Estimation of Living Stature from Foot Dimensions in Uturu Indigenes of Abia State, Nigeria

Loveday Ese Oghenemavwe, Oghenekome Blessing Egwede

ABSTRACT

Stature estimation is an important process in human identification. The aim of the study was to derive regression formulae for estimation of stature from foot dimensions in Uturu indigenes of Abia State. The sample consists of 150 subjects comprising of 69 males and 81 females between 18 to 50 years of age. The parameters measured were age, stature, foot length and foot width. The mean age, stature, foot length and foot width were 29.78 ± 1.08 years, 1738.26 ± 9.34 mm, 261.53 ± 2.01 mm, 84.53 ± 0.94 mm for males and 27.04 ± 0.89 years, 1648.64 ± 7.61 mm, 242.36 ± 1.80 mm, 76.14 ± 0.72 mm for females respectively. The highest correlation was found between the stature and foot length in males ($r = 0.68$). Regression formulae were $St = 2.2926(FL) + 1093.0$ mm and $St = 2.3637(FW) + 1467.1$ mm for females and $St = 3.1687(FL) + 909.54$ mm and $4.6857(FW) + 1342.20$ mm for males. The foot length is a more reliable for estimating stature in Uturu indigenes of Abia.

Keywords: Foot dimensions, regression formulae, stature, Uturu.

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I. INTRODUCTION

Stature is the natural height of a person in an upright position. Estimation of stature is an important parameter in identification of persons in forensic context [1], [2]. It is among the big four questions asked in forensic anthropology when trying to unveil the identity of an individual; the others are sex, age and ancestry [1]. The historical background to stature estimation began with the work of Vitruvius promoted by Leonardo da Vinci who proposed that the human body is in proportions. These proportions were illustrated in his famous art work "the Vitruvian man" [3].

Over the years, researchers have tried to formulate methods for the estimation of stature to aid the process of identification of persons. These methods could either be anatomical or mathematical methods. Anatomical methods estimate the total height and was first formulated by Dwight in 1894, the procedure for estimation was further modified by Fully [4]. It involves the summation of the height of the cranium, vertebra column, femur, tibia, talus and calcaneus. The major setback to this method is that in most case all these bones are not available for the estimation of the needed stature. The mathematical method involves the use of one or more bones to estimate the stature of a person through the formulation of regression formulae [5]. The application of predictive regression models is now so widely used by forensic scientists as some parts of the body could

easily to use for predictive anthropometry of another part, for example the hand and foot dimensions could be used to estimate stature [6]-[12].

Several studies have shown that for regression formula to be effective it should be sex and population specific due to interplay of genetic and environmental factors that could cause variations within and between populations [13]-[18]. This is the main motivation for this study as Nigeria has over 250 ethnic groups with over 500 sub-ethnic population and languages [19]. Most studies on stature estimation in Nigeria appear to be over generalized and do not adequately capture the sub-ethnic groups which are mainly homogenous population [20]-[23].

The Uturu people of Abia State are a sub-ethnic population within the Igbo ethnic group of Nigeria. It is made up of several sub-urban settlements with a growing population of about 40,000 people [24]. Presently, there is paucity of information on the relationship between stature and foot dimensions amongst this group. Developing a regression model for this population would contribute immeasurably to easy identification process. Therefore, the aim of the study was to establish the relationship between living stature and foot dimensions through the formulation of regression formulae.

II. MATERIALS AND METHODS

One hundred and fifty (sixty-nine males and eighty-one females) Uturu indigenes between the ages of 18 to 50 participated in the study. The inclusion criteria included that both parents and grandparents of participants must be from Uturu. Participants with foot deformity were excluded and those below the age of 18 years and above 50 years were also excluded from the study. The study was approved by the Research Ethics Committee of College of Medicine and Health Gregory University of Uturu Abia State. Written informed consents were obtained from participants after the purpose of the study and data collection procedure was explained to them. The following parameters were measured.

A. Stature

This was taken using a stadiometer. The participants stood erect, barefooted on the level platform of the stadiometer such that the back of their head, shoulder blade, buttocks and heels touched the bar of the stadiometer. Participants were asked to relax with arms hanging by the side. Care was taken to avoid a sagging position.

B. Foot Length

This was taken using digital vernier caliper. It is the distance from the most prominent part of the heel to the most distal part of the longest toe (great or second toe).

C. Foot Width

The widest point across the foot was taken with a digital vernier caliper. It is the distance between the most prominent point on the medial aspect of head of first metatarsal and the most prominent point on the lateral aspect of head of fifth metatarsal.

The right foot was used for all measurements, and this was taken thrice, and the average recorded to minimize errors.

D. Statistical Analysis

The data were analyzed with Microsoft Excel Tool Pak version 2010 and Statistical package for the Social Sciences version 23. Descriptive analyses and regression models for estimation of stature and tests of correlation were done.

III. RESULTS

The results are presented in Tables I to IV and Fig. 1 to 6. As shown in Table I, the mean age, stature, foot length and foot width for all participant combined irrespective of sex were 28.30 years, 1689.07 mm, 251.18 mm and 80.00 mm respectively. Tables II and III showed descriptive statistics of measured parameters for females and males. The mean values for stature, foot length and foot width were higher in males. Table III showed descriptive statistics of measured parameters for male subjects. Correlation coefficient, regression formulae, test of correlation and scatter plots are presented in Table IV and Fig. 1 to 6.

TABLE I: DESCRIPTIVE STATISTICS OF MEASURED PARAMETERS FROM ALL SUBJECTS

Parameter	Mean	SEM	SD	Var	Min	Max
Age (yrs)	28.30	0.68	8.38	70.29	18.00	49.00
Stature (mm)	1689.87	6.96	85.29	7273.81	1440.00	1950.00
FL (mm)	251.18	1.55	18.95	358.99	192.80	305.49
FW (mm)	80.00	0.68	8.27	68.41	57.26	101.76

SEM = Standard error of mean, SD = standard deviation, Var = variance, Min = minimum, Max = maximum, FL = Foot length, FW = Foot width

TABLE II: DESCRIPTIVE STATISTICS OF MEASURED PARAMETERS FOR FEMALE SUBJECTS

Parameter	Mean	SEM	SD	Var	Min	Max
Age (yrs)	27.04	0.89	7.99	63.86	18.00	49.00
Stature (mm)	1648.64	7.61	68.50	4691.88	1440.00	1820.00
FL (mm)	242.36	1.80	16.16	261.25	192.80	279.87
FW (mm)	76.14	0.72	6.51	42.43	57.26	92.85

SEM = Standard error of mean, SD = standard deviation, Var = variance, Min = minimum, Max = maximum, FL = Foot length, FW = Foot width

TABLE III: DESCRIPTIVE STATISTICS OF MEASURED PARAMETERS FOR MALE SUBJECTS

Parameter	Mean	SEM	SD	Var	Min	Max
Age (yrs)	29.78	1.04	8.65	74.76	18.00	49.00
Stature (mm)	1738.26	9.34	77.57	6017.52	1570.00	1950.00
FL (mm)	261.53	2.01	16.67	277.76	221.40	305.49
FW (mm)	84.53	0.94	7.84	61.41	67.21	101.76

SEM = Standard error of mean, SD = standard deviation, Var = variance, Min = minimum, Max = maximum, FL = Foot length, FW = Foot width

Fig. 1. Scatter plot of stature against foot length for all subjects.

Fig. 2. Scatter plot of stature against foot width for all subjects.

TABLE IV: PEARSON'S CORRELATION, TEST OF SIGNIFICANCE AND REGRESSION MODEL FOR STATURE ESTIMATION FROM FOOT LENGTH AND FOOT WIDTH

Parameter	Correlation value (r)	P-value	Inference	Regression formula
ALL SUBJECTS				
Stature vs Foot Length	0.23	0.005	Correlation is significant	Stature = 3.21189(FL) + 883.13
Stature vs Foot width	0.53	0.000	Correlation high and very significant	Stature = 5.4619(FW) + 1252.9
FEMALE SUBJECTS				
Stature vs Foot Length	0.54	0.00	Correlation high and significant	Stature = 2.2926(FL) + 1093
Stature vs Foot width	0.23	0.03	Correlation is significant	Stature = 2.3837(FW) + 1467.1
MALE SUBJECTS				
Stature vs Foot Length	0.68	0.00	Correlation high and very significant	Stature = 3.1687(FL) + 909.54
Stature vs Foot width	0.47	0.00	Correlation is significant	Stature = 4.6857(FW) + 1342.2

IV. DISCUSSION

This study has investigated the relationship between living stature and foot length and width among Uturu indigenes of Abia State Nigeria. There is positive significant correlation between stature, foot length and width in the studied population. Several studies on the estimation of stature using foot measurements have shown the human feet to be reliable estimate of stature in the forensic identification [6], [7], [9], [11], [23], [25], [26]. The application of predictive regression models has been used by anthropologists to accurately predict stature using anthropometric measurements of body parts such as foot length and breadth [9], [12], [26].

In the current study, males had higher anthropometric dimensions compared to the females (Stature = 1738.26 $\pm$ 9.34 mm, FL=261.53 $\pm$ 2.01 mm, FW = 84.53 $\pm$ 0.94 mm for males and Stature = 1648.64 $\pm$ 7.61 mm, FL = 242.36 $\pm$ 1.80 mm, FW = 76.14 $\pm$ 0.72 mm for females). These findings are in agreement with related studies by [11], [26]-[28]. The differences could be attributed to the fact that limb growth in females usually ends quickly compared to males as a result of a quicker onset of pubertal changes. The foot dimensions in our study were similar to the result of [29], they reported the average values of the right foot length for Nigerians were 27.1 $\pm$ 1.3 cm and 25.0 $\pm$ 1.1 cm for males and females, and the right foot breadth were 9.8 $\pm$ 0.5cm and 8.9 $\pm$ 0.5cm for males and females respectively.

Correlation of stature with foot length was most significant in males ($r = 0.68$, $p < 0.01$) compared to females ($r = 0.54$, $p < 0.01$). Similar findings in previous studies showed high reliability of foot length in the estimation of stature, however, this study had lower correlation coefficients for both sexes compared to these studies, and this could be due to racial and population differences [6], [23], [30].

Foot width (breadth) showed the poorest correlation with stature in this present study in females ($r=0.23$). In males, there was significant relationship between stature and foot width. These finding are in concordance with those of [11], [31]. Foot length is more reliable for estimating stature compared to foot width and factor influencing this outcome may need to be further investigated.

The stature estimates obtained using the regression formula derived from this study are the appropriate formulae available for Uturu indigenes as they have been tested randomly in clans of Uturu. The formula for females is $St = 2.2926(FL) + 1093.0$ mm and $St = 2.3637(FW) + 1467.1$ mm while for male it was $St = 3.1687(FL) + 909.54$ mm and $4.6857(FW) + 1342.20$ mm. Similar studies among the

Gujj's population of India showed stature = 90.275 $\pm$ 2.9 (FL) [9]. Reference [32] also reported the regression formula to estimate stature from the left foot Indians is $S = 101.96 \pm 2.6(FL)$ and Stature = 89.63 $\pm$ 3.6(FL) for males and females respectively.

Fig 3. Scatter plot of stature against foot length for female subjects.

Fig 4. Scatter plot of stature against foot width for female subjects.

Fig 5. Scatter plot of stature against foot length for male subjects.

Fig 6. Scatter plot of stature against foot width for male subjects.

V. CONCLUSION

Foot length and width correlate with stature and these anthropometric parameters could be used to estimate one another amongst Uturu indigenes. Foot length is much more significant in estimating stature in males compared to their female counterparts. The linear regression formula derived in this study would be useful in estimating the stature of Uturu indigenes of Abia State Nigeria.

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CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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