Journal of Research in Applied and Basic Medical Sciences 2024; 10(4): 389-399

Original Article

Urmia University of Medical Sciences

RABMS Journal of Research in Applied and Basic Medical Sciences

Evaluation of femoral parameters in a Nigerian population sample

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Abstract

***Background & Aims*:** Femoral parameters exhibit geographic variability; hence, population-specific analyses are important. This study aimed to estimate standard femur parameters for the Nigerian population.

***Materials & Methods*:** Fifty-three dried human femurs (26 right femurs, 27 left femurs) were obtained from the skeletal archive of the Department of Anatomy, University of Ibadan. Each parameter was measured with a digital sliding Vernier caliper and the femoral angles were measured with a goniometer. Descriptive analysis was conducted, a paired Student's t-test was used to compare the right and left values, and Pearson correlation was used to test the relationship between the variables. Analysis was done with GraphPad Prism 8, and statistical significance was considered at $p \leq 0.05$.

***Results*:** The right femur parameters have overall higher mean values except in maximal length of the femur (MLF), sub-capital diameter from the anterior-posterior diameter of the femur (SCii), and angle of declination (AOD). MLF, SCii, AOD, latero-medial diameter of the femoral head (LMDF), sub-capital diameter from the superior-inferior diameter of the femur (SCi), mid-cervical diameter from the anterior-posterior diameter of the femur (MCii), and depth of medial condyle (DMC) were statistically significant. A strong positive correlation exists between the MLF, LSAA, SCii, and ICL on the left.

***Conclusion*:** Understanding the variation pattern of these parameters may aid in improving treatment outcomes in the use of implants, limb lengthening procedures and femoral fracture management in the Nigerian population.

***Keywords*:** Bilateral Parameter Comparison, Femur, Nigerian population

Received 21 June 2024; accepted for publication 26 October 2024

Introduction

Femur parameters vary across populations (1, 2) and have been the subject of continuous research. Existing studies have established that proper estimation of proximal femur dimensions, independent of femoral neck bone density, can improve the assessment of hip fracture risk (3, 4). Studies have shown that environmental factors such as diet and genetics play a crucial role in determining bone mineral density (5-7). Hence, there is a need for sufficient femur profiling of the Nigerian population. Anthropometric estimation has guided athletes and health managers in providing fitness advice and interventions (8). Precisely estimated anatomical measurements of femoral parameters are important in the distribution of implants and anatomical plates for treating femur fractures and hip joint dislocations (9).

In forensic anthropology, aside from bone densitometry from Dual-energy X-ray absorptiometry (DXA) scans, femur length can be used to estimate sex and ancestry (9, 10). Studies have shown that varying femur parameters exist across geographical populations (11, 12), and by implication, readings for one population cannot be applied to another. Therefore, varied ancestry-based femur parameters present a significant challenge for designing well-fitting anatomical plates for the mass market (13). Since the femur is the bone most commonly fractured (14, 15), perfection and refinement of techniques for open and closed nailing and plating of femoral hip fractures require precise knowledge of parameters such as diameters, angles, and distances along the femur (16). Therefore, it is important that accurately measured values of specific femur parameters exist for different populations to ensure accessible treatment interventions that suit each population's needs.

The femur is durable, second only to the petrous portion of the temporal bone during decomposition. Consequently, the proximal femur has become a cornerstone in forensic anthropology for sex determination (17). Its morphological measurements provide reliable indicators of biological sex, making it an invaluable tool in anthropological investigations. Studies have shown that by measuring the epicondylar breadth and vertical diameter of the femur head in various samples, it is possible to determine sex with a high degree of accuracy (18). In addition, stature estimation by femur length is an essential method for identifying exhumed bodies in medico-legal cases and in mass disaster victim identification (19–21). Since femoral parameters are population-specific, ancestry or ethnicity estimation may be achieved by comparing the dimensions of a sample against recorded accurate standards for diverse human populations. In age prediction, studies have shown that femur diameters explain between 93% and 97.4% of weight variation, making them essential for age estimation (22–24).

Few studies exist on measuring femoral parameters in the Nigerian population (25–30). However, most of these studies are limited in the number of femoral parameters evaluated. This limitation undermines the ability to provide a well-represented cross-population analysis of femoral parameters in a Nigerian sample. A robust estimation of femoral parameters can provide easy access to Nigeria-specific femoral dimensions.

This study aimed to estimate standard femur parameters for the Nigerian population. We hope that this study contributes to the body of literature that describes anatomical variation patterns among Nigerian populations (31, 32).

Materials & Methods

This article presents a descriptive study of the different parts of the adult femur using a sample from the Nigerian population.

Fifty-three dried human femurs (26 right femurs and 27 left femurs) of unestimated age and gender were obtained from the macerated bodies of Nigerian cadavers in the Department of Anatomy, University of Ibadan, based on sample availability. Each parameter was measured with a digital sliding Vernier caliper, and the femoral angles were measured with a goniometer. Bones with morphological deformities and fractures were excluded from this study.

Statistical analysis: Descriptive analysis was calculated, and a paired Student's t-test was used to compare the mean values of the right and left femurs. Pearson correlation was used to test the correlations between the variables. Analysis was done with GraphPad Prism 8 (33), and statistical significance was considered at $p \leq 0.05$.

The following parameters were measured from the specimens (34):

- Maximal Length of the Femur (MLF): measured from the most distal point of the femoral head to the most distal point of the medial femoral condyle, using an osteometric calibrated board.
- All the parameters below were measured with a digital Vernier caliper and goniometer:
- Length of the Subtrochanteric Apical Axis (LSAA): a line that runs from the most medial point of the lesser trochanter to the center of the femoral head.
- Latero-Medial Diameter of the Femoral Head (LMDF): the distance between the widest points on the lateral and medial sides.
- Sub-capital diameter from the superior-inferior diameter of the femur (SCi): the distance between the

most medial and lateral points of the femoral neck just below the femoral head and the distance between the superior and inferior points of the femoral neck.

- Mid-cervical diameter from the superior-inferior diameter of the femur (MCi): the distance between the most medial and lateral points of the femoral neck at its midpoint and the distance between the superior and inferior points of the femoral neck.
- Basilar diameter from the superior-inferior diameter of the femur (BSi): the distance between the most medial and lateral points of the femoral neck at its base, just above the lesser trochanter, and the distance between the superior and inferior points of the femoral neck.

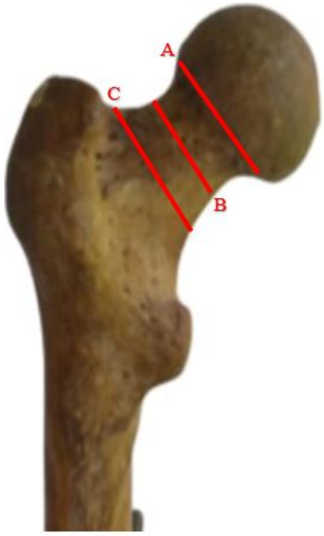

Fig. 1. Superior-inferior diameter of the femur
A-Sub-capital diameter from the superior-inferior diameter of the femur (SCi)
B-Mid-cervical diameter from the superior-inferior diameter of the femur (MCi)
C-Basilar diameter from the superior-inferior diameter of the femur (BSi)

Fig. 2. Showing the proximal end of the femur
A-Latero-Medial Diameter of the Femoral Head (LMDF)
B-Femoral Neck Length (FNL)

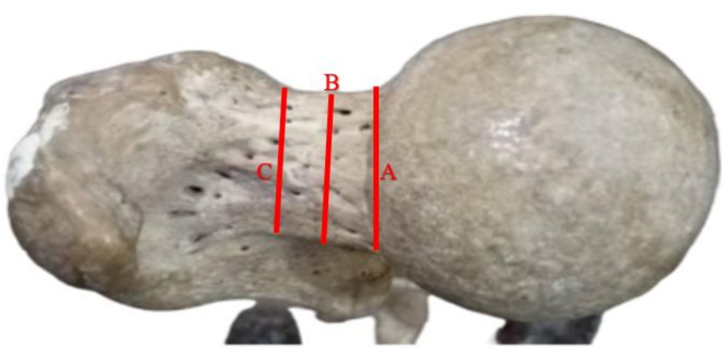

Fig. 3. Showing the superior view of the femoral neck and head
A-Sub-capital diameter from the anterior-posterior diameter of the femur (SCii)
B-Mid-cervical diameter from the anterior-posterior diameter of the femur (MCii)
C-Basilar diameter from the anterior-posterior diameter of the femur (BSii)

Fig. 4. Showing Maximum Length of Femur (MLF)

- Sub-capital diameter from the anterior-posterior diameter of the femur (SCii): the distance between the most medial and lateral points of the femoral neck just below the femoral head and the distance between the anterior and posterior points of the femoral neck.
- Mid-cervical diameter from the anterior-posterior diameter of the femur (MCii): the distance between the most medial and lateral points of the femoral neck at its midpoint and the distance between the anterior and posterior points of the femoral neck.
- Basilar diameter from the anterior-posterior diameter of the femur (BSii): the distance between the most medial and lateral points of the femoral neck at its base, just above the lesser trochanter, and the distance between the anterior and posterior points of the femoral neck.
- Angle of Inclination (AOI): also known as the femoral neck angle, is the angle formed between the axis of the femoral neck and the axis of the femoral shaft.

Fig. 5. Proximal end of the femur showing the angle of inclination (AOI)

- Angle of Declination (AOD): also known as the femoral torsion angle, is the angle formed between the axis of the femoral head and the axis of the distal femoral condyles.
- Epicondyle Breadth (EB): the distance between the most medial and lateral points of the medial and lateral femoral epicondyles.
- Depth of Lateral Condyle (DLC): the distance between the most anterior and most posterior points of the lateral femoral condyle.
- Depth of Medial Condyle (DMC): the distance between the most anterior and most posterior points of the medial femoral condyle.
- Intertrochanteric Crest Length (ICL): the distance between the most medial and lateral points of the intertrochanteric crest.
- Femoral Neck Length (FNL): the distance between the most medial point of the lesser trochanter and the center of the femoral head.
- Femoral Neck Circumference (FNC): the distance around the widest part of the femoral neck.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and the protocol, which concerns the use of human subjects for research, was approved by the UI/UCH Ethics Review Committee with the approval number UI/EC/24/0218.

Results

This study showed noticeable differences between left and right femoral parameters in a sample obtained from the Nigerian population, with the right having overall higher mean values (Table 1).

Table 1. Femur parameters of the Nigerian sample

	Right		Left			
Parameter	**X ± SD (mm)**	**Min – Max**	**X ± SD (mm)**	**Min – Max**	**T-value**	***P-value***
MLF	45.68 ± 3.53	35.9-50.1	45.95 ± 2.42	38.9-49.75	-0.32	*0.02
LSAA	9.1 ± 0.68	7.78-10.54	8.91 ± 0.51	7.43-9.83	1.13	0.2
LMDF	3.75 ± 0.63	2.68-5.82	3.43 ± 0.3	2.93-3.89	2.32	*0.02
Sci	4.31 ± 0.57	2.95-5.8	4.23 ± 0.35	3.59-4.91	0.6	*0.05
MCi	3.27 ± 0.36	2.68-3.9	3.09 ± 0.3	2.47-3.61	1.97	0.24
BSi	4.95 ± 0.6	3.92-6.1	4.44 ± 0.6	2.78-5.35	3.04	0.37
SCii	4.24 ± 0.54	2.72-5.1	4.33 ± 0,32	3.58-4.86	-0.75	*0.04
MCii	2.87 ± 0.52	2.17-4.59	2.67 ± 0.3	1.87-3.27	1.72	*0.03
BSii	3.41 ± 0.59	2.68-5.37	3.13 ± 0.44	2.35-4.17	1.98	0.34
AOI(degree)	36.51 ± 6.15	30.4–49	40.16 ± 4.03	30.1–47	-2.55	0.13
AOD(degree)	34.62 ± 6.15	21.7-40.4	41.63 ± 10.5	33–90	-2.91	*0.04
EB	2.4 ± 0.33	1.73–3	2.31 ± 0.3	1.67-2.88	1.03	0.31
DLC	6.58 ± 1.34	5.27-12.5	5.92 ± 0.48	5.14-6.93	2.4	0.26
DMC	6.19 ± 1.45	4.82-12.3	5.96 ± 0.49	4.81-7.01	0.75	*0.02
ICL	7.3 ± 0.83	5.91-9.3	6.92 ± 0.67	4.65-7.85	1.83	0.16
FNL	3.84 ± 0.67	2.61-5.1	3.81 ± 0.45	2.62-4.65	35.33	0.07
FNC	10.28 ± 0.83	8.3-11.8	10.15 ± 0.82	8.2-11.5	0.57	0.47

$P \leq 0.05$*

MLF: Maximal length of the femur, LSAA: Length of the subtrochanteric apical axis, LMDF: Latero-medial diameter of the femoral head, SCi: Sub-capital diameter from the superior-inferior diameter of the femur, MCi: Mid-cervical diameter from the superior-inferior diameter of the femur, BSi: Basilar diameter from the superior-inferior diameter of the femur, SCii: Sub-capital diameter from the anterior-posterior diameter of the femur, MCii: Mid-cervical diameter from the anterior-posterior diameter of the femur, BSii: Basilar diameter from the anterior-posterior diameter of the femur, AOI: Angle of inclination, AOD: Angle of declination, EB: Epicondyle Breadth, DLC: Depth of lateral condyle, DMC: Depth of medial condyle, ICL: Intertrochanteric crest length, FNL: Femoral neck length, FNC: Femoral neck circumference.

However, the left MLF had a higher mean value of 45.95 mm (SD 2.42) compared to the right, with a mean of 45.68 mm (SD 3.53) and a *P-value* of 0.02, which was statistically significant. Similarly, the left SCii had a higher mean value of 4.33 mm (SD 0.32) compared to the right, 4.24 mm (SD 0.54), with a *P-value* of 0.04, which was statistically significant. Additionally, the left AOD had a higher mean value of 41.63 mm (SD 10.5) compared to the right, with a mean value of 34.62 mm (SD 6.15) and a *P-value* of 0.04, which was statistically significant. The right and left mean values of AOI were 36.51 mm (SD 6.15) and 40.16 mm (SD 4.03), with a *P-value* of 0.13, which was not statistically significant (Table 1).

In the other parameters, the right values were higher than the left values. However, only LMDF, SCi, MCii, and DMC were statistically significant. The right and left mean values of LMDF were 3.75 mm (SD 0.63) and 3.43 mm (SD 0.3), respectively, with a *P-value* of 0.02. The right and left mean values of SCi were 4.31 mm (SD 0.58) and 4.23 mm (SD 0.35), respectively, with a *P-value* of 0.05. The right and left mean values of MCii were 2.87 mm (SD 0.52) and 2.67 mm (SD 0.3), respectively, with a *P-value* of 0.03, while the right and left mean values of DMC were 6.19mm (SD 1.45) and 5.96 mm (SD 0.49), respectively, with a *P-value* of 0.02 (Table 1).

The right and left mean values of LSAA were 9.1 mm (SD 0.68) and 8.91 mm (SD 0.51) with a *P-value* of 0.2, which was not statistically significant. The right and left mean values of MCi were 3.27 mm (SD 0.36) and 3.09 mm (SD 0.3), with a *P-value* of 0.24, which was not statistically significant. The right and left mean values of BSi were 4.95 mm (SD 0.6) with a *P-value* of 0.37, which was not statistically significant. The right and left mean values of BSii were 3.41mm (SD 0.59) and 3.13 mm (SD 0.44), with a *P-value* of 0.34, which was not statistically significant. EB's right and left mean values were 2.4 mm (SD 0.33) and 2.31 mm (SD 0.3) with a *P-value* of 0.31, which was not statistically significant. The right and left mean values of DLC were 6.58 mm (SD 1.34) and 5.92 mm (SD 0.48), with a *P-value* of 0.26, which was not statistically significant. The right and left mean values of ICL were 7.3 mm (SD 0.83) and 6.92mm (SD 0.67), with a *P-value* of 0.16, which was not statistically significant. The right and left mean values of FNL were 3.84 mm (SD 0.67) and 3.81 mm (SD 0.45), with a *P-value* of 0.07, which was not statistically significant. The right and left mean values of FNC were 10.28 mm (SD 0.83) and 10.15 mm (SD 0.82) with a *P-value* of 0.47, which was not statistically significant (Table 1).

Table 2. Correlation of femoral parameters in a Nigerian population sample

MLF		
	Right	**Left**
LSAA	0.472	0.71
LMDF	0.379	0.533
SCi	0.093	0.555
MCi	0.388	0.516
BSi	0.176	0.244
SCii	0.166	0.715
MCii	0.238	0.519
BSii	0.229	-0.224
AOI	0.201	0.361
AOD	-0.211	0.003
EB	0.374	0.319
DLC	0.392	0.471
DMC	0.393	0.535
ICL	0.67	0.782
FNL	0.623	0.179
FNC	0.223	0.584

MLF: Maximal length of the femur, LSAA: Length of the subtrochanteric apical axis, LMDF: Latero-medial diameter of the femoral head, SCi: Sub-capital diameter from the superior-inferior diameter of the femur, MCi: Mid-cervical diameter from the superior-inferior diameter of the femur, BSi: Basilar diameter from the superior-inferior diameter of the femur, SCii: Sub-capital diameter from the anterior-posterior diameter of the femur, MCii: Mid-cervical diameter from the anterior-posterior diameter of the femur, BSii: Basilar diameter from the anterior-posterior diameter of the femur, AOI: Angle of inclination, AOD: Angle of declination, EB: Epicondyle breadth, DLC: Depth of lateral condyle, DMC: Depth of medial condyle, ICL: Intertrochanteric crest length, FNL: Femoral neck length, FNC: Femoral neck circumference.

A strong positive correlation was found between the MLF and LSAA, SCii, and ICL on the left side (Table 2). Other parameters showed weak positive and negative correlations with the right and left MLF.

Discussion

In this study, the dependence of MLF on other femoral parameters is depicted by its strong correlation with LSAA, LMDF, and ICL. This correlation is similarly observed in another Nigerian population where the anteroposterior length of the lateral condyle shows a strong positive correlation with the MLF (26). The strong positive correlation between the MLF and LSAA, SCii, and ICL on the left femur indicated that these parameters also increase as the length increases. This information may be of clinical significance in treating femoral fractures with implants.

This study depicted bilateral differences between right and left femoral parameters, with the right femur having higher values than the left. The statistically significant difference in the overall mean values of the right and left femoral lengths among Nigerians may be considered in conditions that require these anatomical applications: limb-lengthening procedures, plating of femoral fractures, and intramedullary nailing (35). Bilateral asymmetry in the femoral bone has been linked to sexual dimorphism (36). Humans' asymmetric reliance on right and left appendages is related to human behavioral patterns (37, 38).

This study's reported femur neck length is consistent with other measurements in a Nigerian population (28). The consideration of these variations is imperative in gait analysis for the development and use of cemented or cementless large-diameter head total hip replacement (THR) therapy for treating hip arthritis (39–42), which is highly prevalent in medical tourism (43).

Conclusion

This study is relevant to forensics, prognosis, and the treatment of femur fractures, including the development and use of implants and limb-lengthening procedures in the Nigerian population.

Limitations of the study

This study needs to be expanded in sample size, include comparisons with other populations, and identify genders before maceration of dissected cadaveric specimens so that values for both genders can be distinctly compared.

Acknowledgments

The author acknowledges the Head of the Department of Anatomy and the technical staff who performed the maceration.

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki, and the protocol, concerning the use of human subjects for research, was approved by the UI/UCH Ethics Review Committee with approval number UI/EC/24/0218.

Data availability

None declared.

Conflict of interest

The authors declare no conflict of interest.

Funding/support

This research received no external funding.

References

1. Moosa SS, Shaikh MHR, Khwaja M, Shaikh SAH, Siddiqui FB, Daimi SRH, et al. Sexual dimorphic parameters of femur: a clinical guide in orthopedics and forensic studies. J. Med. Life 2021;14(6):762-8. https://doi.org/10.25122/jml-2021-0022

2. Fischer H, Maleitzke T, Eder C, Ahmad S, Stöckle U, Braun KF. Management of proximal femur fractures in the elderly: current concepts and treatment options. Eur. J. Med. Res 2021;26(1):86. https://doi.org/10.1186/s40001-021-00556-0

3. Faulkner KG, Cummings SR, Black D, Palermo L, Glüer CC, Genant HK. Simple measurement of femoral geometry predicts hip fracture: the study of osteoporotic fractures. J. Bone Miner. Res 1993;8(10):1211-7. https://doi.org/10.1002/jbmr.5650081008

4. Bouxsein ML, Zysset P, Glüer CC, McClung M, Biver E, Pierroz DD, et al. Perspectives on the non-invasive evaluation of femoral strength in the assessment of hip fracture risk. Osteoporos Int. 2020;31(3):393-408. https://doi.org/10.1007/s00198-019-05195-0

5. Pollitzer WS, Anderson JJ. Ethnic and genetic differences in bone mass: a review with a hereditary vs environmental perspective. Am. J. Clin. Nutr 1989;50(6):1244-59. https://doi.org/10.1093/ajcn/50.6.1244

6. Nam HS, Shin MH, Zmuda JM, Leung PC, Barrett-Connor E, Orwoll ES, et al. Osteoporotic Fractures in Men (MrOS). Race/ethnic differences in bone mineral densities in older men. Osteoporos Int. 2020;31(3):393-408.

7. Leslie WD. Ethnic Differences in Bone Mass-Clinical Implications. The Journal of Clinical Endocrinology & Metabolism 2012 Dec 1;97(12):4329-4340. https://doi.org/10.1210/jc.2012-2863

8. Hume PA, Kerr DA, Ackland TR. Best practice protocols for physique assessment in sport. Singapore: Springer; 2018. https://doi.org/10.1007/978-981-10-5418-1

9. Meeusen RA, Christensen AM, Hefner JT. The use of femoral neck axis length to estimate sex and ancestry. J. Forensic Sci 2015;60(5):1300-4. https://doi.org/10.1111/1556-4029.12820

10. Muley M, Bhuiyan P. Morphometric study of neck of dry adult femora. Int J Anat Res 2017;5(3.2):4317-20. https://doi.org/10.16965/ijar.2017.321

11. Sousa D, Fernandes E, Mathias RM, Rodrigues MB, Ambram MR, Babinski AJ. Morphometric study of the proximal femur extremity in Brazilians. Int J Morphol 2010 Sep 1;28(3):835-40. https://doi.org/10.4067/S0717-95022010000300027

12. Adetona M, Shokunbi M. Quantitative anthropometric and dermatoglyphic variation of the major ethnic populations in Nigeria. J. Exp. Clin. Anat 2019;18(1):55 https://doi.org/10.4103/jeca.jeca_33_18

13. Wang L, He K, Chen Z. Statistical analyses of femur parameters for designing anatomical plates. Comput. Math. Methods Med 2016;2016:1247560. https://doi.org/10.1155/2016/1247560

14. Gupta A, Tse KM. Vibration analysis of femur bone using Elmer. JESTEC. 2014;12-19

15. Aloudah AA, Almesned FA, Alkanan AA, Alharbi T. Pattern of fractures among road traffic accident victims requiring hospitalization: Single-institution experience in Saudi Arabia. Cureus 2020;12(1):e6550 https://doi.org/10.7759/cureus.6550

16. Pick JW, Stack JK, Anson BJ. Measurements on the human femur-I. lengths, diameters and angles. Q Bull Northwest Univ Med Sch 1941;15(4):281.

17. Castillo RF, Ruiz M del CL. Assessment of age and sex by means of DXA bone densitometry: application in forensic anthropology. Forensic Sci. Int 2011;209(1-3):53-8. https://doi.org/10.1016/j.forsciint.2010.12.008

18. Ghorbanzadeh B, Soltani S, Aghakhani K, Sani SR, Esfahani SA. Gender Identification with Knee Bicondylar Width and Vertical Diameter of the Femur Head Based on Radiography Assessment. IJMTFM. 2017:7(4):209-14.

19. Brits DM, Bidmos MA, Manger PR. Stature estimation from the femur and tibia in Black South African sub-adults. Forensic Sci. Int 2017;270:277.e1-277.e10. https://doi.org/10.1016/j.forsciint.2016.10.013

20. Hauser R, Smoliński J, Gos T. The estimation of stature on the basis of measurements of the femur. Forensic Sci Int 2005;147(2-3):185-190. https://doi.org/10.1016/j.forsciint.2004.09.070

21. Fongkete I, Singsuwan P, Prasitwattanaseree S, Riengrojpitak S, Case DT, Mahakkanukrauh P. Estimation of stature using fragmentary femur and tibia lengths in a Thai population. Aust. J. Forensic Sci 2016;48(3):287-96. https://doi.org/10.1080/00450618.2015.1052758

22. Luna LH, Bosio L, García Guraieb S, Aranda C. Adult sex estimation from the minimum supero-inferior femoral neck diameter in a contemporary osteological sample from Buenos Aires, Argentina. Sci. Justice 2021;61(5):528-34. https://doi.org/10.1016/j.scijus.2021.06.007
23. Maat GJ, Maes A, Aarents MJ, Nagelkerke NJ. Histological Age Prediction from the Femur in a Contemporary Dutch Sample* The decrease of non-remodeled bone in the anterior cortex. J Forensic Sci 2006;51(2):230-237. https://doi.org/10.1111/j.1556-4029.2006.00062.x
24. Sciulli PW, Pfau RO. A method for estimating weight in children from femoral midshaft diameter and age. J. Forensic Sci 1994;39(5):1280-6. https://doi.org/10.1520/JFS13714J
25. Adekoya-Cole T, Akinmokun O, Soyebi K, Oguche O. Femoral neck shaft angles: A radiological anthropometry study. Niger. Postgrad. Med. J 2016;23(1):17. https://doi.org/10.4103/1117-1936.180130
26. Eboh DE, Igbinedion EN. Morphometry of the Distal Femur in a South-South Nigerian Population. MJMHS 2020 Dec 1;16(4).
27. Tahir A, Hassan AW, Umar IM. A study of the collodiaphyseal angle of the femur in the North-Eastern Sub-Region of Nigeria. Niger. J. Med. 2001;10(1):34-6.
28. Obikili EN, Omotoso DR. Morphological evaluation and clinical significance of proximal femoral dimensions among Southern Nigerian population. Int. J. Res. Med. Sci 2020;8(12):4180. https://doi.org/10.18203/2320-6012.ijrms20205285
29. Ogunlade SO, Omololu AB, Alonge TO, Obajimi MO. Femoral head diameter in subcapital fracture of the femur in Ibadan, Nigeria. Afr. J. Med. Med. Sci. 2004;33(3):235-8.
30. Agu AU, Anyanwu GE, Ezugworie JO, Esom EA, Ozoemena FN, Adiri CO, Obikili EN. Femoral head diameters and sex differentiation in Igbos of Nigeria. IJDR 2014 27;4:2519-21.
31. Anyanwu LC. Variations of finger dermatoglyphics among the Esan ethnic group of Edo State, Nigeria. Int. J. Mod. Anthr 2020;2(14):275-89. https://doi.org/10.4314/ijma.v2i14.3
32. Adekunle AA, Olowo AY, Adetona M, James O, Adamson OO, Agbogidi FO, et al. Variations in facial anthropometric measurements among major ethnic groups in Nigeria: A 3-dimentional stereophotogrammetry analysis. FACE (Thousand Oaks) 2021;2(3):236-43. https://doi.org/10.1177/27325016211029013
33. Motulsky HJ. GraphPad Statistics Guide. GraphPad Software Inc., 2020.
34. Pick JW, Stack JK, Anson BJ. Measurements on the human femur-I. lengths, diameters and angles. Q Bull Northwest Univ Med Sch 1941;15(4):281.
35. Park K-W, Garcia R-AN, Rejuso CA, Choi J-W, Song H-R. Limb lengthening in patients with achondroplasia. Yonsei Med. J 2015;56(6):1656-62. https://doi.org/10.3349/ymj.2015.56.6.1656
36. Auerbach BM, Ruff CB. Limb bone bilateral asymmetry: variability and commonality among modern humans. J. Hum. Evol. 2006;50(2):203-18. https://doi.org/10.1016/j.jhevol.2005.09.004
37. Morton BE. Brain executive laterality and hemisity. Personal. Neurosci. 2020;3(e10):e10. https://doi.org/10.1017/pen.2020.6
38. Corballis MC. Left brain, right brain: facts and fantasies. PLoS Biol 2014;12(1):e1001767 https://doi.org/10.1371/journal.pbio.1001767
39. Barnett AJ, Burston BJ, Atwal N, Gillespie G, Omari AM, Squires B. Large diameter femoral head uncemented total hip replacement to treat fractured neck of femur. Injury. 2009 Jul 1;40(7):752-5. https://doi.org/10.1016/j.injury.2009.01.009
40. Karampinas PK, Evangelopoulos DS, Vlamis J, Nikolopoulos K, Korres DS. Confronting hip resurfacing and big femoral head replacement gait analysis. Orthop. Rev. (Pavia) 2014;6(1):5221. https://doi.org/10.4081/or.2014.5221
41. Katchy AU, Njeze NR, Ezeofor S, Nnamani K. Geometrical analysis of the proximal femur and the clinical application in total hip replacement: A study of the Igbo population of south east Nigeria. Niger. J. Clin.

Pract 2019;22(12):1728-36. https://doi.org/10.4103/njcp.njcp_634_18

42. Sidhu GAS, Kaur H, Singh H, Hind J, Ashwood N. Prospective study showing results of large-diameter femoral heads after cementless total hip replacement. Cureus 2021a;13(1):e12610. https://doi.org/10.7759/cureus.12610

43. Crooks VA, Cameron K, Chouinard V, Johnston R, Snyder J, Casey V. Use of medical tourism for hip and knee surgery in osteoarthritis: a qualitative examination of distinctive attitudinal characteristics among Canadian patients. BMC Health Serv. Res 2012;12(1):417. https://doi.org/10.1186/1472-6963-12-417