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Estimation of Ulna Length from its Morphometry in a South West Nigerian Population

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ABSTRACT

Identification of human remains is of high importance in forensic investigation. Estimation of stature is usually based on the mesurement of long bones like femur, tibia, fibular, humerus, ulna and radius which has a particular ratio in the stature of an individual. Since stature estimation is population dependent, this report describe the estimation of stature from ulna in south west Nigeria population. The distance between the anterior-most point on the tip of trochlear notch superiorly and tip of the coronoid process inferiorly (AB). The distance between the superior-most point on the olecranon and anterior-most point on the coronoid process of the ulna in the trochlear notch (CB). Tthe difference between AB andCB (AC). The distance between the tips of the olecranon process posteriorly to the anterior-most point on the trochlear notch inferiorly (EB). The distance between the anterior-most point on the trochlear notch superiorly to the tip of the olecranon process posteriorly (AE). The distance along the perpendicular to the long axis of the ulna from the anterior-most point on the olecranon process toa point on the posterior aspect of the ulna (AD). The distance along the perpendicular to the long axis of the ulna from the tip of coronoid process of ulna to a point on the posterior aspect of the ulna (BF) The distance between the anterior and posterior ends of the radial notch (GH). The distance along the perpendicular to the long axis of the ulna from the posterior-most point on the trochlear notch to a point on posterior aspect of the ulna (IJ). The distance between the anterior-most point on the trochlear notch superiorly to a point on the posterior aspect of the ulna where the perpendicular to the long axis of the ulna passes through the anteriormost point on the trochlear notch inferiorly (AF). The distance between the tip of the olecranon process posteriorly and the anterior- most point on the radial notch distally (EG). The distance between the tips of the olecranon process posteriorly to the posterior-most point on the radial notch distally (EH). The distance between the anterior-most point on the trochlear notch superiorly to a point in the posterior aspect of the ulna where the perpendicular to the long axis of the ulna passes through the posterior-most point of the trochlear notch (AJ). The distance between superior-most point on the olecranon process to a point on the posterior aspect of the ulna where the perpendicular to the long axis of the ulna passes through on the coronoid process (CF). Anterior posterior (dorsal-volar) diameter as the maximum diameter of the diaphysis where the crest exhibits the greatest protrusion in the anterior-posterior (doso-volar) plane (MC). Medial-lateral (transverse) diameter as the distance between medial and lateral surfaces at the level of greatest crest protrusion, taken perpendicular to anterior posterior diameter (APD) were achieved using digital venire caliper. The minimum circumference as the least circumference near the distal end of the bone (MLD) was measured using an anthropometric tape while the maximum length of ulna as the distance from the most superior point on the olecranon to the most inferior point on the styloid process (ML) was measured using anthropometric board. Pearson correlation and Persian regression were used to derive the liner regression equations for the measured parameters that showed correlation with the length of ulna. Dimension GH, IJ and MLD were the best dimension for predicting the length of ulna, dimension CF was the best for right and dimension GH and MC were best dimension for predicting the length of ulna for both sides (irrespective of the side). This finding is a preliminary step in predicting the stature of an individual in South West Nigerian population and may become a potential tool for anatomist, forensic anthropologist and archeological investigation for the identification of unknown body remains using the regression equation within this population.

Key words: Morphometry, Nigeria, ulnar length, regression

INTRODUCTION

Over the years, anthropometric measurements of the body have been developed for various reasons. Anthropometric techniques employed by anthropologists, forensic experts and anatomists have made it possible to use bones obtained from burial site, bodies, parts of bodies or skeletal remains to estimate the stature of individuals[1]. Forensic anthropology encompasses the examination of skeletal remains for the purposes of identification[2]. Stature, which is one of several biological parameters that may be usefully compared with ante-mortem records to include or exclude possible identifications of missing persons, has been reconstructed, using regression formulae for long bones[3,4]. Researchers had successfully correlated the length of long bones with the height of individuals in the past. Rollet[5] measured 100 dissecting room cadavers from Lyon, and calculated the average length of each long bone in men and women of a similar stature. Pearson[6] performed regression analyses on Rollet´s data, and came up with two sets of stature reconstruction formulae, one for men and one for women, which can be used to calculate stature from the length of a single long bone. Eliakis *et al.*[7] studied university dissecting room cadavers from Athens. Dupertuis and Hadden[8] published different sets of formulae for whites and blacks, based on an early twentieth century collection of skeletons from Ohio. Trotter and Gleser[9, 10] complemented that dataset with American soldiers killed in the Pacific during the Second World War and the Korean War. All these regression studies came up with different sets of formulae. The differences in the set of formulae has been traced to the different method used: some measure the bones when they are fresh, others wait for them to dry; some researchers take a living measurement, while some based their measurement on cadavers lying on a table or suspended from the ceiling; some take maximum bone length, others prefer the length to be measured in the anatomical position. However, when this diversity is accounted for, the discrepancy remains absolutely obvious. Physical anthropologists commented on the variation of the formulae ascribing it to genes, and they devised separate sets of formulae for different population. More recently, they realized that even when the genetic composition of a population stays more or less the same, body proportions can still change. The formulae that Trotter and Gleser published on Second World War victims[9] proved not to be valid anymore for those killed during the Korean War, six to ten years later, hence, they concluded that 'Stature and its relationship to long bone length are in a state of flux' and 'equations for estimation of stature should be derived anew at opportune interval[10]. Apparently, body proportions do not only depend upon genes, but also on the environment. Stature reconstruction formulae can therefore only be applied to the population for which they were calculated, or one that is very similar in its genetic composition and its way of life. Although many formulae for stature estimation from long bones exist, they are population specific[11]. It is important to note that there are no universal applicable formulae for stature estimation from the length of one bone as the relationship between them is highly influenced by race, sex and age of an individual. Bony markers are useful in estimating the length of long bone where the body of an individual has been dismembered or if the skeleton is disintegrated[12]. Esomonu *et al.*[13] worked on 30 dry adult Nigerian humeri of unknown sex, he concluded that it is possible to estimate the maximum length of humerus from the measured anatomical neck, distance between the proximal edge of fossa olecrani and the most distal point of trochlear humeri and the mid shaft diameter with a relative accuracy using long bone regression technique. Suja *et al.*[14] worked on a total number of 110 ulnae (right-84, left-26) using fourteen bony markers on the proximal end of ulna in a south Indian population. Badkur and Nath[15] studied three markers on the upper end of ulna, height of ulna from the upper end of the ulna, height of radial facet, the height of the ulna tuberosity and the breadth of the olecranon in an Indian population. Chibba and Bidmos[16] in their study on 50 male and 50 female complete skeletons of South Africans of European descent showed significant correlation between fragments length of tibiae and total length of tibiae from each segment. Since no such data exist for the Nigerian population, the present study attempted to characterize the morphometry of ulna and evaluate if any parts of its segment display any correlation with the entire length and hence formulate a regression equation for the estimation of the length of ulna in adult Nigerian population.

MATERIALS METHODS

Institutional Approval and Ethical Clearance

For this study, strict compliance with institutional rules regarding human experimental research was ensured. Since study specimens were selected from the cadaveric skeletal collection pooled and stored for research purposes in the Department of Anatomy, College of Medicine, University of Lagos, statutory written approval was obtained from the Departmental Research Ethics committee prior to the commencement of specimen collection and processing. Furthermore, as the study was developed in partial fulfillment of the requirement for the award of the degree of Masters of Science in Anatomy of the University of Lagos, ethical clearance was also obtained from the Research Grants and Experimentation Ethics Committee of the College of Medicine of the University of Lagos at the inception of the study (approval letter CM/COM/8/VOL.XI/2014).

Study Sample

A total of forty four radius bones of unknown sex obtained from the anthropometric laboratory of the Department of Anatomy, University of Lagos were used in this study. These bones were pooled, with completely closed epiphyseal plates indicating that they belonged to adults. They were also identified as right or left bones separated and numbered to avoid repetition before measurements were taken. Measurements were taken directly on the bones using osteometric board for all length measures, anthropometric tape for all circumference measures, and digital vernier caliper calibrated to the nearest 0.01 mm for all other measures. Eighteen parameters where considered using techniques recommended by Singh and Bhasin[17]

1. Distance between the anterior-most point on the tip of trochlear notch superiorly and tip of the coronoid process inferiorly (AB).
2. Distance between the superior-most point on the olecranon and anterior-most point on the coronoid process of the ulna in the trochlear notch (CB).
3. The difference between AB and CB (AC).
4. Distance between the tips of the olecranon process posteriorly to the anterior-most point on the trochlear notch inferiorly (EB).
5. Distance between the anterior-most point on the trochlear notch superiorly to the tip of the olecranon process posteriorly (AE).
6. Distance along the perpendicular to the long axis of the ulna from the anterior-most point on the olecranon process toa point on the posterior aspect of the ulna (AD).
7. Distance along the perpendicular to the long axis of the ulna from the tip of coronoid process of ulna to a point on the posterior aspect of the ulna (BF).
8. Distance between the anterior and posterior ends of the radialnotch (GH).
9. Measurement of the distance along the perpendicular to the long axis of the ulna from the posterior-most point on the trochlear notch to a point on posterior aspect of the ulna (IJ).
10. Distance between the anterior-most point on the trochlear notch superiorly to a point on the posterior aspect of the ulna where the perpendicular to the long axis of the ulna passes through the anteriormost point on the trochlear notch inferiorly (AF).
11. Distance between the tip of the olecranon process posteriorly and the anterior- most point on the radial notch distally (EG).
12. Distance between the tips of the olecranon process posteriorly to the posterior-most point on the radial notch distally (EH).
13. Distance between the anterior-most point on the trochlear notch superiorly to a point in the posterior aspect of the ulna where the perpendicular to the long axis of the ulna passes through the posterior-most point of the trochlear notch (AJ)
14. Distance between superior-most point on the olecranon process to a point on the posterior aspect of the ulna where the perpendicular to the long axis of the ulna passes through on the coronoid process (CF)
15. Anterior posterior (dorsal-volar) diameter as the maximum diameter of the diaphysis where the crest exhibits the greatest protrusion in the anterior-posterior (doso-volar) plane (MC).
16. Medial-lateral (transverse) diameter as the distance between medial and lateral surfaces at the level of greatest crest protrusion, taken perpendicular to anterior posterior diameter (APD).
17. Minimum circumference as the least circumference near the distal end of the bone (MLD).
18. Maximum length of ulna as the distance from the most superior point on the olecranon to the most inferior point on the styloid process (ML).

All measurements were taken to the nearest centimeters [Plates 47 in the appendix]. Comparisons between right and left ulnae were performed for all the bony markers using Student's *t*test. Analysis using Pearson correlation coefficient was carried out to assess the relationship between the markers and length. Regression analysis was also carried out to find the markers that were related to the length and for estimating the length using equations. Based on the regression analysis, regression equations were derived to construct the length of the ulna bone from the significant bony markers. Multivariate regression equations were derived after excluding highly correlated markers using a stepwise method. Analysis was done using the Statistical Package for the Social sciences (SPSS version 17.0, Vernier caliper by Sunrise™, Shanghai, China).

RESULTS

Table 1: Independent t-test of the bony markers of right and left Ulna (cm)

Variables	LEFT				RIGHT			
	Mean	SE	SD		Mean	SE	SD	P Value
AB	2.4514	0.05629	0.26402		2.5027	0.05070	0.23779	0.336
CB	3.2368	0.05788	0.27149		3.3114	0.06103	0.28624	0.218
AC	0.7855	0.01941	0.09106		0.8123	0.03126	0.14661	0.456
EB	3.8273	0.06077	0.28503		3.8655	0.05485	0.25729	0.578
AE	2.3877	0.05606	0.26293		2.4500	0.04792	0.2275	0.931
AD	2.4150	0.04926	0.23104		2.4268	0.04484	0.21031	0.887
BF	3.3695	0.06508	0.30525		3.4005	0.06215	0.29151	0.569
GH	1.5536	0.06147	0.28832		1.4605	0.05133	0.24078	0.339
IJ	1.7918	0.10416	0.48854		1.5264	0.04539	0.21288	0.279
AF	3.2359	0.05880	0.27578		3.2723	0.0783	0.33221	0.196
EG	4.0845	0.06212	0.29138		4.1886	0.07610	0.35695	0.627
EH	3.9550	0.06478	0.30384		3.9555	0.07399	0.3402	0.216
AJ	3.3341	0.07916	0.37129		3.3927	0.08498	0.39861	0.529
CF	3.2400	0.09141	0.42874		3.2823	0.07229	0.33906	0.428
MC	4.1455	0.17355	0.81400		4.4000	0.13516	0.63396	0.087
APD	1.5073	0.08030	0.37663		1.5696	0.06618	0.31041	0.196
MLD	1.4191	0.08144	0.38199		1.4873	0.06973	0.32708	0.133
ML	28.6455	0.55769	2.61579		29.0386	0.41602	1.95131	0.894

Table 2: Independent t-test of both sides irrespective of side (cm)

Descriptive Statistics				
Variables				
	Statistic	Mean	SE	SD
AB	44	2.4770	.03764	.24967
CB	44	3.2741	.04195	.27827
AC	44	.7989	.01830	.12137
EB	44	3.8464	.04056	.26903
AE	44	2.4189	.03675	.24377
AD	44	2.4209	.03293	.21842
BF	44	3.3850	.04453	.29538
GH	44	1.5070	.040 21	.26671
IJ	44	1.6591	.05968	.39588
AF	44	3.2541	.04557	.30229
EG	44	4.1366	.04919	.32628
EH	44	3.9552	.04859	.32234
AJ	44	3.3634	.05756	.38184
CF	44	3.2611	.05768	.38259
MC	44	4.2727	.11042	.73243
APD	44	3.1580	1.60170	.2446
MLD	44	7.0332	3.15171	.40605
PL	44	25.6639	.23213	1.53975
ML	44	28.8420	.34512	2.28926

Table 3: Univariate analysis of Ulna of the right and left and both sides (cm)

	Left				Right				Both			
	A	SE	B	P.V	A	SE	B	PV	A	SE	B	P.V
AB	16.107	0.516	4.677	0.003*	26.271	0.135	4.570	0.001*	20.503	0.367	3.276	0.001*
CB	10.311	0.588	5.660	0.086	22.609	0.285	4.856	0.001*	16.620	0.454	3.717	0.001*
AC	22.877	0.256	4.909	0.001*	25.862	0.294	2.346	0.001*	24.857	0.264	2.267	0.001*
EB	8.559	0.686	5.723	0.436	18.613	0.356	6.140	0.007	10.735	0.553	4.217	0.015
AE	13.521	0.637	4.119	0.004*	22.394	0.312	4.536	0.001*	17.158	0.514	3.021	0.001*
AD	18.924	0.358	5.739	0.004*	17.025	0.534	4.273	0.001*	18.030	0426	3.556	0.001*
BF	12.916	0.545	5.454	0.028	26.832	0.097	5.084	0.001*	19.433	0.359	3.793	0.001*
GH	24.859	0.268	3.086	0.002*	27.086	0.165	2.644	0.001*	26.148	0.208	1.982	0.001*
IJ	30.700	0.214	2.169	0.001*	31.728	0.335	2.975	0.001*	31.260	0.252	1.472	0.001*
AF	8.982	0.641	5.288	0.105	26.153	0.150	4.270	0.001*	18.982	0.400	3.500	0.001*
EG	6.100	0.615	6.482	0.358	17.071	0.523	4.380	0.001*	12.634	0.558	3.726	0.002*
EH	10.847	0.523	6.509	0.111	22.205	0.307	4.750	0.001*	17.248	0.413	3.961	0.001*
AJ	18.112	0.448	4.722	0.001*	24.298	0.285	3.583	0.001*	21.298	0.374	2.904	0.001*
CF	26.406	0.113	4.428	0.001*	29.720	0.036	4.243	0.001*	27.624	0.062	3.025	0.001*
MC	22.346	0.473	2.673	0.001*	24.315	0.349	2.866	0.001*	23.043	0.434	1.883	0.001*
APD	24.298	0.415	2.192	0.001*	25.910	0.317	2.130	0.001*	24.911	0.382	1.501	0.001*
MLD	25.039	0.371	2.086	0.001*	25.295	0.425	1.837	0.001*	25.107	0.396	1.372	0.001*

Table 4: Simple regression equations of the right, left and both Ulna, relating length with the bony markers (cm)

LEFT	RIGHT	BOTH
L= 22.877 + (4.909AC)	L= 26.271 + (4.570AB)	L=20.503 + (3.276AB)
L= 13.521 + (4.119AE)	L= 22.609 + (4.856CB)	L= 16.620 +(3.717CB)
L= 18.924 + (5.739AD)	L= 25.862 + (2.346AC)	L=24.857 + (2.267AC)
L= 12.916 + (5.454BF)	L= 18.613 + (6.140EB)	L=10.735 + (4.217EB)
L=24.859 + (3.086GH)	L= 22.394 + (4.536AE)	L=17.158 + (3.021AE)
L=30.700 + (2.169IJ)	L= 17.025 + (4.273AD)	L= 18.030 + (3.556AD)
L=18.112 + (4.722AJ)	L= 26.832 + (5.084BF)	L=19.433 + (3.793BF)
L= 26.406 + (4.428CF)	L= 27.086 + (2.644GH)	L= 26.148 + (1.982GH)
L= 22.346 + (2.673MC)	L= 31.728 + (2.975IJ)	L=31.260 + (1.472IJ)
L= 24.296 + (2.192APD)	L= 26.153 + (4.270AF)	L=18.982 + (3.500AF)
L= 25.039 + (2.086MLD)	L= 17.071 + (4.380EG)	L= 12.634 + (3.726EG)
	L= 22.205 + (4.750EF)	L= 17.248 + (3.961EH)
	L= 24.298 + (3.585AJ)	L=21.298 + (2.904AJ)
	L=29.720 + (4.243CF)	L=27.624 + (3.025CF)
	L= 24.315 +(2.866MC)	L=23.043 + (1.883MC)
	L=25.910 + (2.130APD)	L=24.911 + (1.501APD)
	L=25.295 + (1.837MLD)	L=25.107 + (1.372MLD)

Multivariate linear regression equation to Identify Best Marker for Predicting Ulna length
LEFT= 6.406 + 5.997GH + 5.640IJ +7.369MLD
RIGHT = L= 26.153 + 4.270CF
BOTH= 3.635GH + 1.902MC.

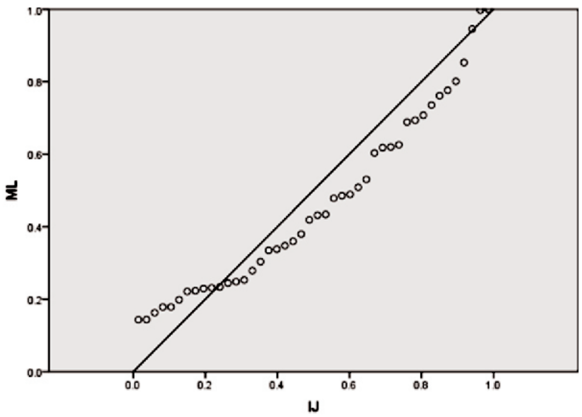

Figure 1: Scattered plot of ML against IJ

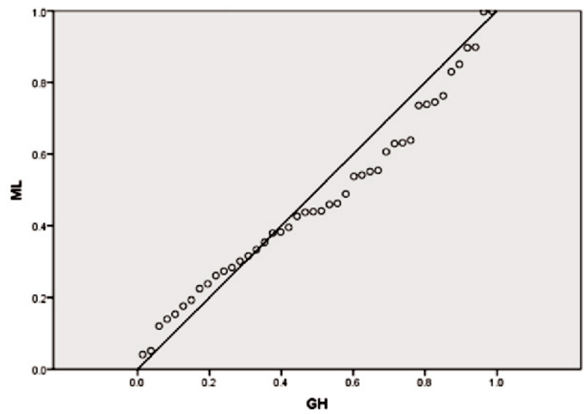

Figure 2: Scattered plot of ML against GH

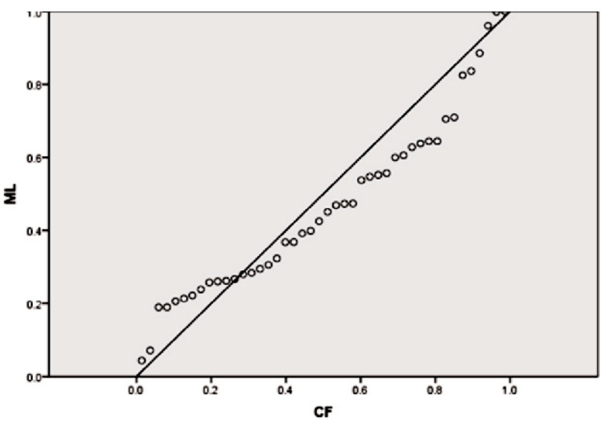

Figure 3: Scattered plot of ML against CF

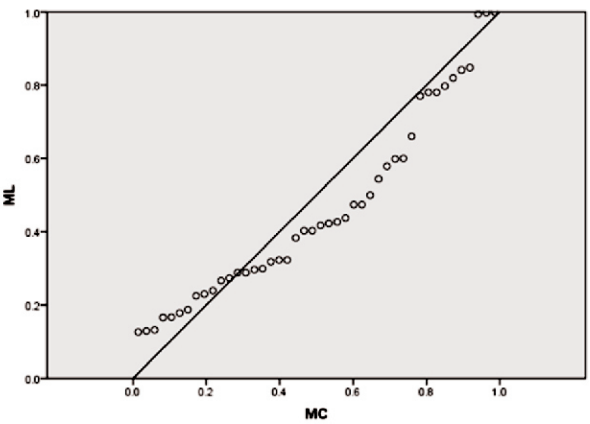

Figure 4: Scattered plot of ML against MC

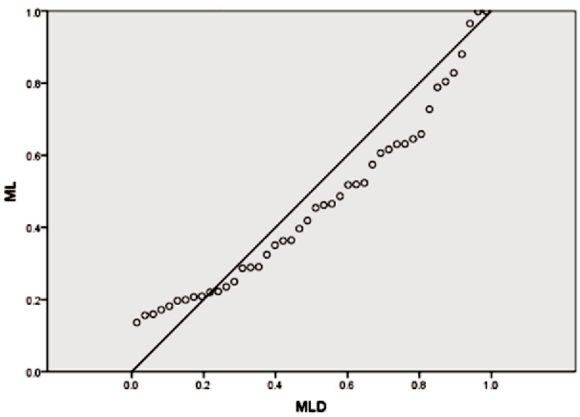

Figure 5: Scattered plot of ML against MLD

DISCUSSION

Previous work has established that long bones generally corellate effectively with the stature [4, 9-13, 16, 18, 19]. Also,studies have shown that bony landmarks when regressed against the lenght of the long bone can be used to deduce the length of the bone. Landmarks of ulna have been used to derive the lengthh of the bone by several researchers[12, 14-16, 20] (Singh *et al* 1974., Badkur & Nath 1990., Chibb & Bidmos 2007., Shende & Perekh [20]2009 and Suja et al 2010). Duyer and Pelin[11] established that not only is there a need for different regression formulae between males, females, and different populations, but also that there is a possible need for different formulae between stature groupings. Therefore, the present study provides regression formulae for the estimation of ulna length in south- west Nigerian population. The ulna length estimates obtained using the formulae derived from the present study are the preliminary data formulae available for the Nigerian population as no literature exist for estimation of the Nigerian ulna. From the statistical analysis, it can be seen that the mean length of the left radius is 28.6±2.6cm and29.0±0.9cm the right (table 1) .When both sides were considered irrespective of sides, the mean length was found to be 28.8±2.3cm (table 2). Thus, there is no statistically significant difference in mean between the two mean of the variables at 0.05leve of significant l. Eleven parameters on the left, sixteen on the right and sixteen when both sides were considered irrespective of sides (Table 3) showed statistically significant correlation with the length of ulna, leaving out EH, EG, AF, BF, and EB on the left while only EB was left out on the right side and when both sides was considered irrespective of sides. When simple regression equation was carried out on the left, right and on both sides to find

Plate 1: Measurement of maximum length of ulna using a customized osteometric board

Plate 2: Measurement of Distance between the anterior-most point on the tip of trochlear notch superiorly and tip of the coronoid process inferiorly (AB) using a digital Vernier caliper

Plate3: Distance along the perpendicular to the long axis of the ulna from the tip of coronoid process of ulna to a point on the posterior aspect of the ulna (BF).

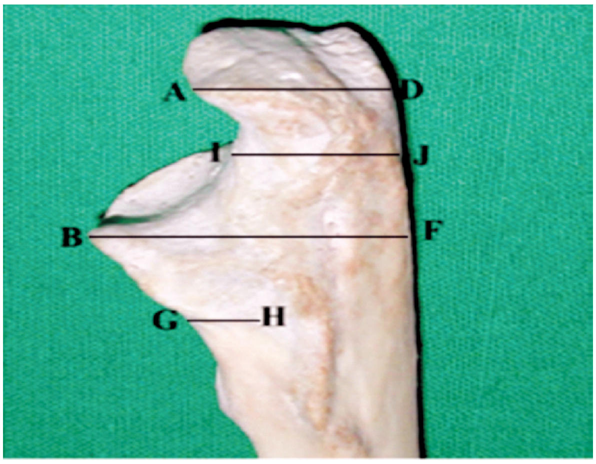

Plate 4: Measurement of proximal breadths of ulna (lateral view) using a digital Vernier caliper

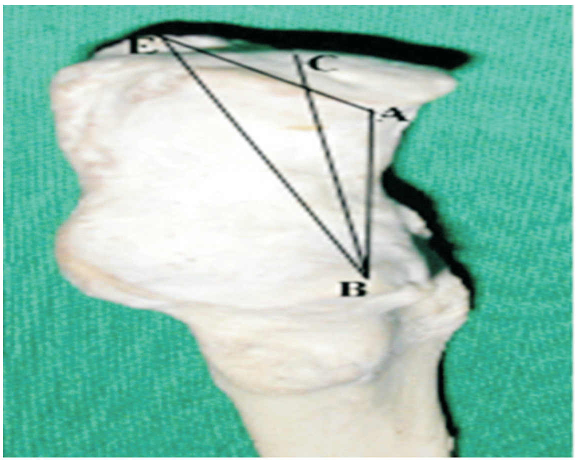

Plate 5: Measurement of proximal Breadths of Ulna (anterior view) using a digital Vernier caliper

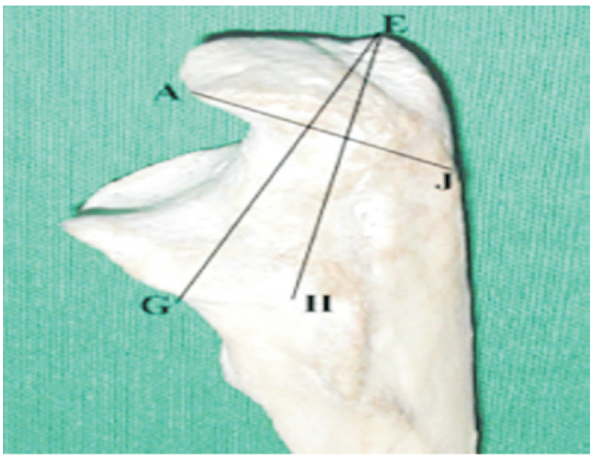

Plate 6: Measurement of proximal Breadths of Ulna (posterior view) using a digital Vernier caliper

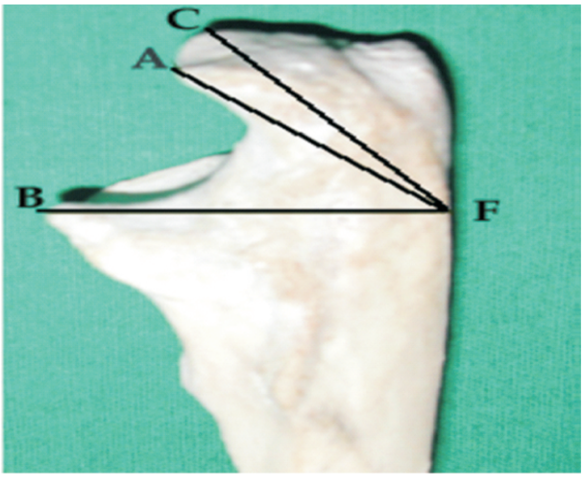

Plate 7: Measurement of Distal Breadth of Radius (DB) using a digital Vernier caliper

the bony marker that could estimate the length of ulna, it was seen that the same parameters regressed significantly (table 4). When multivariate analysis to determine which of the parameters correlate best, it was seen that GH, IJ and MLD correlate best on the left, CF only correlates best on the right while GH and MC correlates best when both sides were considered irrespective of sides.

CONCLUSION

The length of ulna can be obtain from a single available fragments using regression coefficient and intercept for a known measurement that shows significant correlation such as AB, CB,AC, AE, AD, BF, ,GH, IJ, AF, EG, EH, AJ, CF, MC, APD and MLD. The regression values obtained from South West Nigerian population to estimate the length of ulna is an intermediate steps in predicting the stature of an individual in South West Nigerian population. Therefore this study is potential tool for anatomist, forensic anthropologist and archeological investigation for the identification of unknown body remains using regression equation in South West Nigerian population.

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