International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Angular and LinearMorphometry of the Proximal Femur: An Aide to Surgical Reconstruction

Yorkum LK[1], Gbeneol JT[2], Adewunmi RO[3]

[1, 3]Department of Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, University of Port Harcourt, P.M.B. 5323, Rivers State Nigeria

[2]Plastic Division, Department of Surgery, Faculty of Clinical Sciences, College of Health Sciences, University of Port Harcourt, Nigeria.

Corresponding Author: E-mail: *leyira.yorkum[at]uniport.edu.ng*

Abstract: ***The proximal femur is an interesting area of the whole femur bone owing to its vitality to posture, weight bearing and gait. The aim of this study is to radiologically determine the neck-shaft angle and some linear dimensions of the proximal femur of Nigerians.600 radiographs of adult femur (Anterior-Posterior view) of patients with no deformation were obtained from some selected hospitals in Nigeria.The linear and angular morphometry of the proximal femur (right and left sides) were measured from anteroposterior (AP) radiographs of the pelvis. The radiographs were placed on the X-ray viewing box. The linear parameters were measured using a plastic transparent meter rule in centimeter (cm) and the angular morphometry was determined using the goniometer in degrees (°). All lines drawn on the radiographs were drawn with an HB pencil.Details of the subjects like age and sex were noted as gotten from the medical records in the film jacket.Femoral neck axis length (FNAL), femoral neck width (FNW) and femoral Neck-shaft angle (FNA) were all measured and recorded. Statistical analysis was carried out. Sexual dimorphism was observed in FNAL (Female mean- 10.04±0.77 and Male mean – 10.61±1.07), FNW (Female mean - 3.45±0.45 and Male mean- 3.82±0.42). There was no significant difference observed in between right and right side of the FNA. Variations which were statistically significant were observed between the sexes for all the parameters except for Neck Shaft Angle. Femoral Neck Axis length which is a major component of Hip Axis Length is longer in men than in women, which probably explains why Nigerian men are generally taller than women. Independent characteristics like: a longer HAL, valgus femoral neck and larger FNW makes the proximal femur vulnerable to fracture. This study is therefore a useful tool in the hands of physiotherapist and Orthopaedic Surgeons.***

Keywords: Angular, Linear, Morphometry, Sexual Dimorphosm, Nigeria

1. Introduction

The femur is the longest and heaviest bone in the body. It transmits body weight the hip bone to the tibia when a person is standing. Its length is approximately a quarter of the person's height. The femur consists of a shaft (body) and two ends, superior or proximal and inferior or distal (Keith et al., 2010). The superior (proximal) end of the femur consists of a head, neck, and two trochanters (greater and lesser). The proximal femur is "bent" (L-shaped) so that the long axis of the head and neck projects superomedially at an angle to that of the obliquely oriented shaft. This useful angle of inclination is greatest (most nearly straight) at birth and gradually diminishes (becomes more acute) until the adult angle is reached (115- 140°, averaging 126°) (Keith et al., 2010).

The neck of the femur, as it inclines upwards and medially, makes an angle of about 125° with the shaft in the adult male. This angle of inclination is widest at birth and diminishes until adolescence; it is less in females. The neck is also tilted forwards slightly as it passes proximally to the head. This angle of anteversion is about 10-15°.

The angle of inclination is less in females because of the increased width between the acetabula (a consequence of wider lesser pelvis) and the greater obliquity of the femoral shaft. The angle of inclination allows greater mobility of the more rpendicular to the acetabulum in the neutral position.The angle of inclination also allows the obliquity of the femur within the thigh, permits the knees to be adjacent and inferior to the trunk as explained previously. This is advantageous for bipedal walking; however, it imposes considerable strain on the neck of the femur.

Issac et al., (1997) in their study on Prediction of the femoral neck-shaft angle n the length of the femoral neck where a total of 171 adult South Indian femora, devoid of gross pathology, are used to measure the neck-shaft angle, length of the neck, intertrochanteric apical axis length, maximum vertical diameter of the head, kinematic radius, and maximum femoral length. The neck-shaft angle ranges from 120° to 136° with a mean of 126.7° and no significant side difference. The angle significantly and positively correlates with neck length, intertrochanteric apical axis length, kinematic radius, and minimum femoral length (P < 0.001) but not with the vertical diameter of the head.

A study of the collodiaphyseal angle of the femur in the North-Eastern Sub region of Nigeria by Tahir et al., (2001), the neck-shaft (collodiaphyseal) angle of 320 femora (200 males and 120 females) from indigenes of North-East sub-region of Nigeria were measured. The average collo-diaphyseal angle in males (136.70°±3.905) was greater than in females (126.65°±3.397) with a highly significant statistical difference between both sexes (P<0.001). Regional variation was also shown to exist in the neck-shaft angles.

According to the study conducted on 105 femoral radiographs (70 males and 35 females left and right sides) on the determination of femoral angle of inclination in the adult Hausa ethnic group of Nigeria by Ibrahim and

Ugochukwu, (2009). The mean value of the Neck Shaft Angle irrespective of the sex and sides was 121.6°. The mean angle is slightly greater in males 122° than in females 121.5°. A greater mean of the right femoral angle was recorded in males 122.4° than females 120°, but a greater mean of the left femur in females 122° than in males 121.3° was also observed. A conspicuous difference was also noticed on analysis of the means of one side of the same sex; a greater value was seen on the left side of the female 122^0 than on the right 120.8° while males have a mean value of 122.4° on the right sides and 121.3° on the left. But $p>0.05$ so there was no statistical difference between the sexes and between the sides.

In this part of the world, the possibility of proximal femoral fracture is not considered, as people have strong religious beliefs that it can never happen to them, while ignorant of their skeletal health status.

Secondly, it has been observed that most Nigerian fracture patients frequent the Orthopaedic unit of hospitals after total hip replacement owing to the fact that the prostheses used for them are not very suitable for them. These prostheses are imported and no doubts that the measurements used for their productions are not for Nigerians. This is evident in the patients' discomfort even after the replacements.

A baseline data is needed from Nigerians subjects to enhance surgeon's adequate and accurate medical attention for Nigerian victims of proximal femoral fracture replacement therapy.

The aim of this study therefore is to radiologically determine the neck-shaft angle of the proximal femur of Nigerians.

2. Materials and Methods

This was limited to adult femurs which were specifically selected by age and 600 clean and clear radiographs of adult femur (Anterior-Posterior view) obtained from some selected hospitals in Nigeria. According to Caetano-Lopes et al., (2007) in their study on Osteoblasts and Bone Formation, the age of ossification of lower limb ranges from 18 to 23 years of age, and nearly all bones are completely ossified by 25 years of age. Thus, this study covers three (3) age GROUP 1 (26-35), GROUP 2 (36- 45) and GROUP 3 (46-55). This study was conducted between July and December 2013.

Exclusive criteria: Radiographs with medical history of malformed hip and abnormality of the shape of the pelvic due to fracture, dysplasia, osteoporosis, osteonecrosis, osteoarthritis, metabolic bone disease, femoral diseases and malignancy were excluded from this study (Michael et al., 2006: Irdesel& Ari, 2006). The BMD and BMI of subjects are not considered in this study, this study was only based on records.

Measurements: The linear and angular morphometry of the proximal femur (right and left sides) were measured from anteroposterior (AP) radiographs of the pelvis. The The radiographs were placed on the X-ray viewing box. The linear parameters were measured using a plastic transparent meter rule in centimeter (cm) and the angular morphometry was determined using the goniometer in degrees (°). All lines drawn on the radiographs were drawn with a HB pencil.Details of the subjects like age and sex were noted as gotten from the medical records in the film jacket.
The following parameters were measured and analysed:

The Femoral Neck Axis Length (Fnal): The femora neck axis length (ENAL) was determined by drawing a line from the base of the lateral part of the greater trochanter to the caput femoris.

The Femoral Neck Width (Fnw): The femoral neck width (FNW) was determined by drawing a line through the narrowest cross-section of the femoral neck.

The Femoral Neck-Shaft Angle (Nsa): The femoral Neck-shaft angle was determined by drawing a line median and parallel to the femoral shaft to intersect with the femoral neck axis length (FNAL). The Goniometer was then placed on the lines. The red lines on the plates of the goniometer were then made to align with the femoral neck axis the median shaft lines and the angle in between the red lines was measured.

Limitations to Study: This study was based on records gotten from Hospitals and was limited by inconsistencies in record keeping system which vary from one hospital to another; another factor was inadequate storage system.

Data Analysis: The Mean, Standard Deviation (SD), Minimum and Maximum values, Standard Error (SE), Variance, Range and P-value were determined from all measurements to establish the differences and relations of the variables between:
1) Gender
2) Sides

All measurement were taken and recorded by the same observer. Data were statistically analysed and tabulated with the Minitabvl6 software.

3. Results

Table 1: Mean, Standard Error Mean, Standard Deviation, Variance, Minimum, Maximum and Range values of the morphometric analysis of the proximal femur for total sample

Parameter	N	Mean	SE Mean	St Dev	Variance	Minimum	Maximum	Range
FNAL (cm)	600	10.329	0.398	0.976	0.952	7.800	13.600	5.800
FNW (cm)	600	3.6298	0.0174	0.4265	0.1819	2.9000	5.1000	2.2000
NSA (°)	600	128.85	0.288	7.05	49.65	110.00	150.00	40.00

* Femoral neck axis length (FNAL), femoral neck width (FNW), Femoral neck shaft angle (NSA)

Table 2: Mean, Standard Error Mean, Standard Deviation, Variance, Minimum, Maximum and Range values of the morphometric analysis of the proximal femur for male sample

Parameter	N	Mean	SE Mean	St Dev	Variance	Minimum	Maximum	Range
FNAL (cm)	298	10.624	0.0619	1.068	1.140	8.500	13.600	5.100
FNW (cm)	298	3.8158	0.0244	0.4211	0.1773	2.900	5.1000	2.2000
NSA (^{o})	298	128.62	0.415	7.17	51.38	110.00	145.00	35.00

* Femoral neck axis length (FNAL), femoral neck width (FNW), Femoral neck shaft angle (NSA)

Table 3: Mean, standard Error Mean, Standard Deviation, Variance, Minimum, Maximum and Range values of the morphometric analysis of the proximal femur for female total

Parameter	N	Mean	SE Mean	St Dev	Variance	Minimum	Maximum	Range
FNAL (cm)	302	10.038	0.0445	0.773	0.597	7.800	11.800	4.000
FNW (cm)	302	3.4464	0.0198	0.3449	0.1190	2.9000	5.0000	2.1000
NSA (^{o})	302	129.09	0.399	6.93	48.00	110.00	150.00	40.00

* Femoral neck axis length (FNAL), femoral neck width (FNW), Femoral neck shaft angle (NSA)

Table 4: Mean, standard Error Mean, Standard Deviation, Variance, Minimum, Maximum and Range values of the morphometric analysis of the proximal femur for right total

Parameter	N	Mean	SE Mean	St Dev	Variance	Minimum	Maximum	Range
FNAL (cm)	296	10.312	0.571	0.983	0.966	7.800	13.300	5.500
FNW (cm)	296	3.6213	0.0245	0.4221	0.1782	2.9000	5.1000	2.2000
NSA (^{o})	296	129.04	0.417	7.17	51.35	110.00	150.00	40.00

* Femoral neck axis length (FNAL), femoral neck width (FNW), Femoral neck shaft angle (NSA)

Table 5: Mean, standard Error Mean, Standard Deviation, Variance, Minimum, Maximum and Range values of the morphometric analysis of the proximal femur for left total

Parameter	N	Mean	SE Mean	St Dev	Variance	Minimum	Maximum	Range
FNAL (cm)	304	10.346	0.556	0.969	0.940	7.800	13.600	5.800
FNW (cm)	304	3.6382	0.0247	0.4312	0.1859	2.9000	5.0000	2.1000
NSA (^{o})	304	128.67	0.398	6.93	48.09	110.00	147.00	37.00

* Femoral neck axis length (FNAL), femoral neck width (FNW), Femoral neck shaft angle (NSA)

Table 6: Mean, standard Error Mean, Standard Deviation, Variance, Minimum, Maximum and Range values of the morphometric analysis of the proximal femur for age Group I (26-35 years)

Parameter	N	Mean	SE Mean	St Dev	Variance	Minimum	Maximum	Range
FNAL (cm)	313	10.088	0.0476	0.842	0.709	7.800	13.300	5.500
FNW (cm)	313	3.5489	0.0266	0.4710	0.2218	2.9000	5.1000	2.2000
NSA (^{o})	313	128.41	0.413	7.31	53.45	110.00	150.00	40.00

* Femoral neck axis length (FNAL), femoral neck width (FNW), Femoral neck shaft angle (NSA)

Table 7: Mean, standard Error Mean, Standard Deviation, Variance, Minimum, Maximum and Range values of the morphometric analysis of the proximal femur for age Group II (36-45 years)

Parameter	N	Mean	SE Mean	St Dev	Variance	Minimum	Maximum	Range
FNAL (cm)	135	10.464	0.0823	0.956	0.915	7.800	12.600	4.800
FNW (cm)	135	3.7089	0.0334	0.3885	0.1510	2.9000	4.6000	1.7000
NSA (^{o})	135	127.24	0.668	7.76	60.29	115.00	145.00	30.000

* Femoral neck axis length (FNAL), femoral neck width (FNW), Femoral neck shaft angle (NSA)

Table 8: Mean, standard Error Mean, Standard Deviation, Variance, Minimum, Maximum and Range values of the morphometric analysis of the proximal femur for age Group III (46-55 years)

Parameter	N	Mean	SE Mean	St Dev	Variance	Minimum	Maximum	Range
FNAL (cm)	152	10.707	0.0895	1.103	1.217	8.500	13.600	5.100
FNW (cm)	152	3.7263	0.0257	0.3172	0.1006	3.0000	4.6000	1.6000
NSA (^{o})	152	131.21	0.403	4.97	24.68	118.00	139.00	21.00

* Femoral neck axis length (FNAL), femoral neck width (FNW), Femoral neck shaft angle (NSA)

Table 9: Showing z-test result for left and right sides at p = 0.05

Variable	N	Min	Max	Mean	S.D	Difference	z (observed)	|z| Critical	p-observed	Inference
L-FNAL	304	7.80	13.60	10.35	0.97	0.04	0.34	1.96	0.73	Not sig
R-FNAL	296	7.80	13.30	10.31	0.98					
L-FNW	304	2.90	5.00	3.64	0.43	0.15	0.15	1.96	0.88	Not sig
R-FNW	296	2.90	5.10	3.62	0.42					
L-NSA	304	110.0	147.00	128.67	6.93	0.63	0.10	1.96	0.92	Not sig
R-NSA	296	110.0	150.00	128.04	7.17					

*Femoral neck axis length (FNAL), femoral neck width (FNW), femoral neck shaft angle (NSA), Sample size (N), Right side (R), Left side (L), Standard Deviatinon (SD).

Table10: Showing z-test result for male and female at p = 0.05

Variable	N	Min	Max	Mean	S.D	Difference	z (observed)	|z| Critical	p- observed	Inference
F-NAL	302	7.80	11.30	10.04	0.77	0.58	7.84	1.96	< 0.0001	Sig
M-FNAL	298	8.50	13.60	10.62	1.07					
F-FNW	302	2.90	5.00	3.45	0.35	0.37	11.67	1.96	> 0.0001	Sig
M-FNW	298	2.90	5.10	3.82	0.42					

* Femoral neck axis length (FNAL), femoral neck width (FNW), femoral neck shaft angle (NSA), Sample size (N), Right side (R), Left side (L), Standard Deviatinon (SD).

4. Discussion

The proximal femur is an interesting area of the whole femur bone owing to its vitality to posture, weight bearing and gait. Studies among different racial populations and in sub-groups in many races for more specific details have been carried out. Different characteristics and relationships have therefore been established by the proximal femur in each of the population studied. The results gotten by this study are relatively close to other studies found in the literatures conducted by the same method.

As the number of hip fractures continues to rise, finding better ways to identify people at risk becomes crucial, and a gradient of femoral fracture risk was established by Brownbill et al, (2003) that hip axis length (HAL) shows the greatest promise for enhancing fracture risk assessment in the clinical setting, followed by neck shaft angle (NSA) and femoral neck width (FNW).

Isaac et al., (1989) 'Based on classical literature, the angle of inclination is about 150^0 in infants, 140^0 in youngsters, 125° in adults and 120^0 in the elderly', this can buttressed by the average mean (128.85°) of NSA for the whole sample in this study which is considerably closer to the NSA given for adults.

When compared to Reikeras et al.,(1982) results for male (127^0) and female (128.3°), this study's results for male (128.62°) and female (129.09°) was significantly higher although their study was osteometric. Even when the bilateral differences were analysed for their result between male and female, they realized there was no significant differences between the sexes.

For a study of NSA conducted by Ibrahim and Ugochukwu on Hausa ethnic group of Nigeria, the mean value was 121.6° but for this study, the mean and standard deviation (SD) is 128.85°±7.05.

The mean value for the NSA gotten from this study for females (129.09°) when compared to the mean value (131.52°) of NSA gotten from Turkish women by Irdesel& Ari, (2006) is lower. Though the same methods were used, the difference can be attributed to environmental status linked with life style and differences. Irdesel& Ari also studied the BMI which the mean value was g/m^2 which explain the nutritional status of the population as probably normal. But in this study, the BMI was not studied, so no relationship can be drawn about nutrition when considering the possible causes of the difference in the NSA between this study and their study.

For FNW, a similarity was noticed between the Turkish women (35.4mm) to that of Nigerian women (34.5mm). For the TW, this study's mean value for Nigerian women (71.2mm) is higher compared to that of the Irdesel and Ari (84.2mm). So, it can be said that the mean value for some of the linear morphometry of the proximal femur shows that the Turkish proximal femur is similar to Nigerian female.

The role of FNAL is not so clear although it is the major component of HAL. FNAL appears to have a limited utility in the prediction of hip fracture. The mean FNAL (108.0mm) for women studied by Irdesel& Ari is quite higher than that of this study (100.4mm). It is obvious perhaps Turkey women have broader hips compared to Nigerian women. The Turkish women may also be said to have a roader femoral head than the Nigerian women because according to Irdesel and Ari (2006), the mean FHW was 52.1mm for Turkish women and according to this study it is 49.1mm for Nigerian women.

According to this study, FNAL was significantly longer in men, which is probably explained by the fact that men are generally taller than women, and according to Bergot et al., (2002) FNAL was common with most femoral dimensions are highly independent on the subjects heights. The results of previous studies have shown that a relationship exists between hip fracture risk and HAL, FAL, FW, and NSA (Faulkner et al., 1993, Gnudi et al., 2002). A longer hip axis length (HAL), a larger neck-shaft angle (NSA) and a larger neck width (FNW) are associated with an increased risk of hip fracture (Faulkner et al., 1993; Faulkner et al., 1994; Gnudi et al., 2002). The exact mechanism of this fact is not yet known, since contradictory data were gotten from ex vivo biomechanical s showing that the NSA does not correlate with femoral neck strength (Pinilla et al., 1996). The impact direction associated primarily with a fall is a critical determinant of hip fracture risk that is both independent of bone density and associated primarily with fall biomechanics (Pinilla et al..,1996). HAL has been studied extensively and it has been shown to predict hip fractures independently of age and bone mineral density in women as concluded by Brownbill et al., (2003). However, hip adduction increases HAL measurements because of the inner shape of the pelvis which is unavoidable when the position is unstandardized (Mitchelotti et al.., 1990).

Significant difference in NSA (p < 0.O5) has been established over the years in Nigeria and it can be used to identify sex (Tahir et al..,2010 ; igbigbi and Msamati 2002; lgbigbi PS 2Q03) while for sides no significant difference (Reikeras et al.., 1982; Isaac et al.., 1997; Da Silva et al., 2003).

The greater hip strength in black women and men resulting in a lower incidence of fractures compared with white women is also attributed to more favourable geometric parameters, and Asian women, who have a lower incidence of fractures than white women, have a shorter HAL and a smaller NSA. A longer HAL and a greater NSA and FNW all increase the risk of fracture, though controversies exist due to the use of different subject populations and measurement tools (Brownbill et al.., 2003). The association of proximal femur morphometry to femoral neck fracture rate appears to be continually supported by an increasing number of clinical studies (Gnudi et al.., 1999).

5. Conclusion

In as much as a normal frame of references has been established so far in this study for production of local prosthesis for Nigerians, there was no variation served significantly between the sides for all the parameters measured.

However, variations which were statistically significant were observed between the sexes for all the parameters except for Neck Shaft Angie. Femoral Neck Axis length which is a major component of Hip Axis Length is longer in men than in women, which probably explains why Nigerian men are generally taller than women. Independent characteristics like: a longer HAL, valgus femoral neck and larger FNW makes the proximal femur vulnerable to fracture.

6. Conflict of Interest

No conflict of interest.

References

[1] Brownbill RA and Ilich JZ (2003): Hip geometry and its role in fracture: what do we know so far? *CurrOsteoporos* Rep 1 (1):25 -31
[2] Camblin JG (1970): Five years retrospective study of femoral neck fractures. Department of Surgery.The Queens University, Belfast.
[3] Da Silva Vi, Oda JY and Sant'anna DM (2003): Anatomical aspects of the proximal femur of adult Brazilians. *Int. J. Morphol*., 21(4):303-8.
[4] De Sousa EB, Fernandes RM, Mathias MB, Rodrigues MR, Ambram AJ and Babinski MA (2010): Morphometric study of the proximal femur extremity in Brazilians. *Int. J. Morphol*., 28(3):835-40.
[5] Faulkner KG (1995): Letter to the editor: Hip axis length and osteoporotic fractures. *J Bone Miner Res*, 10: 506-508.
[6] Faulkner KG, Cummings SR, Black D, Palermo L, Glüer CC and Genant HK (1993): Simple measurements of femoral geometry predict hip fracture: the study of osteoporotic fractures. *J Bone Miner Res*, 10: 1211-1217.
[7] Faulkner KG, McClung M. and Cummings SR (1994): Automated evaluation of hip axis length for predicting hip fracture. *J Bone Miner Res*, 9: 1065 - 1070.
[8] Faulkner KG, Wacker WK, Barden HS, Simonelli C, Burke PK, Ragi S and Del Rio L (2006): Femur strength index predicts hip fracture independent of bone density and hip axis length. *OsteoporosInt*. 17: 593 -599.
[9] Garcia FG and Uribe AR (1995): Anthropomorfometriaendosticadel femur proximal n poblacion Mexicana. *Rev. mex.Ortop.Traumatol*., 9(2):59-70.
[10] Gnudi S, Ripamonti C, Lisi L, Fini M, Giardino R and Giavaresi G (2002): Proximal femur geometry to detect and distinguish femoral neck fractures from trochanteric fractures in postmenopausal women. *OsteoporosInt*, 13: 69-73.
[11] Gnudi S. Ripamonti C, Gualtieri G and Malavolta N (1999): Geometry of proximal femur in the prediction of hip fracture in osteoporotic women. *Br J Radiol*, 72: 729-733.
[12] Gujar S, Sanjav V, Jigna P, Bondre KV (2013): *International Journal of Biomedical and Advance Research*.4:(05)
[13] Hamill J, Knutzen KM (1995): Biomechanical Basis of Human Movement. Williams and Wilkins.Pp 298-9.
[14] Ibrahim YA and Ugochukwu GE (2008): Femoral angle of inclination in the adult Hausa ethnic group in Nigeria. Journal of Anatomical Sciences 2(1): 24-26.
[15] Igbigbi PS (2003): Collodiaphyseal angle of the femur in East African subjects. *Clin. Anat.*, 16(5):416-9.
[16] Igbigbi PS and Msamati BC (2002): The femoral coliodiaphyseal angle in Malawian adults. *Am. J. Orthop*., 31(12):682-5
[17] Irdesel J and Ari I (2006): The proximal femoral morphometry of Turkey women on radiographs. *Eur J Anat*. 10 (1):21-26.
[18] Isaac B, Vettivel S, Prasad R and Chandi G (1998): Prediction of the femoral neck-shaft angle from the length of the femoral neck. *Clin. Anat*., 10(5):318-23.
[19] Keith LM, Arthur FD and Anne MR (2007): Lower limb. Clinically oriented anatomy.6th edition.Lippincott Williams & Wilkins. Page 516-518.
[20] Krishan K (2007): Anthropometry in Forensic Medicine and Forensic Science. *The Internet Journal of Forensic Science*.Vol. 2(1).
[21] LuizCj and Jose C (2005): Bone. Basic histology text and atlas.11th edition. McGraw-Hill Companies. Page 250-253.
[22] Martin R and Burr D (1984): Non-invasive measurement of long bone cross- sectional moment of inertia by photon absorptiometry. *J Biomech 17: 195—201*.
[23] Michael RO, John JC and Boezaart AP (2006): The adult Hip. 103 -116.
[24] Michelotti J. and Clark I: Femoral neck length and hip fracture risk. J Bone Miner Res (1999): 14(10):1714-720
[25] Mourao AL and Vasconcellos H (2001): Geometria do Femur Proximal em ossos de Brasileiros. *Actafisiatr* 8(3):113-9.

[26] Nwaogazie IL (2011): Tests of Hypothesis and Significance. Probability and Statistics for Science and Engineering Practice 2nd Edition. University of Port Harcourt Press. Page 163-197.
[27] Osunwoke EA, Udoka AI, GwinireamalU, Olotu EJ and Emefiele EM (2008): Sex determination from the femoral head by demarking points in Southern-Nigeria population. *J. Biomed. Afric*. 6 (1&2) 18-20.
[28] Pinilla TP, Boardman KC, Bouxsein ML, Myers ER and Hayes WC (1996) Impact direction from a fall influences the failure load of the proximal femur as much as age-related bone loss. *Calcf Tissue Int*, 58: 231-235.
[29] Reikeras O, Hoiseth A, Reigstad A and Fonstelien E (1982): The Femoral Neck Angles: a specimen study with special regard to bilateral differences. *ActaOrthap. Scand*., 53(5): 775-779.
[30] Sinnatamby CS (2006): Lower Limb. Last's Anatomy: Regional and Applied. 11th edition. Churchill Livingstone. 173-176.
[31] Snell RS (2007): Clinical Anatomy by Regions. Chapter 10: Lower Limb. 8th edition.Lippincott Williams & Wilkins. 561.
[32] Spencer A (1978): Practical Podiatric Orthopaedic Procedures. Ohio College of Podiatric Medicine.Pp 21-3.
[33] Srimathi T, Muthukumar T, Anandarani VS, Umapathy S. and Rameshkumar S (2012): A study of femoral neck anteversion and its clinical correlation. Journal *of Clinical and Diagnostic Research*. 6(2):155-158.
[34] TahirA, Hassan AW and Umar IM (2001): A study of the colloidiaphyseal angle of the femur in the North-Eastern Sub-Region of Nigeria. *Niger. J. Med.*, 10(1) : 34-36.
[35] Tai PT, Ying C, Wee KL, Wynne H, Tet SH and Meng AP (2000): Computing neck-shaft angle of femur X-Ray fracture detection. *NMRC 04(82):1-4.*
[36] Takada J, Thomas JB, Kouske I and Toshihiko Y (2007): structural trends in the aging proximal femur in Japanese postmenstrual women. *Bone* 41:97-102.
[37] Ujaszek SJ and Mascie-Taylor CG (2005): Anthropometry: The Individual and the Population. Cambridge University Press. Page 183-186.1.