement exhibited statistically significant correlation coefficient with stature. A higher correlation was observed for foot length in males (r = 0.84) than in females (r = 0.76). Comparing the left and right footprint measurement, a higher correlation was observed in the right foot print (r = 0.84) as against the left footprint (r = 0.76). Based on this it can be inferred that the right foot print is more accurate in terms of stature estimation than the left foot length, this was in concordance with the work carried out by Petra *et al.,* (2011); who in their work estimated the correlation to be r = 0.73 for males, and r = 0.72 for females. This present study contradicts the findings of Patel *et al*.,(2008), who worked on Indians. In their work the correlation between height and foot print was (r= 0.65) for males and (r = 0.80) for females. The difference observed in their study and this present study may be due to racial variation among the subjects.

In this study a regression equation was done separately by calculating stature from left and right footprint in both sex groups. Since the regression equations are calculated from measures of central tendency, the estimation of stature by means of regression method is more reliable than the division factor method. Robbins (1985), based on her study, recommended the use of percentage formula with a margin of variation instead of using regression equations for estimation of stature and she remarked that estimating height by means of other methods than foot length as a percentage of height was 'unduly complicated'. This present study contradicts the opinion expressed by Robbins (1985).

Ozden *et al.*, (2005) in their study conducted on Turkish population, found a definite correlation between stature and foot length. In their study, they took the shoe length and shoe number into consideration while in this present study only foot length was taken. But the problem in the equation of ozden *et al.,* (2005) is that if some dismembered human's remains were found at some accident site for instance, bomb blast or natural calamity, then shoe number and the shoe length of the person cannot be guessed, so the formula becomes invalid in that case.

Furthermore, from the footprints obtained, differences in the foot structures and shape were observed, and this is known as foot arch pattern (Anderson 2011). The different foot arch patterns according to him are Neutral pronation (normal), over pronation and under pronation (supination), this difference is as a result of the way the body distributes it weight as it cycles through the gait in different subjects. These different foot arch patterns observed in this study were similar to the findings of saddler (2011); who in his findings stated that neutral pronation are the most frequent pronation because it is the most efficient type of gait as it helps the body in shock absorption.

In conclusion, this study therefore clearly reveals footprints to be of utmost importance in the estimation of stature in forensic examinations. Footprint and foot lengths are strongly correlated with stature; the right foot length was found to have a higher correlation in both gender and thus gives better prediction of stature than the left foot length and other measurements.

Furthermore, in view of the significance in sexual dimorphism in the footprint measurements in the Nigerian population, one should be careful in using these formula and the use of appropriate formula for the appropriate gender is recommended. An important point to remember is that people from different regions of the world bear different morphological features depending upon their geographical distribution and primary racial characteristics hence a single formula cannot represent all parts of the world. Also, in designing shoes for the Nigerian population neutral pronators should be taken into consideration followed by over pronators and supinator so as to avoid frequent injuries that occur in the foot. As part of our recommendation, we therefore, recommend similar studies be conducted on the major tribes of Nigeria which can aid in the scientific identification of these different tribes in Nigeria as well as aiding local shoe manufactures in the rightful planning of their shoe design.

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