Research Article
Volume 13:06, 2022

Journal of Forensic Research

ISSN: 2157-7145

Open Access

Determination of Sex and Stature from Percutaneous Anthropometric Dimensions of the Upper Arm and Forearm Bones in an Adult Nigerian Population in Lagos

Osahon Itohan Roli[1], Obi-Ojinika Chukubueze[2] and Ibeabuchi Nwachukwu Mike[1]

[1]*Department of Anatomy, College of Basic Medical Sciences, Edo University Lyamho, Edo State, Nigeria*

[2]*Department of Anatomy, College of Medicine, University of Lagos, Lagos, Nigeria*

Abstract

Background: Stature is an important indicator for identification like other phenotypic traits; it is determined by a combination of genetic and environmental factors. Stature or body height is one of the most important and useful anthropometric parameters that determine the physical identity of an individual, it is also considered as one of the important and significant parameters for the establishment of personal identity in the forensic medical examination or anthropological studies, particularly with the alarming increase in the frequency of road, floods, deliberate mutilation, and natural disasters.

Objectives: To predict stature and sex from the percutaneous length of arm and forearm bones in an adult Nigeria population.

Methods: The sample group used for this research consists of staff, students, and volunteers from the University of Lagos, comprising 222 individuals (115 males and 107 females) aged between 18-65 years. Various anthropological instruments such as Stadiometer: a product of SECA alpha® model 770, Germany, anthropometric Tape: calibrated in centimeters, weighing balance, and caliper were used for taking the measurement.

Results and Conclusion: Logistic regression showed statistical significance in sex prediction with the highest value gotten from the intercondylar width. All parameters showed a positive correlation with stature with the strongest from ulnar while the weakest was in the intercondylar measurement. Percutaneous measurement of arm and forearm length of both males and females provides good reliability in the estimation of stature and predicting of sex. Sexual dimorphism correlates more with the intercondylar. Simple and multiple linear regressions proved that the best way to predict and estimate stature is by taking the foot length.

Keywords: Arm and forearm length • Stature • Sex • Correlation coefficient • Simple • Multiple linear regressions

Introduction

Stature the distance between the vertex and the standing surface of an individual is regarded as an important parameter for personal identification in forensic medicine [1] and is affected by several factors including genetics, nutrition, environment, gender, age, and physical activity [2]. The stature and length of bones, as well as the factors affecting stature and bone length, differs widely from one race, ethnic origin, and geographical location to another [3]. Furthermore, stature has been reported as an indicator of growth and development [4]. In clinical settings, it has been applied in nutrition and health research [5]. Studies have reported stature as an important parameter in calculating basal energy expenditure, body mass index, basal metabolic rate, body composition, vital capacity, and estimations of nutrient requirements [6,7]. Anthropometric dimensions have been reported to vary with populations, even in subjects of the same continent [8]. These variations are attributed to genetic and environmental factors [9]. Anthropometric techniques have been commonly used to determine stature and bone length from skeletal remains an unknown body parts by anthropologists, medical scientists, and anatomists for over a hundred years [10-12]. Two basic methods used to determine living stature from long bones and body parts are anatomical and mathematical methods. The anatomical method is considered to provide the best approximation of stature, but its main lapse is that it requires a complete skeleton [13,14]. While the mathematical method requires a single bone or body part but has a less predictive ability. However, in the mathematical method, regression analysis is considered to be a better and more reliable tool than multiplication analysis [15,16]. Anthropometric measurements are imperative in the reconstruction of the biological profile of the deceased such as age, sex, ethnicity, and stature [17-19]. Among these 'big fours' of forensic anthropology, estimation of stature is considered as one of the main parameters of personal identification in forensic examinations. Sexual dimorphism is the biological base for sex determination based on the physical and behavioral differences existing between males and females [20]. Sexual differences that determine the shape, size, and appearance of bones usually arise during development and are consequences of individual genetic markers and response to sex hormones during puberty [21]. Bone development in either sex is dependent on a combination of genetic markers and hormone exposure [22]. The age at which these sex-specific morphological changes start to appear is dependent on several population-specific genetic and environmental factors [23]. As the degree of sexual dimorphism, and the age at which it occurs in males and females, varies between different populations, sex estimation standards are necessary to be population-specific [24]. The current study was unable to document any study that analyses the determination of stature and gender from percutaneous bones of arm and forearm as over the years, the anthropologist has focused on how to determine stature from skeletal remains. However, this research will be carried out in living subjects to determine stature from percutaneous bones of arm and forearm length and the result gotten will be used to educate anthropologists in this region how stature can be detected from partly skeletonized bodies where the tissues are still needed for further forensic investigation.

***Address for Correspondence:** Osahon Itohan Roli, Department of Anatomy, College of Basic Medical Sciences, Edo University Iyamho, Edo State, Nigeria; E-mail: itohanroli61@gmail.com*

Received: 06-Sep-2019, Manuscript No. JFR-19-001-PreQc-19; **Editor assigned:** 11-Sep-2019, PreQC No. JFR-19-001-PreQc-19 (PQ); **Reviewed:** 01-Oct-2019, QC No. JFR-19-001-PreQc-19; **Revised:** 27-Jul-2022, Manuscript No. JFR-19-001-PreQc-19 (R); **Published:** 03-Aug-2022, DOI: 37421/2157-7145.22.13.502.

Materials and Methods

Health Research and Ethics Committee (HREC) of the College of Medicine University of Lagos, Nigeria approved the experimental procedure and design. A cross-section of randomly selected staffs and students in the college of medicine and Lagos Teaching Hospital (LUTH), Idi-Araba were measured using the assigned and verified anthropometry Laboratory, Department of Anatomy to collect and analyze data obtained from the subjects to determine sex and stature from percutaneous anthropometric dimensions of the upper arm and forearm bones. The research made use of adult participants whose ancestral parents are of Nigerian origin and excluded some participants whose religious and ethnic belief is against body contacts during measurement. To avoid the bridge of these believes an informed consent form containing the procedure for measurement, purpose, and benefits of the research was given and explained to the participants. Participants of two hundred and twenty-two (222) between the ages of 18-65 years gotten from the random sampling method responded positively and were used to carry out the research. Other studies have used similar sample sizes [25,26]. The measurements obtained in this research are specifically for developing equations for estimating the sex and stature when body parts are located. It is accepted that adult stature is achieved by 18 years of age and an increase in stature after 18 years is statistically insignificant [27,28]. At the end of each measurement, a little token of biscuit and carbonated drink as a reward was used to encourage the subject [29-32] with stature and body mass details secretly communicated to them with medical advice to improve their living standards, changes in lifestyle, dietary modification to regulate body weight when the subject is over or underweight [33].

Materials

Weighing Scale: The digital balance (SECA alpha® model 770, Germany) calibrated in kilograms (capacity-150 kg), a vernier caliper (sliding) (Mitutoyo, Japan) was used to measure the percutaneous length of arm and forearm and stadiometer: A portable holding stadiometer calibrated in centimeters. All measurements were recorded by one observer to the nearest 0.1 cm.

Measurements procedures

Measurements of stature, weight, arm, and forearm dimensions were adopted from the International Society for the Advancement of Kinanthropometry ISAK [30]. To ensure consistency and accuracy, the same measuring instrument was used for all participants and their data was recorded in a sheet drafted for the recording purpose. The measuring procedures are as follows:

Stretch stature (SS) measurement: the vertical distance between the vertex, the highest point on the top of the head, and the floor with the subject standing barefoot in standard anatomical position and head in Frankfurt Horizontal (FH) plane. Measurement of stature was taken with a standard calibrated stadiometer. The measurement was taken by making the subject stand barefooted and erect on a horizontal resting plane of the stadiometer, having the palms of the hands turned inwards and the fingers pointing downwards after inhalation. The stature was measured as the vertical distance from the vertex to the floor of the stadiometer on a barefooted person.

Arm length: The distance from the acromiale, the point where the clavicle and scapula meet at the shoulder region, to the radiale. Measurement of the arm length was taken with a standard anthropometric measuring tape, measuring the distance from the acromiale to the radiale (Acromiale-radiale).

Forearm length: The distance from the head of the radius (radiale) to the tip of the lateral styloid (stylion). Measurement of forearm length was taken with the aid of anthropometric tape. The subject was asked to flex the elbow at 90 degrees and the measuring tape was placed to measure the distance from the radiale to the styloid [25].

The measurement of intercondylar humerus was taken by the caliper. The subject assumes a relaxed standing or seated position. The right arm is raised anteriorly to the horizontal and the forearm is flexed at right angles to the arm. The distance is measured between the medial and lateral epicondyles of the humerus. With the small sliding caliper gripped correctly, and the middle fingers were used to palpate the epicondyles of the humerus.

The weights of the subjects are measured with a weighing balance. The measurement was taken with the individual on barefoot, standing erect, and hands by the side (Figure 1).

Figure 1. Measurement taken during the experimental procedure.

Statistical analysis

Statistical Package for Social Sciences (SPSS) software version 23, Chicago inc was used to analyze the data. With this package, descriptive statistics was done and presented as mean ± SD, Pearson's correlation coefficients (r) were analyzed to ascertain the relationship between stature and long bones of the upper limb dimension with sex, Simple and Multiple regression models were derived to reconstruct stature using Durbin Watson enter and stepwise method while Logistic regression models were derived for sex. Independent t-test was also used to determine the level of significance between male and female at p-value less than 0.05 ($p<0.05$) and also paired t-test was used to compare right and left hand measurement [8].

Results

Data report summary

Descriptive statistics which includes mean, minimum and maximum, standard deviation and standard error of mean for all measured dimensions in males and females separately and combined were calculated before doing other testing processes. The left and right sides were done differently. This is presented in Table 1 and 2. This shows the mean difference between male and female arm and forearm dimensions. In all the measured parameters, males had higher right and left arm and forearm bone dimensions compared to females. The highest recorded mean was seen in the right humerus with males having a mean of 35.71 ± 2.6 cm while that of females having a mean of 33.21 ± 3.9 cm. All Data analysis was carried out with Statistical Package for the Social Sciences (SPSS) for windows, version 25.0, Armonk, New York: IBM Corporation. Scatter plots showing regression lines were analyzed using Microsoft for excel 2016 for Windows 10.

Sexual dimorphism

To determine sexual dimorphism, an independent t test was used (Table 2) to test for the existence of left to right differences in arm and forearm. The results showed that males have statistically significant larger mean than females in any given parameter measured ($p<0.001$). The dimension that demonstrated the highest degree of sexual dimorphism in the right and left hand was the ulnar lengths with t-values of 8.256 and 7.504 respectively. Table 2 also showed that the highest record mean difference between male and female arm and forearm dimension was recorded in also in the right humeral length with a mean difference of 2.50 cm.

Table 1. Descriptive statistics for data used in sex and stature estimation.

		Mean ± SD	Minimum	Maximum	Standard error
RIGHT					
Humerus	Male	35.71 ± 2.6	23.9	42.5	0.24
	Female	33.21 ± 3.9	21.3	39.5	0.37
	Combined	34.50 ± 3.5	21.3	42.5	0.23
Ulna	Male	30.70 ± 1.6	24.6	34.6	0.14
	Female	28.66 ± 2.1	23.6	39.1	0.2
	Combined	29.71 ± 2.1	23.6	49.1	0.14
Radial	Male	29.16 ± 2.5	13.1	37.9	0.23
	Female	27.86 ± 2.2	22.4	37.4	0.22
	Combined	28.77 ± 2.5	13.1	37.9	0.17
Intercondylar	Male	6.13 ± 1.3	3.7	11.3	0.08
	Female	5.25 ± 0.8	3.6	10.4	0.08
	Combined	5.71 ± 1.2	3.6	11.3	0.08
LEFT					
Humerus	Male	35.65 ± 2.6	23.8	42.3	0.25
	Female	33.25 ± 3.9	20.1	39.3	0.37
	Combined	34.49 ± 3.5	20.1	42.3	0.23
Ulna	Male	30.68 ± 1.6	24.5	34.4	0.15
	Female	28.76 ± 2.1	23.5	39.7	0.21
	Combined	29.75 ± 2.1	23.5	39.7	0.14
Radial	Male	29.54 ± 2.4	13.4	37.8	0.23
	Female	27.87 ± 2.3	22.3	37.6	0.22
	Combined	28.74 ± 2.5	13.4	37.8	0.17
Intercondylar	Male	6.08 ± 1 .3	3.6	11.7	0.12
	Female	5.21 ± 0.8	3.7	10.7	0.08
	Combined	5.66 ± 1.2	3.6	11.7	0.08

Table 2. Result of test for sexual dimorphism for measuring arm and forearm dimension.

	The difference in Mean (Male-Female)	Standard error (difference)	t-value	p-value	95%CI
Right hand					
Humerus	2.503	0.439	5.707	<0.001*	1.639,3.367
Ulna	2.044	0.248	8.256	<0.001*	1.556,2.532
Radial	1.755	0.318	5.52	<0.001*	1.128,2.381
Intercondylar	0.884	0.143	6.18	<0.001*	0.602,1.166
Left hand					
Humerus	2.393	0.44	5.44	<0.001*	1.526,3.260
Ulna	1.914	0.255	7.504	<0.001*	1.411,2.417
Radial	1.67	0.321	5.205	<0.001*	1.037,2.302
Intercondylar	0.869	0.166	5.927	<0.001*	0.580,1.158

Note: t-value= 10.356, * refers to p<0.001

Bilateral asymmetry

Bilateral asymmetry was conducted to check the differences between the left and right measurements. As obtained, Table 3 only measured stature the intercondylar width showed a mean significant difference in all the dimensions measured while others showed no statistically significant difference (p=0.004). The result is suggestive of the fact that there is little bilateral asymmetry, despite that side-specific models were still generated.

Sex estimation

As shown on table logistic regression models using single left and right forearm and arm dimensions for the prediction of sex. In all eight tested logistic models, all single body dimension showed a statistical significant prediction of sex (p<0.001). The highest overall classification accuracy of 76.6% and 74.8% was achieved using right and left intercondylar measurement respectively. This was followed by 73.4% and 73.0% obtained on the right and left ulna measurement respectively. Sex biases were 7.1 and 2.4. The lowest overall accuracies were seen in right and left humerus with overall percentages of 68.5% and 66.7%. Sex bias was 7.7 and 4.4 respectively. In other words, the table also showed the highest classification accuracy for females and males were achieved using right intercondylar measurement with 72.9% and 80.0% correctly classified with a classification cut off of 0.5 (Figure 2).

Stature estimation

All measured variables were correlated with stature Table 4 showed a correlation between stature and right and left forearm and arm measured parameters. All parameters measured in left and right hand showed a positive significant correlation. The strongest correlations with stature were noted in ulna measurement in both left and right forearm and arm with (r=0.516), in the right and (r=0.492) in the left. However, from the Table 5, weakest correlations were shown in intercondylar measurement with r=0.200 in the right and r=0.180 in the left.

Table 3. Paired t-test comparing left and right hand measurement.

	Difference in Mean (Right-Left)	Standard error (difference)	t-value	p-value	95%CI of difference
Humerus	0.011	0.036	0.314	0.754	-0.059, 0.082
Ulna	-0.039	0.029	-1.343	0.181	-0.097, 0.018
Radial	0.031	0.028	1.117	0.265	-0.024, 0.086
Intercondylar	0.046	0.015	2.94	0.004*	0.015, 0.076

Note: t-value= 10.356, * refers to p<0.001

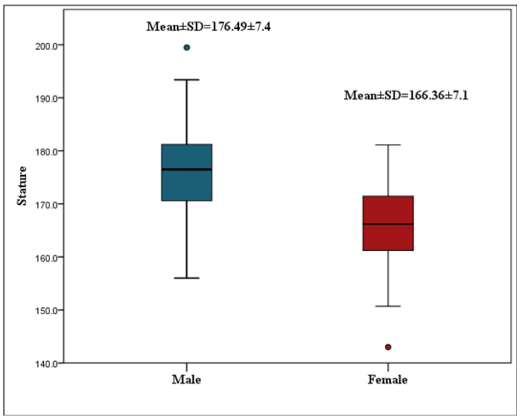

Figure 2. Box plot showing sexual dimorphism in stature

Table 4. Logistic regression using single left and right arm and forearm dimension.

	b0	b1	SE(b1)	p-value	Correctly classified (%)			Hosmer-Lemeshow p-value
					Male	Female	Overall	
Right hand								
Humerus	11.509	-0.335	0.063	<0.001*	72.2	64.5	68.5	0.636
Ulna	19.025	-0.643	0.099	<0.001*	76.5	70.1	73.4	0.535
Radial	10.731	-0.376	0.077	<0.001*	73.9	63.6	68.9	0.025
Intercondylar	6.59	-1.185	0.214	<0.001*	80	72.9	76.6	<0.001*
Left hand								
Humerus	10.851	-0.316	0.062	<0.001*	68.7	64.5	66.7	0.899
Ulna	17.053	-0.576	0.095	<0.001*	76.5	69.2	73	0.429
Radial	9.85	-0.346	0.074	<0.001*	72.2	66.4	69.4	0.006*
Intercondylar	6.334	-1.15	0.214	<0.001*	77.4	72	74.8	0.008*

Note: * refers to p<0.001

Table 5. Percentages of correctly classified for gender determination for multiple logistic regression.

Groups	Right upper limb			Left upper limb		
	Correct	Incorrect	Correctly%	Correct	Incorrect	Correctly%
Male	100	15	88.40%	96	19	83.5
Female	88	17	87.90%	89	18	83.2
Combined	188	24	86.20%	185	37	83.3

Note: Classification cut off 0.5

Simple linear regression

As obtained, Table 6 and 7 shows simple linear regression models for individual right and left arm and forearm measurements. The results showed that ulna measurement had the lowest SEEs for all groups (combined ± 11.82, male ± 5.48, and female ± 15.67) with the highest coefficient of determination (R^2) for the combined 26.6%, females 9.4% and male 45.3%. This was followed by humerus (combined ± 12.86, male ± 65.55, females ±16.341) with coefficient of determination R^2 (combined 13.1%, females 1.40% and males 40.0%) on the right dimensions while on the left Ulna measurement had the lowest SEEs for all dimensions measured (combined 12.009, female ± 15.853, and males ± 5.311) with the highest coefficient of determination (R^2) (combined 24.2, female ± 7.2 and male ± 49.1). This was followed by the humerus SEE values of combined ± 14.3, female ± 2.3 and male ± 45.3. Intercondylar measurement had the highest SEE value (combined ± 7.441, female ± 16.427, and male ± 7.441) with the lowest coefficient of determination (combined 0.000%, females 0.4% and males 3.0%). Tables 8-10 showed the final models for estimating stature using the measured parameters in right and left arm and forearm in males and females and when combined. The multiple regression table also showed significant results in both left and right arm and forearm measurements of males and females and when combined (p<0.001) and a no significant difference in left arm and forearm measurement in females (p=0.091). In addition, males gave the highest percentage of coefficient of determination of 57.3% in both left and right measurement while that of males were 54.7% (Figures 3-8).

Table 6. Correlation between stature and measured parameter in right and left arm and forearm.

	Right		Left	
	Correlation coefficient (r)	**p-value**	**Correlation coefficient (r)**	**p-value**
Humerus	0.362	<0.001*	0.378	<0.001*
Ulna	0.516	<0.001*	0.492	<0.001*
Radial	0.308	<0.001*	0.314	<0.001*
Intercondylar	0.2	0.003*	0.18	0.007*
Note: * refers to p<0.001				

Table 7. Correlation between stature and measured parameter according to gender in right and left arm and forearm.

	Right		Left	
	Male	**Female**	**Male**	**Female**
Humerus	0.667 (<0.001*)	0.119(0.222)	0.673(<0.001*)	0.150(0.123)
Ulna	0.676 (<0.001*)	0.306(0.001*)	0.700 (<0.001*)	0.269(0.005*)
Radial	0.314 (0.001)	0.154(0.114)	0.320 (0.001*)	0.174(0.074)
Intercondylar	-0.015 (0.872)	0.113 (0.248)	0.005 (0.957)	0.062(0.528)
Note: * refers to p<0.001				

Table 8. Simple linear regression models for Individual measurement in Right arm and forearm measurement.

Groups	Equation	p-value	SEE	R	R^2
Humerus (H)					
Male	108.83+ (1.90) H	<0.001*	5.55	0.667	0.4
Female	148.311+(0.51)H	0.222	16.341	0.119	0.014
Combined	121.83+(1.43)H	<0.001*	12.86	0.362	0.131
Ulna (U)					
Male	79.475+ (3.16) U	<0.001*	5.48	0.676	0.453
Female	96.224+(2.41) U	<0.001*	15.67	0.306	0.094
Combined	70.85+(3.37)U	<0.001*	11.82	0.516	0.266
Radial (R)					
Male	148.75+ (0.94)R	<0.001*	7.06	0.314	0.091
Female	133.70+ (1.13)R	<0.001*	16.26	0.154	0.024
Combined	122.64+ (1.68)R	<0.001*	13.12	0.308	0.095
Intercondylar (I)					
Male	177.044+(-0.09)I	0.872	7.44	0.015	0
Female	153.34+(2.25)I	0.248	16.34	.0.113	0.013
Combined	157.37+(2.39)I	4.595	13.51	0.2	0.04
Note: SEE=Standard error of estimates; * refers to p<0.001					

Table 9. Simple linear regression model for Individual measurement in left arm and forearm measurement.

Groups	Equation	p-value	SEE	R	R^2
Humerus (H)					
Male	108.83+(1.90)H	<0.001*	5.502	0.673	0.453
Female	143.90+(0.64)H	<0.001*	16.272	0.15	0.023
Combined	119.42+(1.50)H	<0.001*	12.766	0.378	0.143
Ulna (U)					
Male	79.391+(3.17)U	<0.001*	5.311	0.7	0.491
Female	106.06+(2.05)U	<0.001*	15.853	0.269	0.072
Combined	76.23+(3.19)U	<0.001*	12.009	0.492	0.242
Radial (R)					
Male	148.23+(0.96)R	<0.001*	7.051	0.32	0.012
Female	130.54+(1.24)R	0.074	16.209	0.174	0.03
Combined	121.89+(1.71)R	<0.001*	13.095	0.314	0.098
Intercondylar (I)					
Male	176.31+(0.03)I	0.957	7.441	0.005	0
Female	158.95+(1.19)I	0.528	16.427	0.062	0.004
Combined	159.04+(2.12)I	0.007	13.565	0.18	0.033
Note: SEE=Standard error of estimate; * refers to p<0.001					

Table 10. Multiple linear regression model using measured parameter.

Groups	Equation	p-value	Adjusted r^2
	Right		
Male	74.081+(1.141)H+(2.031)U+(0.034) R+(0.051)I	<0.001*	0.542
Female	94.664+(-0.018)H+(2.757)U+(-0.591) R+(1.629)I	0.024*	0.069
Combined	66.025+ (0.350)H+(3.057)U+(-0.172) R+(1.233)I	<0.001*	0.271
Left			
Male	72.133+(1.085)H+(2.176)U+(-0.084) R+(0.234)I	<0.001*	0.573
Female	102.708+(0.218)H+(1.939)U+(-0.084) R+(0.334)I	0.091	0.039
Combined	69.320+(0.550)H+(2.612)U+(-0.016) R+(0.967)I	<0.001*	0.251

Note: Right and 57.3% for left arm and forearm measurement. Females had a percentage coefficient of 6.9% in the right and 3.9% on the left arm and forearm measurement.

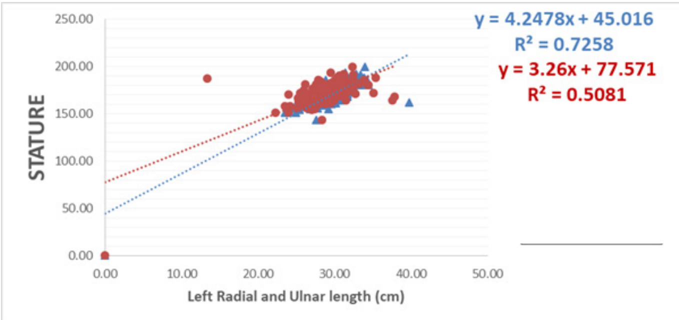

Figure 3. Scatter plot of stretched stature (cm) *vs*. Left Radial length (cm) and Left Ulnar length (cm).

Note: (▲) SS *vs*.UI, (●) SS *vs*.RI

Figure 4. Scatter plot of stretched stature (cm) *vs*. Right Radial length (cm) and Right Ulnar length (cm).

Note: (▲) SS *vs*.UI, (●) SS *vs*.RI, (·······) Linear (SS *vs*.UI), (·······) Linear (SS *vs*.RI).

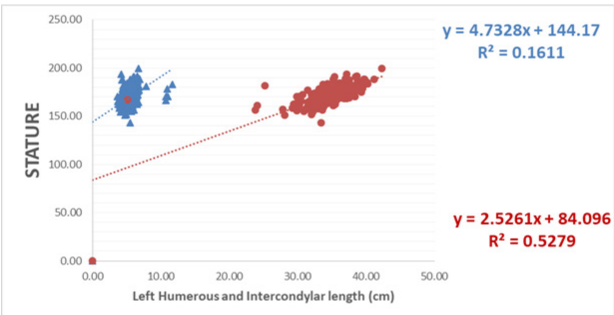

Figure 5. Scatter plot of stretched stature (cm) *vs*. Left Humeral length and Right Intercondylar length (cm).

Note: (▲) SS *vs*.In-L, (●) SS *vs*.HI.

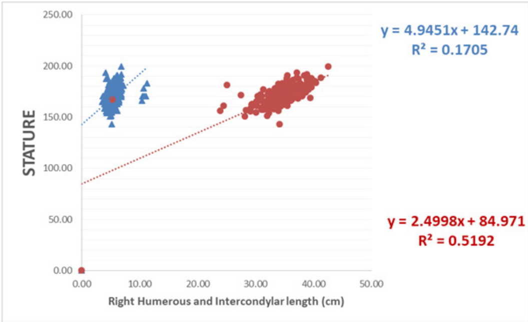

Figure 6. Scatter plot of stretched stature (cm) *vs*. Right Humeral length and Right Intercondylar length (cm).

Note: (▲) SS *vs*.In-L, (●) SS *vs*.HI, (……) Linear (SS *vs*.In-L)

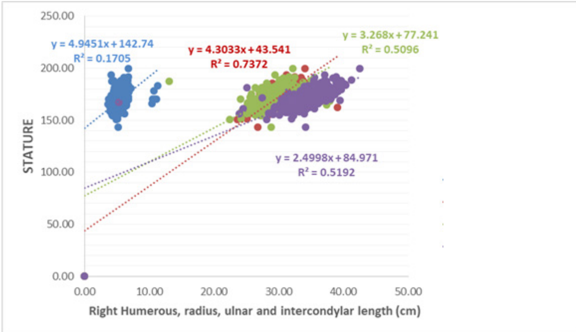

Figure 7. Scatter plot of stretched stature (cm) *vs*. Right Humeral length (cm), Right radius length (cm), Right ulnar length and Right Intercondylar length (cm).

Note: (•) SS *vs*.In-L, (•) SS *vs*.Ul, (•) SS *vs*.Rl, (•) SS *vs*.Hl, (……) Linear (SS *vs*.In-L), (……) Linear (SS *vs*.Ul), (……) Linear (SS *vs*.Rl), (……) Linear (SS *vs*.Hl).

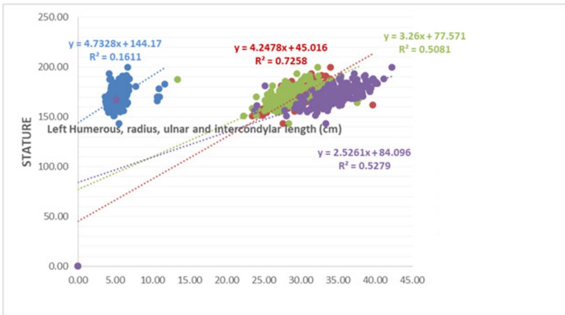

Figure 8. Scatter plot of stretched stature (cm) *vs*. Left Humeral length (cm), Left radius length (cm), Left ulnar length and Left Intercondylar length (cm).

Note: (•) SS *vs*.In-L, (•) SS *vs*.Ul, (•) SS *vs*.Rl, (•) SS *vs*.Hl, (……) Linear (SS *vs*.In-L), (……) Linear (SS *vs*.Ul), (……) Linear (SS *vs*.Rl), (……) Linear (SS *vs*.Hl).

Discussion

The establishment of identity has significant importance in judicial and criminal cases. However, in our country were we are faced with mass accidents, victims of traffic accidents and mass disasters it is expected that anthropologist and forensic investigators discern special means or formulae for human identification. Thus, appropriate practice and experience in identification by the collection of the available and appropriate data concerning the victims is indispensable Knight. Although the final and definitive identification of human remains may require DNA evidence, the forensic anthropologist provides a rapid, low-cost, and convenient way of narrowing down the focus of an investigation and without a reasonably small number of 'suspects', reference DNA samples are unlikely to be available Issa. The preliminary answers sought from any anthropologist include whether studied remains are human, and what are the probable age, sex and stature of the deceased Linda. Higher mean values were observed for male subjects in the following variables as compared to the female subjects. The current study revealed that males had higher right and left arm and forearm dimensions when compared to the females (Table 3) during percutaneous measurement tandem to similar results obtained from several researches [26-29]. As reported by Cutler, 1999 from a research that fusion of epiphyses of bones occurs earlier in females giving the males more chance of bone growth of up to two years more than the females. Bone development in either sex is dependent on a combination of genetic markers and hormone exposure Franklin. However, this study showed that there was little significant difference between the male right and left ulna bone measurement while in females, the left arm and forearm measurement was slightly higher that the right except for the intercondylar width which had no significant difference. From this study, it was seen that in cases of severe damage to body parts, with the presence of the right and left arm and forearm bone, sex of the individual can be predicted.

As obtained, independent t test results showed that males have statistically significant larger mean than females in any given parameter measured ($p<0.001$). The dimension that demonstrated the highest degree of sexual dimorphism in the right and left hand was the ulnar with t-values of 8.256 and 7.504 respectively Table 2. This was in accordance with results from Ilayperuma on estimation of personal stature from the length of forearm revealed that there was a significant difference of the ulnar length between genders (p<0.001) and same result was gotten from a study carried out by Ahmed, on stature and gender estimation on Sudanese Arabs.

From the present study, the right humerus has the highest recorded mean difference of 2.50 cm as seen in Table 2. This shows that the right humerus can also be used for sex prediction in the absence of Ulnar. However, the study recorded its set back as it could not relate with other study on how the humerus can be used for sexual dimorphism as previous studies was based on stature prediction.

Using Logistic regression, each single measured dimension was tested to show its ability to predict sex a statistical significant prediction of sex (p<0.001) with the highest regression overall classification accuracy of 76.6% and 74.8% achieved using right and left intercondylar measurement respectively. The results were similar to research carried out by Tradowsy, 1990 which recorded that intercondylar distance in men is 6 mm larger than in women from the distribution curve, it was hypothesized that about 5% of women have an intercondylar distance smaller than 90 mm, while less than 1% of men have an intercondylar distance smaller than 90 mm. This present study shows that the right and left ulnar have a percentage value of 73.4% and 73.0%. Sex biases were 7.1 and 2.4. The lowest overall accuracies were seen in right and left humerus with overall percentages of 68.5% and 66.7%. Sex bias was 7.7 and 4.4 respectively. Table 4 also showed the highest classification accuracy for females and males were achieved using right intercondylar measurement with 72.9% and 80.0% correctly classified. Using logistic regression, this study has humerus as the lowest predictor for sex at a classification cut off of 0.5. In forensic examinations and anthropological studies, prediction of stature from incomplete and decomposing skeletal remains is vital in establishing the identity of an unknown individual Ebite. Correlation between stature, right and left forearm and arm measured parameter, the study deduces that all parameters showed a positive significant correlation with stature. The ulnar had the strongest correlation with stature while the intercondylar had the weakest correlation with stature. This was in accordance with the study carried out by Okai stating that height correlated more strongly with ulna than with radial length. However, comparing the measured parameter between male and female, correlation between stature, right and left arm and forearm, the ulna and humerus had the strongest correlation in male while the ulna and radial were strongest in female. However, this study was limited in comparing with other studies as much work has not been carried out in this area. This was in accordance with the research carried out by Ilayperuma whose research showed a positive statistically significant correlation between height and ulnar length in both sexes. The study carried out by Borkar, deduced that correlation co-efficient is between height and length of humerus in males is 0.849 and in females is 0.793, which is much more significant. However, from the Table 5, weakest correlations were shown in intercondylar measurement with r=0.200 in the right and r=0.180 in the left showing that the intercondylar cannot be used in stature estimation. From this study, it could be deduced that intercondylar is best used for sex determination than for stature estimation.

The present study showed in simple linear regression for individual right arm and forearm measurement that ulna measurement had the lowest SEEs for all groups (combined ± 11.82, male ± 5.48, and female ± 15.67) with the highest coefficient of determination (R^2) for the combined 26.6%, females 9.4% and male 45.3%. This was in consonant with the study carried out by Torimisu, their research was on stature estimation based on radial and ulnar lengths using three dimensional images from multi-detector computed tomography in a Japanese population. The study revealed SEE values which range from 4.18-4.72 cm for all subjects, 4.09-4.58 cm for females revealing that the SEE values for males were slightly lower than those for the females. However, both studies were not in consonant with the study carried out by Hasegawa. In their study, they measured the lengths of the lower limb bones (femur and tibia) using dual-energy X-ray absorptiometry from 2004-2006 and derived regression formulae for stature estimation in a Japanese population. Lower SEEs (2.63-3.03 cm) were found in their study. Although, this present study does not make use of data from the lower limb but the information gotten from Torimisu and Hasegawa shows that in the absence of the limb during forensic investigation, the presence of the upper limb can be used to predict the stature and at the same time determine the sex of an individual. This was followed by humerus (combined ± 12.86, male ± 65.55, female ± 16.341) with coefficient of determination R^2 (combined 13.1%, females 1.40% and males 40.0%). This study also deduces that the intercondylar had the highest SEE value (combined ± 7.441, female ± 16.427, and male ± 7.441) with the lowest coefficient of determination (combined 0.000%, females 0.4% and males 3.0%) which also signifies that the intercondylar has no significance in stature estimation.

In the present study, multiple linear regression equations provided lower SEE values and higher coefficients of determination than the simple linear regression equations in all cases. These results indicate that the multiple regression equations for the estimation of stature were more reliable than the single linear regression equations. The current study also demonstrated that the multiple regression equations derived using bilateral variables (all of the four parameters) were the most accurate regression formulae in all cases. Therefore, if both forearms are well preserved, stature could be estimated using multiple equations based on all of the four parameters. This was in accordance with the research carried out Ahmed, who observed that multiple regression models developed for the upper limb dimensions demonstrated a higher degree of prediction accuracy, as indicated by a lower SEE (3.54-3.68 cm) and higher R^2 (0.633-0.663) in comparison to the simple linear model.

Conclusion

Examination of right, left arm and forearm provides important evidence in identification of individual as it helps in the estimation of stature and sex. The parameters measured from the right, left arm and forearm are important for forensic investigation and are reliable. Higher bone dimension and a statistically significant mean shows that male has a higher bone dimension than the female. It shows that sex of a deceased individual can be predicted through sexual dimorphism table. From this study, height correlate strongly with ulna length, followed by the humeral length. The intercondylar length has low statistically significant mean SEE for height estimation. The logistic regression shows that the best parameter for sexual dimorphism is the intercondylar while the humerus cannot be used for sex prediction. From this study, all parameters showed a positive significant correlation with stature. The ulnar had the strongest correlation while the intercondylar had the weakest correlation with stature. In this study, while comparing the correlation between stature with the right, left arm and forearm of an individual, ulnar and humerus were the strongest in male, ulnar and radius were the strongest in female. The intercondylar on both hands still had the weakest correlation with stature on both arm and forearm. Simple linear regression table for individual right arm and forearm measurement showed that ulna measurement had the lowest SEEs for all groups (combined ±11.82, male ±5.48, females ± 15.67) with the highest coefficient of determination (R^2) for the combined 26.6%, females 9.4% and male 45.3%, followed by the humerus (combined ± 12.86, male ± 65.55, females ± 16.341) with coefficient of determination R^2 (combined 13.1%, females 1.40% and males 40.0%). The multiple regression table also showed significant results in both left and right arm and forearm measurements of males and females and when combined (p<0.001) and a no significant difference in left arm and forearm measurement in females (p=0.091).

References

1. Abdel-Malek, Adel Kamel, Afaf Mohamed Ahmed, and Sawsan Abd El Aziz El Sharkawi, et al. "Prediction of Stature from Hand Measurements." *Forensic Sci Int* 46 (1990): 181-187.
2. Adams, Bradley J., and Nicholas P. Herrmann. "Estimation of Living Stature from Selected Anthropometric (Soft Tissue) Measurements: Applications for Forensic Anthropology." *J Forensic Sci* 54 (2009): 753-760.
3. Agnihotri, Arun Kumar, Smriti Agnihotri, Nilima Jeebun, and Krishna Googoolye. "Prediction of Stature Using Hand Dimensions." *J Forensic Leg Med* 15 (2008): 479-482.

4. Ahmed, Altayeb Abdalla. "Estimation of Stature from the Upper Limb Measurements of Sudanese Adults." *Forensic Sci Int* 228 (2013): 178-e1.
5. Akhlaghi, Mitra, Marzieh Hajibeygi, Nasim Zamani, and Behzad Moradi. "Estimation of Stature from Upper Limb Anthropometry in Iranian Population." *J Forensic Leg Med* 19 (2012): 280-284.
6. Borkar, Meenakshi P. "Estimation of Height from the Length of Humerus in Western Region of Maharashtra." *Int J Res Med Sci* 2 (2014):498-500.
7. Blau, Soren, and Douglas H. Ubelaker. Handbook of Forensic Anthropology and Archaeology. Vol. 534. Walnut Creek: Left Coast Press, 2009.
8. Campobasso, Carlo Pietro, Giancarlo Di Vella, and F. Introna Jr. "Using Scapular Measurements in Regression Formulae for the Estimation of Stature." *Boll Soc Ital Biol Sper* 74 (1998): 75-82.
9. Cutler Jr, G. B. "The Role of Estrogen in Bone Growth and Maturation During Childhood and Adolescence." *J Steroid Biochem Mol Biol* 61 (1997): 141-144.
10. De Mendonça, M. C. "Estimation of Height from the Length of Long Bones in a Portuguese Adult Population." Am J Phys Anthropol: The Official Publication of the *American Journal of Physical Ant* 112 (2000): 39-48.
11. Howley, Donna, Peter Howley, and Marc F. Oxenham. "Estimation of Sex and Stature Using Anthropometry of the Upper Extremity in an Australian Population." *Forensic Sci Int* 287 (2018): 220-e1.
12. Oladunni, A. Ebeye. "Stature Estimation from Upper Extremity Long Bones in a Southern Nigerian Population." *Aust J Basic Appl Sci* 7 (2013): 400-403.
13. Ebite, L. E., T. C. Ozoko, A. O. Eweka, and P. O. Otuaga, et al. "Height: Ulna Ratio: A Method of Stature Estimation in a rural Community in Edo State, Nigeria." *J Forensic Sci* 3 (2008): 12-18.
14. Esomonu, U. G., M. G. Taura, N. M. Ibeabuchi, and M. A. Madibo. "Regression Equation for Estimation of Foot Length from its Morphometry in Nigeria Population. Nigeria. Quaterly." *Hospital* 23 (2013).
15. Franklin, Daniel. "Forensic Age Estimation in Human Skeletal Remains: Current Concepts and Future Directions." *Leg Med* 12 (2010): 1-7.
16. Gray, Colin D., and Paul R. Kinnear. IBM SPSS Statistics 19 Made Simple. Psychology Press, 2012.
17. Hasegawa, Iwao, Kazuhiro Uenishi, Tatsushige Fukunaga, and Ryousuke Kimura, et al. "Stature Estimation Formulae from Radiographically Determined Limb Bone Length in a Modern Japanese Population." *Leg Med* 11 (2009): 260-266.
18. Hemy, Naomi, Ambika Flavel, Nur-Intaniah Ishak, and Daniel Franklin. "Estimation of Stature Using Anthropometry of Feet and Footprints in a Western Australian Population." *J Forensic Leg Med* 20 (2013): 435-441.
19. Ilayperuma, Isurani, Ganananda Nanayakkara, and Nadeeka Palahepitiya. "A Model for the Estimation of Personal Stature from the Length of Forearm." *Int J Morphol* 28 (2010): 1081-1086.
20. İşcan, Mehmet Yaşar. "Forensic Anthropology of Sex and Body Size." *Forensic Sci Int* 147 (2005): 107-112.
21. Ishak, Nur-Intaniah, Naomi Hemy, and Daniel Franklin. "Estimation of Sex from Hand and Handprint Dimensions in a Western Australian Population." *Forensic Sci Int* 221 (2012): 154-e1.
22. Jasuja, O. P., and G. Singh. "Estimation of Stature from Hand and Phalange Length." *J Indian Acad Forensic Med* 26 (2004): 100-106.
23. Jit, I., and S. Singh. "Estimation of Stature from Clavicles." *Indian J Med Res* 44 (1956): 137-155.
24. Kanchan, Tanuj, Kewal Krishan, Abhilasha Sharma, and Ritesh G. Menezes. "A Study of Correlation of Hand and Foot Dimensions for Personal Identification in Mass Disasters." *Forensic Sci Int* 199 (2010): 112-e1.
25. Kanchan, Tanuj, and Prateek Rastogi. "Sex Determination from Hand Dimensions of North and South Indians." *J Forensic Sci* 54 (2009): 546-550.
26. Kanchan, Tanuj, Ritesh G. Menezes, Rohan Moudgil, and Ramneet Kaur, et al. "Stature Estimation from Foot Length Using Universal Regression Formula in a North Indian Population." *J Forensic Sci* 55 (2010): 163-166.
27. Knauft, Bruce M. "Anthropology in the middle." *Anthropol Theory* 6 (2006): 407-430.
28. Saukko, Pekka, and Bernard Knight. Knight's Forensic Pathology. CRC press, 2015.
29. Kozak, J. E. R. Z. Y. "Stature Reconstruction from Long Bones. The Estimation of the Usefulness of Some Selected Methods for Skeletal Populations from Poland." *Variability Evol* 5 (1996): 83-94.
30. Krishan, Kewal, and Abhilasha Sharma. "Estimation of Stature from Dimensions of Hands and Feet in a North Indian Population." *J Forensic Leg Med* 14 (2007): 327-332.
31. Krishan, Kewal, Tanuj Kanchan, and Abhilasha Sharma. "Sex Determination from Hand and Foot Dimensions in a North Indian Population." *J Forensic Sci* 56 (2011): 453-459.
32. Krishan, Kewal, Tanuj Kanchan, and Abhilasha Sharma. "Multiplication Factor versus Regression Analysis in Stature Estimation from Hand and Foot Dimensions." *J Forensic Leg Med* 19 (2012): 211-214.
33. Zhaotao, Liang. "The Scope and Function of Anthropology." *Chinese Sociol Anthropol* 20 (1988): 33-42.

How to cite this article: Roli, Osahon Itohan, Obi-Ojinika Chukubueze and Ibeabuchi Nwachukwu Mike" Determination of Sex and Stature from Percutaneous Anthropometric Dimensions of the Upper Arm and Forearm Bones in an Adult Nigerian Population in Lagos ." *J Forensic Res* 13 (2022): 502