

Anthropometric Estimation of Foot Parameters for the Igbos of Nigeria

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ABSTRACT

The aim of the study is to anthropologically measure foot parameters with a view to identifying and isolating the morphologic and morphometric peculiarities of the Igbo ethnic tribe of Nigeria. The research was carried on 1200 adult population males and females chosen randomly from the Igbo geopolitical states of Nigeria. Six foot parameters were measured, while two parameters were calculated as: Foot Index calculated as Foot breadth / Foot length x 100; Toe shape as Toe length/ Foot length x 100. Data analysis included descriptive and inferential statistics, Anova-test. Confidence level was set at 95%, as P-values ≤ 0.005 were considered significant. Findings showed ethnic and sex differences to be highly significant ($P < 0.005$) with males having higher values than the females. This study observed that foot length, showed positive correlation and significantly predicted ethnicity with better accuracy ($P < 0.005$) while foot breadth and toe shape had varied correlations and predicted ancestry but with low accuracy ($p > 0.005$). Conclusively the study showed that foot parameters are morphometric ally and morphologically ethnic specific.

Keywords: Anthropometric; Foot dimensions; Foot indices; Foot length; Foot breadth; Foot Index; Ethnicity; Toe shape

INTRODUCTION

Anthropometry is often viewed as a traditional and perhaps the basic tool of biological anthropology, but it has a long tradition of use in forensic sciences and it is finding increased use in medical sciences especially in the discipline of forensic medicine. . The human foot has a high degree of individuality in terms of size, shape and function which may be of assistance in the process of identification. It is observed that over 90% of people have different sizes of the feet and the individual foot has an infinite morphological variation due to genetic, natural and environmental factors. This is further complicated by the distribution or proportions of foot mass which differ with individuals resulting in linear measurement such as length and breadth of the foot as inadequate. The morphometric parameters of the foot show considerable sexual dimorphism in many populations. Also study of sexual dimorphism in hand and foot length, indices, stature-

ratio and relationship to height in Nigerians has been reported [1].

Hence, the need to get documentation of this particular discourse as foot measurements has been proven to exhibit great sexual dimorphism as well as ethnicity even as standards of morphological and morphometric sex differences in bones may differ with the population sample involved especially with reference to dimensions and indices and thus one of a region cannot be applied universally according to [2] and more so as Nigeria is a multi-ethnic populations. Since human beings differ in size from each other between races, their morphological proportions would affect metric assessment of sex. For this reason different standards exist for identification of skeletal tissues like bones in different populations

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The main aim of this research study is to anthropometric estimation of foot parameters for the Igbo population in South-east Nigeria.; with the specific aim to measure anthropometric parameters of Igbo population in south-east Nigeria towards creating a biological profile of identity for the individual; and to evaluate the indices in the stratified groups of south-east Nigerians with view to identifying sex differences and ethnic morphological and morphometric peculiarities as well as establish relationship among the various parameters from its cross population.

METHODOLOGY

The research was carried on 1200 adult population comprising of 662 male and 572 female of age range from 18 to 30 year. The samples were chosen randomly from the Igbo tribe in South-east geopolitical states of Nigeria across inhabitants of selected rural communities of the region. Exclusion criteria included subjects under 18 and above 30 years of age and with apparent foot anomalies, inflammation, orthopedic deformities, developmental disorder and surgery (if any) which have affected the foot growth. The present study was conducted after taking approval for human population study. Before carrying out the experiments, the subjects were informed of requirements and procedures of the measurements with assurance for confidentiality of information for openness in line with standard protocol.

Instruments used include plain sheet of paper, a foot place, digital caliper, marker, rigid transparent meter rule and a steel measuring tape. Foot measurements and foot outlines were taken for barefoot subjects standing in anatomical position with both feet apart 100-150 mm, and weight distributed equally on both feet with the feet axis parallel or slightly divergent and the head balanced on neck and measurement was taken with the head on the Frankfurt Horizontal Plane [3].

The foot dimensions were measured based on the specific anatomical landmarks specified as adopted from [4] and the values measured in millimeters. The sequence of the measurements was randomly assigned to each subject.

The length and breadth of the foot was marked by a marker, the foot length points were then measured by a steel measuring tape while other parameters were measured by the digital caliper (Mitutoyo Corp., Tokyo, Japan) while erect on a plain paper particularly to measure foot dimensions based on the specific anatomical landmarks for each selected parameter and index hence the values were recorded. The resolution of the digital caliper was calibrated within 0.01 mm so as to get accuracy within 0.01 mm. Each subject was repeatedly measured twice, all measurements were taken by the researcher and the figures recorded in millimeters with the support of an assistant to reduce incidence of observation error.

Measurements of Six foot parameters were taken as: foot breadth at heel (FBEL), foot height (FH), Ball of foot length (BFL), outside Ball of foot length (OBFL), foot arch length (FAL) and toe length

(TL) that provided a high level of anatomical details; while two parameters were calculated as follows: Foot Index calculated as $\text{Foot breadth} / \text{Foot length} \times 100$; Toe shape calculated as $\text{toe length} / \text{foot length} \times 100$. Methods of data analysis include descriptive and inferential statistics of mean and standard deviation. Correlation coefficient and linear regression analysis was derived to help determine the predictability of sex and ancestral differences various foot dimensions. Confidence level was set at 95%, as P-values ≤ 0.005 were considered significant (Figure 1).

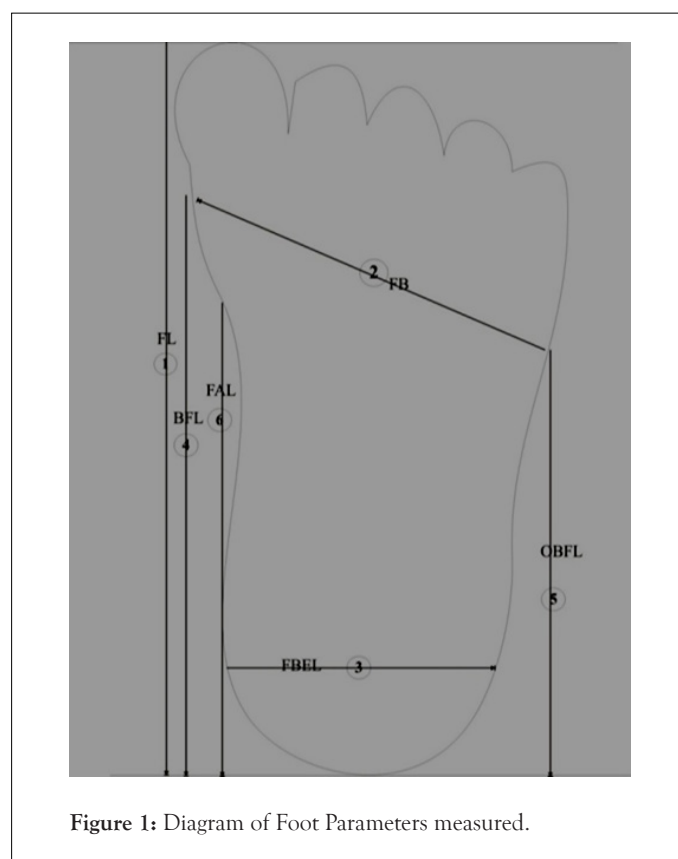


Figure 1: Diagram of Foot Parameters measured.

RESULTS AND DISCUSSION

The statistics for toe length, left and right foot in males and females. Subsequently toe length male (21–30 years) was 53.14 ± 5.95 mm and 53.46 ± 6.07 mm; and females 54.40 ± 4.56 mm and 54.64 ± 4.54 mm right and left foot respectively which was significantly higher in the females than the male subjects and agrees with the work of [5]. The establishment of toe length as a viable and accurate dimension of sex and ancestral identity in our study also agrees with the work of [6] on the use of Regression analysis for Stature Prediction in Nigerian tribes From Toe Length and Toe-Length Ratios which opines that toe length gives the most accurate predictive rate among the Igbos more than other tribes of Hausa and Yoruba's from the variation in mean values observed between the ethnic groups (Table 1).

Table 1: Toe length for males and females.

Age group	Male toe (Length mm)			Female toe length (mm)			
	No in group	X	S.D.	No in group	X	S.D.	
21 -25	Right	69	53.14	5.95	60	54.40	4.56
	Left		53.46	6.07		54.64	4.54
26 -30	Right	65	54.22	5.18	55	49.43	5.97
	Left		54.30	5.09		49.43	5.98
31 -35	Right	61	53.62	4.91	52	52.59	5.89
	Left		54.12	5.17		52.75	5.87
36 -40	Right	39	49.11	6.62	30	54.90	4.82
	Left		49.27	6.60		55.38	4.70

The Mean value for Male in younger age group of (21–30 years) shows a significant higher values in the left foot with Foot Index, Foot arch length, Foot height length and Foot breadth at heel and were significantly higher in males’ $p < 0.001$ than females; also significantly higher in the left foot than the right.

Mean values for male (21–30 years) for Foot Index (FI) was 38.76 ± 66 mm and 38.75 ± 63 mm; Foot height length (FHL) was 83.45 ± 5.58 mm right and 83.55 ± 5.55 mm left; foot arch length (FAL) was 66.22 ± 9.26 mm right and 66.43 ± 9.23 mm left; ball of foot length (BFL) was 84.20 ± 11.94 mm right and 84.18 ± 11.66 mm left; outside ball of foot length (OBFL) was 78.35 ± 7.18 mm right and 77.98 ± 6.89 mm left; foot breadth at heel (FBEL) was 63.23 ± 5.45 mm right and 63.33 ± 5.17 mm left (Table 2).

The Foot Index here in Table 3 is in agreement with [1] on Nigerians and [7] on Mauritian population observed higher

mean foot indices on left side in males and higher foot index on right side in females. However the mean right foot index was found to be more in males in studies [3]. This may be because of environmental and genetic differences. Somatic asymmetry is well known and widespread in the animal kingdom.

From the data of Table 4, the findings of our study indicate that the correlation ‘r’ between sex and foot dimensions were significant for Foot Length, Foot Breadth, Foot arch Length, Foot Height, Ball of foot Length, Outside ball of foot length, Toe Shape in both right and left foot which agrees with work of [8]; with the correlation as $P < 0.005$ but lower than work of [9] between stature and Foot Length, which in males and females was 0.716 and 0.699 respectively while correlation between ethnicity and foot dimensions were significant for Foot length, Toe Shape, Toe Length and Foot arch Length with correlation as $P < 0.001$ and no significant with Foot Index alone.

Table 2: Group distribution for other foot dimensions for males.

Age group	No in group	FI (X±SD)		FHL (X±SD)		FAL (X±SD)		BFL (X±SD)		OBFL (X±SD)		FBEL (X±SD)	
		Right		Right		Right		Right		Right		Right	
		Left		Left		Left		Left		Left		Left	
21 -2t5	69	38.76 ± 1.66		83.75 ± 5.80		66.15 ± 9.21		85.07 ± 11.88		78.44 ± 6.86		62.97 ± 5.28	
		38.75 ± 1.63		84.14 ± 5.77		66.39 ± 9.20		84.75 ± 11.58		78.18 ± 6.63		63.13 ± 5.04	
26 -30	65	39.05 ± 1.59		84.11 ± 6.12		64.98 ± 9.94		82.33 ± 10.80		76.70 ± 6.79		63.30 ± 4.95	
		39.02 ± 1.48		84.50 ± 6.14		65.22 ± 9.91		82.26 ± 10.76		76.92 ± 7.02		63.33 ± 4.99	
31 -35	61	38.80 ± 1.59		83.89 ± 6.00		63.79 ± 9.41		82.21 ± 10.17		77.04 ± 6.41		62.57 ± 4.78	
		38.81 ± 1.57		84.14 ± 5.92		63.88 ± 9.46		82.07 ± 10.26		76.93 ± 6.20		62.47 ± 4.72	
36 -40	39	38.32 ± 1.99		82.81 ± 6.56		62.59 ± 8.75		83.48 ± 12.85		75.31 ± 7.62		57.49 ± 7.82	
		38.28 ± 1.81		82.72 ± 6.75		62.73 ± 8.77		83.58 ± 13.07		75.36 ± 7.54		57.62 ± 8.27	

Table 3: Group distribution for other foot dimensions for females.

Age group	No in group	FI (X±SD)	FHL (X±SD)	FAL (X±SD)	BFL (X±SD)	OBFL (X±SD)	FBEL (X±SD)
21 -25	60	38.11 ± 1.84	82.77 ± 6.88	63.67 ± 8.46	82.14 ± 10.22	77.71 ± 7.09	62.06 ± 5.04
		38.12 ± 1.79	82.95 ± 6.89	63.82 ± 8.69	82.45 ± 10.15	77.64 ± 6.92	62.12 ± 4.91
26 -30	55	38.11 ± 5.26	78.92 ± 5.45	59.66 ± 8.53	78.07 ± 10.74	72.63 ± 6.12	58.32±7.64
		38.12 ± 5.36	79.15 ± 5.40	59.81 ± 8.63	78.16 ± 10.91	72.61 ± 6.17	58.72 ± 8.13
31 -35	52	38.19 ± 1.94	83.20 ± 5.96	62.69 ± 9.48	83.02 ± 9.98	77.90 ± 5.32	60.73 ± 5.04
		38.17 ± 1.94	83.66 ± 5.69	62.68 ± 9.56	82.37 ± 10.04	77.95 ± 5.36	60.74 ± 4.98
36 -40	30	38.57 ± 1.62	85.12 ± 5.95	66.46 + 8.72	81.17 ± 10.77	78.17 ± 6.34	62.90 ± 4.00
		38.54 ± 1.60	85.46 ± 5.68	66.48 ± 8.97	81.14 ± 10.83	78.30 ± 6.38	62.50 ± 4.02

Table 4: Correlation statistics of foot dimensions.

Foot Dimension	Logic Regression	Male					Female					
		R	R ²	T-cal	Correlation Prediction %	F-cal	Logic Regression	R	R ²	T-cal	Corr Prediction %	F-cal
FI	0.943	0.64	0.409	14.92	40.9	222.584	0.984	0.979	0.959	79.76	95.9	6362.88
	2.304						0.598					
FH	0.984	0.979	0.958	85.66	95.8	7337.426	0.966	0.976	0.953	74.50	95.3	5550.27
	1.52						2.942					
FAL	0.999	0.995	0.990	182.02	99.0	33132.549	1.010	0.994	0.987	145.22	98.7	21088.28
	0.270						-0.450					
BFL	0.990	0.986	0.972	104.63	97.2	10946.388	0.994	0.984	0.969	92.19	96.9	8498.53
	0.705						0.422					
OBFL	0.979	0.980	0.961	89.38	96.1	7988.250	0.992	0.991	0.982	121.04	98.2	14650.91
	1.558						0.571					
FBEL	0.987	0.985	0.970	102.16	97.0	10435.722	0.988	0.984	0.969	91.34	96.9	8342.52
	0.883						0.841					
TL	0.973	0.951	0.905	55.37	90.5	3065.662	0.992	0.978	0.957	77.43	95.7	5995.39
	1.663						0.575					
TS	0.936	0.926	0.858	37.48	85.8	1404.785	0.983	0.993	0.985	134.57	98.5	18107.62
	1.541						0.434					

From the findings, correlation coefficient between Toe Length and Foot Length was strong in both males and females. It was also significant between Foot Length and Foot arch Length in both males and females. This means there is a strong bond between Foot Length and Toe Length, and Foot Length and Foot arch Length if either of the dimensions is known the other can be calculated and this would be of utmost important to Anthropologist and Forensic experts. Thus if any of these significant foot dimensions or foot anthropometry (Foot Length, Toe length, Foot arch length, and Foot Index) has been established or known the other could be generated from the regression equations constructed by applying simple substitution. This indicated that the foot length, toe length and foot arch length provides the highest reliability and accuracy in estimating sex and ethnicity of Igbo individuals.

This is in agreement with the findings of [10] that estimated stature from dimensions foot in North Indian population and observed that correlation between stature and all the measurements of foot were positive and statistically significant.

However close observation of the predictor variables of sex or ancestry showed that four foot dimensions produced significantly similar predictions of stature for both males and females on left and right foot while two variables dissimilarly produced significant models. This is an indication of uniformity in prediction as well as sex difference for the dissimilar predictor variables for ancestry. The very low correlation values of the predictor variables are suggestive that despite the significant predictions produced by toe-length, there is no guarantee of reliable predictions.

The identified difference in prediction accuracies across sex and the two ancestral tribe for the Foot Length, Toe Length, Foot arch Length and Foot Index is an indication that prediction differs across ethnic/tribal groups as well as sex. This is in line with the findings of [6] on toe and ethnic stature differences and credibility and also [11]. The present study agree with researchers who have identified some factors which affect this anatomical data as feeding pattern/ nutritional qualities, geographical location, physical activity and racial difference [12]. Therefore it is most welcomed to define the extent of relationship of the various anatomical parts for prediction. Also in view of the fact that populations across the globe have diverse ethnic variations, it is expected that the anthropometric characteristics will differ in different geographical locations; thus, and warns that the estimation models derived for any defined geographical region; as well as ethnic groups should not be applied to another ethnic group even of the same region [13,14].

Ethnic differences is seen in the Table 4 where there is a lower correlation percentage prediction and significance $P < 0.001$ in foot length (FL) in both male and female sex ($r=0.86$ and $r=0.996$) as well as in foot arch length (FAL), ($r= 0.995$ and $r=0.994$). The small percentages of coefficient of variation also observed in males and females in the right and left foot length and breadth, implies that small variation occurs between the mean values of foot length and foot breadth for sample population and mean values of foot length and foot breadth by age [15-18].

Since all the $t\text{-cal} > t\text{-tab}$, we conclude that the correlation coefficient (R) > 0 (this means that there is strong significant relationship between right and left of all the foot dimensions measured) and thus higher prediction percentage with foot length (FL) in female sex than males and foot arch length (FAL) in both sex than other parameters measured [19-22].

In the above table, if p values have (*) the model is not useful for sex prediction.

CONCLUSION

The study provided a database of anthropological bio-profile of foot dimensions for the native Igbo populations which are of significant relevance in demographic and epidemiologic studies and forensic analysis. An establishment of foot shape index as an ethnological feature for the morphologic identification of individuals within the stratified Igbo crosses population.

DECLARATION

Ethics approval and consent to participate: Approval for the study was given by the Faculty Research committee and consent given by subjects for measurements.

Consent for publication

No personal information or image hence not applicable.

Competing interests

There is no competing interest in this study.

Availability of data and materials: The datasets used and/or analyzed during the current study are included in this published article and can also be available from the corresponding author on reasonable request in supplementary information files.

Authors' contributions

VWB is the main researcher and executor of the study responsible for data collection, analysis and interpretation. Both CIPA and AOCA being co-authors are supervisors that guide the progress along the stages. Authors have read and approved of the study.

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