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Osteometric morphometry of the proximal tibia end in Nigerian population: Forensic and clinical implications

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Abstract
Osteometry is the branch of anthropometry concerned with the measurement of bones. Osteometric parameters of the proximal tibia is important in forensics (sex and racial identification), prosthesic (precision in implant sizing) and in clinical practice (diagnosis and treatment). It is therefore important to have reference data for the Nigerian population. The study sought to determine morphometric parameters of the proximal tibia in Nigerians. The study involved a total of 100 dried tibia bones consisting of 60males and 40 females obtained from cadavers in anatomy departments of various Universities in Nigeria. The bones were macerated and measurements taken directly using a verner caliper. Data were expressed as mean ± standard deviation. Z-test was used to compare mean values and a probability level of $p<0.05$ was considered significant. Measurements were taken in centimeters. Identification and demarking point analysis was used for sexing of proximal tibia parameters. The index of sexual dimorphism was also applied to ascertain level of sexual difference. There was statistically significant difference between males and females ($p<0.05$) in all the parameters. No significant bilateral difference was seen in any parameter. Identification and demarking point analysis showed a higher degree of sexual difference between male and female and more bones were identified with identification point. The index of sexual dimorphism also indicated a higher level of sexual difference in all parameters with values greater than 100. This study provides reference data of the proximal tibia morphology in Nigerian population.The differences recorded in the proximal tibia morphology between genders might be useful in sexual and racial identification and in the design of knee prosthesis for the Nigerian population. Since no significant bilateral differences were observed, the contralateral healthy side can be safely used for preoperative templating.

Keywords: Proximal tibia,tibia condyles, osteometry, identification and demarking points, index of sexual dimorphism

1. Introduction
Osteometry is the branch of anthropometry concerned with the measurement of bones. It has enabled forensic scientist to study variations in bones of the skeleton of different world populations. Oteometric techniques have proved useful in the estimation of stature, age gender and race in forensic and legal sciences which are the big fours of forensic anthropology [1, 2]. Gender identity from skeletal remains is of great importance in medico legal investigation [3, 4]. It is often seen as one of the simplest and most reliable determinations from skeletal remains if essential parts of the skeleton or bones are available in good condition [5].The long bones have proven to be reliable for determination of sex with ninety five percent accuracy [6] and often relied on in sexing skeletal remains [5, 6]. Morphometric data obtained from osteological studies have been applied in the area of prosthesics and in clinical practice [7]. The tibia is a long bone and it is the large weight bearing medial bone of the leg and contributes greatly to knee stability [8]. The proximal end of the tibia is a crucial component of the knee joint through the tibio-femoral articulation and therefore contributes to the day- to –day functioning of the knee. The bone could be fractured (tibia plateau) and injuries to its associated ligaments are common in athletes. It may also be injured in road traffic accidents [9]. One of the most common pathological disorders of the knee joint is osteoarthritis and the treatment for that is usually total knee anthroplasty or unilateral knee arthroplasty.

These procedures are precision operations, requiring precise soft-tissue balancing and resection of bone thickness equal to the thickness of the prosthetic component implanted, so that flexion-extension spacing are same, enabling the stability of the joint [7]. Hence accurate sizing of the prosthetic component is vital to the success of this procedure. Racial identification is still one of the most difficult areas of skeletal identification [10]. It has been argued that sexual and racial differences exist in the tibia bone a fact that could lead to mismatched prosthesis if not taken into consideration and also in other anthropometric applications. It is well known that Asian sub population are smaller with shorter stature compared to their Caucasian counterparts [11, 12] it follows that these discrepancies may give rise to implant size mismatch with the resected bony surfaces of Nigerian patients since most of these prosthetic components are imported from the west based on their own morphometry [13]. The use of highly complex surgical techniques in joint replacement involving the proximal tibia is required as this would involve the correct or accurate placement of well fitted implants and adequate balancing of the surrounding tissues [14]. An appropriate tibia component size is essential in order to maintain normal functional range of motion of the knee. Where there is a mismatch between the prosthesis size and bone, there may be a number of severe complications [15].Morphometry of the proximal end of the tibiaintends to answer questions as to whether the tibia bone is sexually dimorphic in Nigerians and differs from other race so as to provide a reference base for forensic and medico legal use and in designing optimal prosthesis for the Nigerian population.

2. Materials and Methods

One hundred paired dried femori bones consisting of 60 males and 40 females were used. The bones were obtained from cadavers in Anatomy departments of selected Universities in Nigeria. Tibia bones with evidence of fracture, post mortem damage or arthritis were excluded from the study on gross inspection. All measurements were taken with a vernier caliper. A pair of divider was also used to confirm the measurements at its point and measured with a calibrated ruler or metre rule. Each measurement was repeated twice and the mean value was recorded. The osteometric parameters were defined as follows; Transverse diameter of total tibia condyle: measured from both ends of the medial and lateral condyle(Figure 1A);Transverse diameter (TD) of medial tibia condyle: Measured as the distance from both ends of the medial condyle in the transverse plane (Figure 1B); Transvers diameter (TD) of lateral tibia condyle: measured from both ends of the lateral condyle in the transverse plane (Figure 1C); Anterio posterior diameter or length of intercondylar region: taken from the anterior end of the intercondylar region to the most posterior end (Figure 1D); Anterio posterior (AP) diameter of medial tibial condyle: Measured as the distance from the two ends of the medial condyle in the anterior posterior plane (Figure 1E); Anterio posterior diameter of lateral tibia condyle: measured from the two ends of lateral tibia condyle in the anterior posterior plane (Figure 1F); Length between the upper end and tibia tuberosity: taken from the upper end of the bone(marked by the anterior and of the intercondylar region to the lowest point of the tibia tuberosity (Figure 1G); Circumference of the upper end: measured with a tape rule wound around the head from the anterior end (marked by the anterior end of the inter condylar region) to the most posterior end of the intercondylar region (Figure 1H).

Area of condyle was measured as: anterior posterior length (AP) multiplied by Transverse diameter (TD) of condyle.

% area covered by both tibia condyle (medial and lateral) was determined as: Area of single condyle/ total area of condyle multiplied by 100 [7].

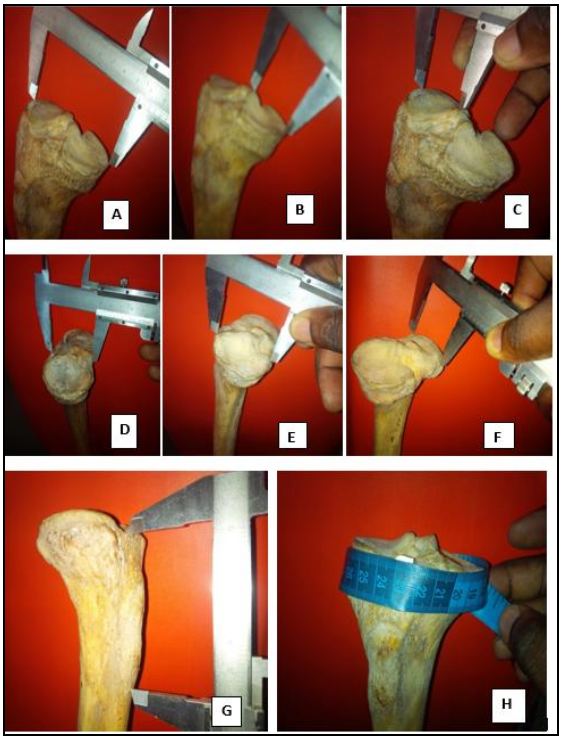

Fig 1: Measurement of Transverse diameter of Total tibia condyle (Figure 1A); Transverse diameter(TD) of medial tibia condyle (Figure 1B); Transvers diameter(TD) of lateral tibia condyle (Figure 1C); Anterio posterior diameter or length of intercondylar region: (Figure 1D); Anterio posterior(AP) diameter of medial tibial condyle: (Figure 1E); Anterio posterior diameter of lateral tibia condyle: (Figure 1F); Length between the upper end and tibia tuberosity: (Figure 1G); Circumference of the upper end: (Figure 1H).

The data was analyzed using Statistical Package for Social Sciences (SPSS IBM Version 20.0, Inc., Chicago, IL) and expressed as mean standard deviation. Z-test was used to compare mean values and a probability level of $p<0.05$ was considered significant. Measurements were taken in centimetres. Identification and demarking point analysis was used for sexing of these femoral condyle parameters. The index of sexual dimorphism was calculated as follows:

$$\text{Index of sexual dimorphism (ISD)} = \frac{\text{Mean value of male}}{\text{Mean value of female}} \times 100$$

This index indicates the level of difference between sexes. Values close to hundred indicate low level of sexual difference and on the other hand the level of sexual difference increases with the increase of the distance from hundred [16].

3. Results

The results are presented in tables 1, 2, 3 and 4.

Table 1: Mean values and side distribution of Proximal Tibia Parameters

Parameters (CM)		Right	Left	Total	P-value	Inference
Transverse diameter (TD) Of tibia condyleF	M	7.61±0.73	7.74±0.67	7.68±0.69	(p>0.05)	Not significant
	F	6.73±0.60	6.84±0.63	6.70±0.60	(p>0.05)	Not significant
Anterior posterior (AP) Length of condyle RegionF	M	4.61±0.32	4.28±0.42	4.72±0.31	(p>0.05)	Not significant
	F	3.88±0.42	3.64±0.38	3.76±0.40	(p>0.05)	Not significant
Transverse diameter of medical CondyleF	M	3.32±0.27	3.39±0.25	3.36±0.25	(p>0.05)	Not significant
	F	2.50±0.35	2.58±0.33	2.94±0.33	(p>0.05)	Not significant
Anterior posterior Length ofmedial CondyleF	M	4.77±0.46	4.68±0.36	4.68±0.39	(p>0.05)	Not significant
	F	4.06±0.48	3.93±0.19	3.94±0.48	(p>0.05)	Not significant
Transverse diameter of lateral CondyleF	M	3.10±0.36	3.27±0.40	3.19±0.38	(p>0.05)	Not significant
	F	2.49±0.22	2.65±0.22	2.57±0.22	(p>0.05)	Not significant
Anteriorposterior length Of lateralcondyleF	M	4.29±0.28	4.22±0.30	4.26±0.28	(p>0.05)	Not significant
	F	3.37±0.26	3.67±0.30	3.70±0.28	(p>0.05)	Not significant
Circumference of upper End of Tibia	M	21.92±1.71	22.20±1.74	4.26±1.71	(p>0.05)	Not significant
	F	20.40±1.39	20.70±0.30	20.30±1.36	(p>0.05)	Not significant
Length between upper end And Tibia tuberosity	M	6.31±0.34	6.35±0.35	6.35±0.35	(p>0.05)	Not significant
	F	5.25±0.40	5.32±0.41	5.30±0.41	(p>0.05)	Not significant
Total area of Tibia condyle	M	36.83±4.75	32.92±5.3	34.86±5.0	(p>0.05)	Not significant
	F	26.15±3.20	24.89±4.02	25.52±4.1	(p>0.05)	Not significant
Area of medial condyle	M	15.83±2.75	15.52±3.45	15.41±2.85	(p>0.05)	Not significant
	F	10.50±1.35	9.88±1.22	10.02±1.30	(p>0.05)	Not significant
Area of lateral condyle	M	13.29±2.25	12.98±3.15	12.87±2.45	(p>0.05)	Not significant
	F	9.28±0.98	9.72±1.15	9.50±1.15	(p>0.05)	Not significant

Table 2: Mean Values of Proximal Tibia Parameters and Test of Significance of Nigerian Males and Females

Parameters (CM)		Male	Female	P-value	Inference
Transverse diameter (TD) Of tibia condyle	R	7.61±0.73	6.73±0.60	(p<0.05)	significant
	L	7.74±0.67	6.84±0.63	(p<0.05)	significant
Anterior posterior (AP) Length of condyle Region	R	4.28±0.42	3.88±0.42	(p<0.05)	significant
	L	4.61±0.32	3.64±0.38	(p<0.05)	significant
Transverse diameter of medical Condyle	R	3.32±0.27	2.50±0.25	(p<0.05)	significant
	L	3.39±0.25	2.58±0.33	(p<0.05)	significant
Anterior posterior Length ofmedical Condyle	R	4.77±0.46	4.06±0.48	(p<0.05)	significant
	L	4.68±0.36	3.93±0.49	(p<0.05)	significant
Transverse diameter of lateral Condyle	R	3.10±0.36	2.49±0.22	(p<0.05)	significant
	L	3.27±0.20	2.65±0.22	(p<0.05)	significant
Anteriorposterior length Of lateralcondyle	R	4.29±0.28	3.73±0.26	(p<0.05)	significant
	L	4.22±0.30	3.37±0.30	(p<0.05)	significant
Circumference of upper End of Tibia	R	21.92±1.71	20.40±1.39	(p<0.05)	significant
	L	22.20±1.74	20.70±1.37	(p<0.05)	significant
Length between upper end And Tibia tuberosity	R	6.31±0.34	5.25±0.40	(p<0.05)	significant
	L	6.35±0.35	5.32±0.41	(p<0.05)	significant
Total area of Tibia condyle	R	36.83±4.75	26.15±3.2	(p<0.05)	significant
	L	32.92±5.30	24.89±4.02	(p<0.05)	significant
Area of medical condyle	R	15.83±2.75	10.50±1.35	(p<0.05)	significant
	L	15.52±3.45	9.88±1.22	(p<0.05)	significant
Area of lateral condyle	R	13.29±2.25	9.28±0.98	(p<0.05)	significant
	L	12.98±3.15	9.72±1.15	(p<0.05)	significant

Table 3: Mean, SD, Range, Calculated range, Identification and Demarking points of the Proximal Tibia parameters.

			Mean ±SD	Range	Calculated range= mean ± 3SD	Identification point (IP)	Demarking point (DP)	%IP	%DP
TD. of tibia condyle	(R)	M	7.61 ± 0.73	**6.45- 9.0**	**5.42-9.80**	> 7.62	> 8.53	20%	15%
		F	6.73 ± 0.6	**6.24-7.62**	$4.93 - 8.53$	< 6.45	< 5.42	15%	5%
	(L)	M	7.74 ± 0.67	$6.50 - 9.05$	$5.73 - 9.75$	> 7.8	> 8.73	20%	10%
		F	6.84 ± 0.63	$6.3 - 7.8$	$4.95 - 8.73$	< 6.50	< 5.73	12%	4%
AP length of condyle region	(R)	M	4.82 ± 0.42	$3.90 - 5.80$	$3.56 - 6.08$	> 4.62	> 5.14	27%	10%
		F	3.88 ± 0.42	$3.0 - 4.62$	$2.62 - 5.14$	< 3.90	< 3.56	20%	15%
	(L)	M	4.61 ± 0.32	$3.80 - 5.60$	$3.65 - 5.57$	> 4.40	> 4.78	20%	8%
		F	3.64 ± 0.38	$2.8 - 4.40$	$2.50 - 4.78$	< 3.80	< 3.65	15%	12%

TD.of medial condyle	(R)	M	3.32 ± 0.27	$2.72 - 3.71$	$2.51 - 4.13$	> 3.12	> 3.55	21%	13%
		F	2.50 ± 0.35	**2.07 -3.12**	$1.45 - 3.55$	< 2.72	< 2.51	19%	14%
	(L)	M	3.39 ± 0.25	$2.76 - 3.16$	$2.64 - 4.14$	> 3.15	> 3.57	25%	10%
		F	2.50 ± 0.33	**2.10-3.15**	$1.59 - 3.57$	< 2.76	< 2.64	20%	11%
AP. Length of medial condyle	(R)	M	4.77 ± 0.28	$3.85 - 5.65$	$3.93 - 5.61$	> 4.80	> 5.50	18%	9%
		F	4.06 ± 0.48	$3.10 - 4.80$	$2.62 - 5.50$	< 3.85	< 3.93	15%	10%
	(L)	M	4.58 ± 0.36	$3.80 - 5.0$	$3.5 - 5.61$	> 4.6	> 5.30	15%	8%
		F	3.83 ± 0.49	$2.80 - 4.6$	$2.36 - 5.30$	< 3.80	< 3.50	14%	8%
TD.of lateral condyle	(R)	M	3.10 ± 0.36	$2.40 - 3.78$	$2.02 - 4.18$	> 2.84	> 3.15	10%	7%
		F	2.49 ± 0.22	**2.10-2.84**	$1.83 - 3.15$	< 2.40	< 2.02	8%	2%
	(L)	M	3.27 ± 0.40	$2.45 - 3.86$	$2.02 - 4.47$	> 2.98	> 3.31	10%	8%
		F	2.65 ± 0.22	$2.20 - 2.98$	$1.99 - 3.31$	< 2.45	**< 2.02**	6%	3%
AP. Length of lateral condyle	(R)	M	4.29 ± 0.28	$3.58 - 4.67$	$3.42 - 5.13$	> 4.67	> 4.51	11%	10%
		F	3.73 ± 0.26	$2.95 - 3.95$	$2.95 - 4.51$	< 2.20	**< 3.42**	10%	9%
	(L)	M	4.22 ± 0.30	$3.52 - 4.62$	$3.32 - 5.12$	> 3.90	> 4.57	10%	7%
		F	3.67 ± 0.30	$2.90 - 3.90$	$2.77 - 4.57$	< 3.52	< 3.32	5%	2%
Circumference of upper end of tibia	(R)	M	21.92 ± 1.71	$18.00 - 25.0$	$16.79 - 27.05$	> 21.98	> 24.04	13%	10%
		F	20.40 ± 1.39	$16.73 - 21.9$	$16.23 - 24.54$	< 18.00	< 16.79	10%	6%
	(L)	M	22.20 ± 1.74	$17.50 - 24.6$	$16.98 - 27.42$	> 22.90	> 24.81	10%	8%
		F							
Length btw upper end &tibia tuberosity	R	M	6.31 ± 0.34	$5.6 - 7.6$	$5.29 - 7.33$	< 6.20	< 6.27	10%	6%
		F	5.25 ± 0.40	$4.6 - 6.20$	$4.05 - 6.27$	> 560	< 5.4	8%	2%
	L	M	6.35 ± 0.35	$5.9 - 7.8$	$5.30 - 7.40$	< 6.20	> 6.50	18%	7%
		F	5.32 ± 0.41	$4.8 - 1.29$	$4.09 - 6.06$	> 5.90	< 5.30	15%	0%

Table 4: Mean, SD and Index of Sexual Dimorphism (ISD) of Proximal Tibia Parameters on Dry Bone

Parameters (CM)		Male	Female	Index of Sexual Dimorphism
Transverse diameter(TD)	R	7.61±0.73	6.73±0.60	113
Of tibia condyle	L	7.74±0.67	6.84±0.63	113.2
Anterior posterior (AP)	R	4.28±0.42	3.88±0.42	110
Length of condyle Region	L	4.61±0.32	3.64±0.38	126.6
Transverse diameter (TD)	R	3.32±0.27	2.50±0.25	132.8
of medial Condyle	L	3.39±0.25	2.58±0.33	131.4
Anterio posterior (AP)	R	4.77±0.46	4.06±0.48	117.5
Length of medical Condyle	L	4.58±0.36	3.83±0.49	119.6
Transverse diameter (TD)	R	3.10±0.36	2.49±0.22	124.5
of lateral Condyle	L	3.27±0.20	2.65±0.22	123.4
Anterio posterior (AP)	R	4.29±0.28	3.73±0.26	115
length 0f lateral condyle	L	4.22±0.30	3.37±0.30	125
Circumference of upper	R	21.92±1.71	20.40±1.39	107.5
end of Tibia	L	22.20±1.74	20.70±1.37	107.3
Length between upper end	R	6.31±0.34	5.25±0.40	120.2
And Tibia tuberosity	L	6.35±0.35	5.32±0.41	119.4
Total area of Tibia condyle	R	36.83±4.75	26.15±3.2	140.5
	L	32.92±5.30	24.89±4.02	132.6
Area of medial condyle	R	15.83±2.75	10.50±1.35	150.7
	L	15.52±3.45	9.88±1.22	157
Area of lateral condyle	R	13.29±2.25	9.28±0.98	143.2
	L	12.28±3.15	9.72±1.15	126

Table 5: Comparison of parameters of the Proximal end of Tibia in Nigerian population with data on previous studies

Parameters (CM)		Male Present study	Female Present study	Southern Indian (not sex specific) Author [7]	Northern Indian (not sex specific) Author [17]
Transverse diameter (TD) Of tibia condyle	R	7.61±0.73	6.73±0.60	6.77±0.31	
	L	7.74±0.67	6.84±0.63	6.84±0.54	
Anterior posterior (AP) Length of condyle Region	R	4.82±0.42	3.88±0.42	4.66±0.32	
	L	4.61±0.32	3.64±0.38	4.49±0.44	
Transverse diameter of medical Condyle	R	3.32±0.27	2.50±0.25	2.70±0.24	2.97±0.28
	L	3.39±0.25	2.58±0.33	2.76±0.27	2.75±0.25
Anterior posterior Length of medical Condyle	R	4.77±0.46	4.06±0.48	4.55±0.46	3.86±0.36
	L	4.68±0.36	3.93±0.49	4.36±0.47	3.99±0.37
Transverse diameter of lateral Condyle	R	3.10±0.36	2.49±0.22	2.66±0.24	2.92±0.27
	L	3.27±0.20	2.65±0.22	2.92±0.27	2.97±0.30
Anterior posterior length Of lateral condyle	R	4.29±0.28	3.73±0.26	4.08±0.27	3.64±0.24
	L	4.22±0.30	3.67±0.30	4.06±0.40	3.69±0.26
Circumference of upper End of Tibia	R	21.92±1.71	20.40±1.39	18.95±0.68	
	L	22.40±1.74	20.70±1.37	19.07±1.65	
Length between upper end And Tibia tuberosity	R	6.31±0.34	5.25±0.40	5.06±0.39	
	L	6.35±0.35	5.32±0.41	5.24±0.71	
Total area of Tibia condyle	R	36.83±4.75	26.15±3.2	31.64±3.01	29.88±3.75
	L	32.92±5.30	24.89±4.02	31.16±5.46	29.51±4.20
Area of medical condyle	R	15.83±2.75	10.50±1.35	12.30±1.45	11.52±2.45
	L	15.52±3.45	9.88±1.22	12.12±2.12	11.01±2.85
Area of lateral condyle	R	13.29±2.25	9.28±0.98	10.89±1.44	10.75±2.15
	L	12.28±3.15	9.72±1.15	11.92±2.09	10.52±3.15

Observations from table 1 show no significant difference between sides in all proximal tibia parameters studied (p>0.05). Sex differences was observed in all proximal tibia parameters measured on dry bones (p<0.05) as shown on table 2 as male had significantly higher values than females. It was observed that when all parameters were subjected to identification and demarking point analysis for sex determination, they showed a high percentage of differences between males and females. As seen in table 3 the Transverse diameter (TD) of tibia condyle (Right) of males was in the range of 6.45- 9.00cm while that of female (Right) was 6.24- 7.62cm. All male Transverse diameter (TD) of tibia condyle (Right) greater than 7.62cm were males and all female Transverse diameter (TD) of tibia condyle (Right) less than 6.45cm were females therefore 7.62 served as identification point (IP) for males (Right) identifying 20% of bones, and 6.45 served as an identification point for females (Right) identifying 15% of bones. Transverse diameter (TD) of tibia condyle between 6.45- 7.62 for the right were not sexed. Also for the left, the Transverse diameter (TD) of tibia condyle of males was in the range of 6.50- 9.05cm while that of female was 6.30- 7.80cm. All male Transverse diameter (TD) of tibia condyle (Left) greater than 7.80cm were males and all female Transverse diameter (TD) of tibia condyle (Left) less than 6.50cm were females therefore 7.80 served as identification point (IP) for males (Left) identifying 20% of bones, and 6.50 served as an identification point for females (Left) identifying 12% of bones. Transverse diameter (TD) of tibia condyle between 6.50 and 7.80 for the left were not sexed as these values fall outside the identification points. This similar method was made applicable to all the parameters for the identification point analysis. Also the calculated range was obtained using mean ± 3SD. The calculated range of the Transverse diameter (TD) of tibia condyle (Right) of male was 5.42- 9.80 while that of female (Right) was 4.93- 8.53. All male Transverse diameter (TD) of tibia condyle (Right) greater than 8.53 were males and all female Transverse diameter (TD) of tibia condyle (Right) less than 5.42 were females therefore 8.53 served as males DP (Right) identifying 15% of bones, and 5.42 served as females DP (Right) identifying 5% of bones. Transverse diameter (TD) of tibia condyle between calculated range of 5.42 and 8.53 for the right were not sexed as these values fall outside the demarking points for right. Also for the left, transverse diameter (TD) of tibia condyle of males was in the range of 5.73- 9.75 cm while that of female was 4.95- 8.73cm. All male Transverse diameter (TD) of tibia condyle (Left) greater than 8.73cm were males and all female Transverse diameter (TD) of tibia condyle (Left) less than 5.73cm were females therefore 8.73 served as DP for males (Left) identifying 10% of bones, and 5.73 served as demarking point for females (Left) identifying 4% of bones. Transverse diameter (TD) of tibia condyle between 5.73 and 8.73 for the left were not sexed as these values fall outside the demarking points for left.

In Table 4, the mean, and the Index of sexual dimorphism (ISD) of the proximal tibia parameters on dry bones. ISD is worked out by dividing the mean male value by the mean female value. Values greater than 100 indicate greater level of sexual difference between male and female parameters. All parameters indicated values above 100.

4. Discussion

The transverse diameter (TD) of tibia condyle was 7.61 ±0.73 and 7.74 ±0.67 for right and left tibia in men with a total of 7.68 ±0.69, in women it was 6.73 ±0.60 and 6.84 ±0.63 for right and left with a total of 6.78±0.61 There was a statistically significant relation between those of men and women (P<0.05). But no significant side difference in both parameters. These findings are in agreement with the study of [7], which reported insignificant side relation in both limbs.

Comparism with those of South Indian population reveals significant higher Nigerians values (P<0.05). [7] Recorded, 6.77 ±0.31 and 6.88 ±0.65 for right and left Transverse

diameter (TD) of tibia condyle with a total mean value of 6.83 ±0.51showing some racial differences. The study by [7] was not sex specific. [18] Found 6.62 ±0.51 and 6.66 ±0.56 for right and left Transverse diameter (TD) of tibia condyle with a total mean value of 6.64 ±0.53 she also reported insignificant differences between values of the right and left limb which agrees with that of this study. This study found the mean Antero posterior (AP) length of intercondylar region in the proximal tibia section to be 4.82 ±0.42 and 4.61 ±0.32 for right and left tibia in men with a mean total of 4.72 ±0.31, while women recorded 3.88 ±0.42 and 3.64 ±0.38 for right and left proximal tibia, with a mean total of 3.76 ±0.40. There was a statistically significant relation between those of men and women (P<0.05) but no significant side difference this is in accordance with the study [7] which recorded insignificant side to side differences in this parameter, 4.66 ±0.32 and 4.49 ±0.44 for right and left Anteroposterior (AP) length of intercondylar region of tibia with a total mean value of 4.57 ±0.39.[18]found 4.25 ±0.42 and 4.49 ±0.44 for right and left Anteroposterior (AP) length of intercondylar region of tibia with a total mean value of 4.57 ±0.53 she reported insignificant side to side differences in the right and left limb which agrees with that of this study.

This study found the mean Transverse, AP diameter of medial and lateral condyle of tibia on the right side as 3.32 ±0.27, 4.77 ±0.46 cm and 3.10 ±0.36, 4.29 ±0.28 for men and 3.39 ±0.25, 4.58 ±0.36cm and 3.27 ±0.40 and 4.22 ±0.30 on the left. Women had 2.50 ±0.35, 4.06 ±0.48 cm and 2.49 ±0.22, 3.73 ±0.26 on the right side and 2.58 ±0.33, 3.83 ±0.49cm and 2.65 ±0.22, 3.67 ±0.30 on the left. There was a statistical significant difference between the mean values recorded in men and women in these four parameters but no statistical significant relation was recorded between right and left side.

This disagrees with the study by [7].which reported significant relation between the right and left Anteroposterior (AP) length of medial condyle and transverse diameter of lateral condyle they reported the mean Transverse, AP diameter of medial and lateral condyle of tibia on the right side as 2.70 ±0.24, 4.55 ±0.46 cm and 2.66 ±0.24, 4.08 ±0.27cm and 2.76 ±0.27, 4.36 ±0.47cm and 2.92 ±0.32, 4.06 ±0.40 on the left side for the southern Indian population. The insignificant side to side differences found in these parameters however agrees with the study of [18] which reported the mean Anteroposterior (AP) length (diameter) of medial and lateral condyle as 4.08 ±0.42 and 3.67 ±0.41 for the right, 4.13 ±0.42 and 3.54 ±0.39 for the left she found no statistical significance difference in any parameters of tibia on both limbs. In the Northern Indian population, [17] found the mean Transverse, AP diameter of medial and lateral condyle of tibia on the right side as 2.97 ±0.28, 3.86 ±0.36 cm and 2.92 ±0.27, 3.64 ±0.24cm and 2.75 ±0.25, 3.99 ±0.37cm and 2.97 ±0.30, 3.69 ±0.26 on the left side. The study was not sex specific but reported insignificant differences in all parameters measured which also is in consonance with findings in this study, which found no statistical significant relation between right and left AP diameter of medial condyle, and transverse diameter of lateral condyle. In Caucasians (French) [19] found Anteroposterior length of medial and lateral tibia to be 5.08 ±0.33 and 4.72 ±0.33 respectively. [20] Found the AP length of medial and lateral tibia condyle to be 4.80 ±0.31 and 3.98 ±0.29 respectively. The findings from this study reveals racial differences in the proximal tibia morphology in Nigerians and those of Asians (Indians) and Caucasians (French) a fact to be considered in the design of tibia prosthesis and even in racial identification in forensics.

This study found the mean circumference of the upper tibia and on the right, left and total tibia as 21.92 ±1.71, 22.20 ±1.74 and 20.06 ±1.71 respectively in males and 20.40 ±1.39, 20.70 ±1.37 and 20.50 ±1.36 respectively in women. There was a significant difference between males and females (p<0.05) but no significant side relation though the left had higher values. [7[, found the mean circumference of the upper end of tibia as 18.95 ±0.68, 19.07 ±1.65 and 19.02 ±1.27 for the right, left and total tibia respectively. They reported insignificant differences between the mean values of circumference of the upper tibia in both the right and left limb which agrees with this study. Ivan (2014) found the mean circumference of the upper tibia and on the right, left and total tibia as 19.33±1.44, 19.36±1.5 and 19.35±1.56.17cm respectively they reported insignificant differences between the right and left mean value of circumference of the upper tibia which agrees with findings of this study. Both studies were not sex specific.

This study found the length from upper tibia to the tibia tuberosity for right, left and total tibia condyle to be 6.31 ±0.34, 6.35 ±0.35 and 6.33 ±0.35 for men while women had 5.25 ±0.40, 5.32 ±0.41 and 5.30 ±0.41 respectively. There was a significant difference between males and females (p<0.05) but no significant side relation though the left had higher values this agrees with [7, 18]. The values of this study were higher than those of the South Indian population as reported by [7], they gave the length from upper tibia to the tibia tuberosity for right, left and total tibia condyle given as 5.06±0.39, 5.24±0.71 and 5.15±0.65 respectively [18]. Found the mean length from upper tibia to the tibia tuberosity for right, left and total tibia condyle given as 4.47±0.61, 4.60 ±0.68 and 4.54 ±0.51 respectively.

The study found the total tibia condyle, medial condyle, lateral condyle area on right and left side as 36.83 ±4.75 cm², 15.83 ±2.75 cm², 13.29 ±2.25 cm² and 32.92 ±5.3 cm², 15.52 ±3.45 cm², 12.28 ±3.15 cm² for men while women had 26.15 ±3.2 cm², 10.50 ±1.35 cm², 9.28± 0.98 cm² and 24.89 ±4.02 cm², 9.88 ±1.22 cm², 9.72 ±1.15 cm² respectively. These values were significantly greater in men (P<0.05) and were also significantly higher than those found in some Indians population. [17] found the total tibia condyle, medial condyle, lateral condyle area on right and left side as 29.88 ±3.75 cm², 11.52 ±2.45 cm², 10.75 ±2.15cm² and 29.51 ±4.2 cm², 11.01 ±2.85 cm², 10.52 ±3.15 cm². [7] found the total tibia condyle, medial condyle, lateral condyle area on right and left side as 31.64 ±3.01 cm², 12.30 ±1.45 cm²,10.89 ±1.44cm² and 31.16 ±5.46 cm², 12.12 ±2.12 cm², 11.92 ±2.09 cm².

The findings from this Oteometric study reveals sexual dimorphism in all parameters measured which is a good lead in the process of sex identification and consequently establishment of identity. Identification and demanding point analysis for sex determination shows a higher percentage of differences between males and females. More bones were identified with the identification point compared to demarking point in both the distal femur and proximal tibia. Due to the fact that the overlapping range where sex could not be identified was small in identification point analysis but larger in the demarking point analysis. This agrees with previous authors on identification and

demarking point analysis [21, 22, 23]. Both identification and demarking points for males were greater than those of females, an indication of the usefulness of these parameters in sex determination. It therefore implies that when distal femur and proximal tibia are provided with these parameters intact, sex can be assigned to them. The bones which were sexed using demarking points were however of greater degree of certainty than those sexed using identification points and it is not necessary for all parameters to cross the demarking points before sex can be identified.

5. Conclusions

Variability in geometry and anatomy of the knee exists irrespective of gender and human race and should be taken into consideration [24]. This study establishes the morphometric attributes of proximal end of tibia in Nigerian population and found sexual dimorphism in all parameters of the proximal tibia measured but found no significant side difference in the parameters measured. The difference in proximal tibia anatomy between genders provides a biological profiling system for sex identity and would add to the design of knee prostheses for the Nigerian population where precision is required. In comparism with other population, higher values were seen in this study than those of Northern and Southern Indians. Hence data obtained in this study would presumably provide a basis for application in forensics, prosthesis and in clinical practice in the Nigerian population.

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7. References

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