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# Radiologic Evaluation of the Relationship of the Femoral Head Diameter to the Intertrocanteric Line Diameter in Adults Resident in South-South, Nigeria.

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## ABSTRACT

Understanding skeletal relationship in the human body are essential for clinical diagnosis, design of prostheses and biological profiling in forensics. The aim of the study was to determine the relationship between the femoral head diameter (FHD) and the intertrochanteric line diameter (ILD) of adult Nigerians in South-South Nigeria, using radiologic approach. A total of 250 (125 males and 125 females) normal antero-posterior (AP) X-ray films of the pelvis were used. The average value of FHD for the right and left sides were 5.52 ± 0.02 and 5.56 ± 0.02 for males and 4.98 ±0.02 and 4.98 ± 0.28 for females respectively. While the ILD had 8.56 ±0.04 and 8.60±0.04 for males and 7.67±0.06 and 7.65±0.06 for females. Test for bilaterism showed no significant difference ($p>0.05$). Both the FHD and ILD were significantly higher in males compared to females ($p<0.05$). The correlation between FHD and ILD for both males and females were positive and significant. Regression model for the estimation of FHD and ILD has also been formulated. There is sexual dimorphism in FHD and ILD and the anthropometric relationship between these parameters have been well established.

Key words: *femoral head diameter (FHD), intertrochanteric line diameter (ILD), sexual dimorphism and correlation*

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## Introduction

The anthropometry of the proximal femur holds huge clinical significance in designing implants and prostheses for proximal femoral fractures and hip joint arthroplasties[1]. Mechanically worn-out or damaged sections of the femoral head are replaced with artificial implants made from ceramics or metal alloys[2]. The femur is known for being the largest and longest bone in the human skeleton[3,4,5]. It supports all of the weight of the body during such activities as standing, walking and running[6]. The structural function of the femur requires that it endures these mechanical loads, by changing its shape, size and mass[7]. The femur is the most measured and reported bone of the human skeleton[8]. Biological and forensic anthropologists for its great role in estimating sex and stature, study the femur[9,10,11,12]. The femur bone is also studied extensively for its contribution to accessing ancestry when craniofacial feature are absent. Researchers have discovered differences between human populations in femoral size, anterior shaft curvature, torsion and sub-trochanteric shape in various populations[13,14]. The femur is also greatly studied, because it separates modern humans greatly from primates and early hominids, such that the evolution of the femur and its changing shape and structure has allowed increased capacity for human habitual biped locomotion and balance[15,16,17].

The role femur plays in locomotion and forensic identification has been of great interest to reseachers[9,10,15,16,17]. There is greater interest in elucidating the contributions of various parts of the femur in these roles. For instance, the relationship of femoral head to the diaphysis defines the geometric properties and torsion effects of loading and stability. The purpose of this study was to investigate the relationship of the femoral head diameter with the intertrochanteric line diameter in Nigerian adults using radiologic approach. The intention is to generate anthropometric data base for correlation and the formulation of regression model for the femoral head and intertrochanteric line dimensions that could be applicable in clinical diagnosis, design of prosthesis and forensic identification.

## Material and Methods

A total of 250 (125 males and 125 adult females) antero-posterior (AP) plain radiographs of the pelvis of adult Nigerians were used for the study. The radiographs were taken from Tertiary and secondary Healthcare Centres in Selected States of South-South Nigeria. Radiographs with fractures and those shown to have other forms of pathologies were excluded. The measurements were obtained from the archives of the Radiology departments of the following hospitals: University of Port Harcourt Teaching Hospital (UPTH) Choba, Port Harcourt; Braithwaite Memorial Specialist Hospital (BMSH) Port Harcourt; Niger Delta University Teaching Hospital (NDUTH), Okolibiri, Yenagoa, Bayelsa State and Nigerian National Petroleum Corporation Hospital, Warri, Delta state. The femoral head diameter was measured as the maximum breadth across the head of the femur indicated by line AB in figure 1 below. The intertrochanteric line is the maximum diameter between the greater and lesser trochanter as indicated by line CD. The values were measured twice and the average taken to minimize measurement errors.

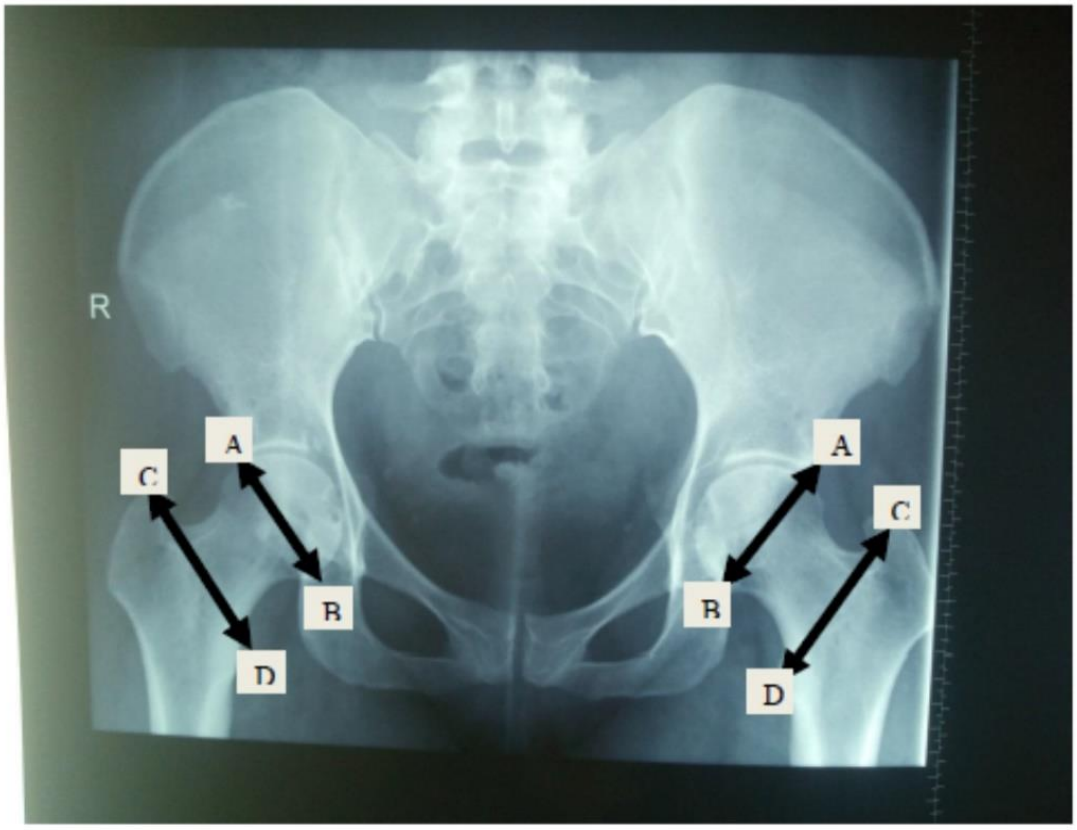


**Figure 1: AP Radiograph of the pelvis showing the femoral head diameter and the intertrochanteric line diameter.**

## Results

The data collected were statistically analyzed using Microsoft Excel Tool Pak 2016. Table 4.1 below shows the descriptive statistics of the measured parameters. Table 4.2 shows test for bilateralism, table 4.3 shows comparison of mean values for males while table 4.4 shows the correlation test and regression model for the estimation of FHD and ILD.

**Table 4.1: Descriptive Statistics Based on the Sides And Gender**

| Parameters | *SEX* | N | SIDE | Mean | SEM | SD | Var | MinV | MaxV |
|---|---|---|---|---|---|---|---|---|---|
| FHD (cm) | Males | 150 | Right | 5.52 | 0.02 | 0.38 | 0.14 | 4.50 | 6.30 |
| | | 150 | Left | 5.56 | 0.02 | 0.38 | 0.14 | 4.40 | 6.40 |
| ILD (cm) | | 150 | Right | 8.56 | 0.04 | 0.70 | 0.49 | 6.50 | 10.50 |
| | | 150 | Left | 8.60 | 0.04 | 0.71 | 0.50 | 6.00 | 10.20 |
| FHD (cm) | Females | 150 | Right | 4.96 | 0.02 | 0.39 | 0.15 | 4.00 | 5.90 |
| | | 150 | Left | 4.98 | 0.02 | 0.38 | 0.14 | 4.00 | 5.90 |
| ILD (cm) | | 150 | Right | 7.67 | 0.06 | 0.68 | 0.46 | 6.50 | 9.90 |
| | | 150 | Left | 7.65 | 0.06 | 0.70 | 0.49 | 6.50 | 9.90 |

*M = Male; F = Female; N = Sample size; SEM = Standard error of mean; SD = Standard deviation; Var = Variance; Maxv = Maximum value; Minv = Minimum value.*

**Table 4.2: Comparison of Mean Values of Parameters by Sides in Males and Females**

| *Parameters* | Sex | Calculated Z score | Critical Z score at 0.05 level | P value | Inference |
|---|---|---|---|---|---|
| *FHD (cm)* | Males | 0.92 | 1.96 | 0.35 | Not Significant |
| *ILD(cm)* | | 0.42 | 1.96 | 0.62 | Not Significant |
| *FHD(cm)* | Females | 0.45 | 1.96 | 0.65 | Not Significant |
| *ILD(cm)* | | 0.25 | 1.96 | 0.80 | Not Significant |

**Head diameter** **Intertrochanteric Line diameter** **Head diameter** **Intertrochanteric line diameter**

**Table 4.3: Comparison of Mean Values of Parameters by Gender**

| Parameters | Side Mean | Calculated Z score | Critical Z score at 0.05 level | | Inference |
|---|---|---|---|---|---|
| FHD | Right | 12.74 | 1.96 | 0.00 | Significant |
| ILD | Right | 11.18 | 1.96 | 0.00 | Significant |
| FHD | Left | 13.42 | 1.96 | 0.00 | Significant |
| ILD | Left | 11.69 | 1.96 | 0.00 | Significant |

**Table 4.4: Pearson's Correlation (R), Correlation Test and Equation for Parameters**

| parameter | Side | Sex | Pearson correlation value (r) | Calculated z score for r -value | Critical zscore at 0.05 level | Inference | Regression coefficient for estimation of Parameters |
|---|---|---|---|---|---|---|---|
| FHD Vs LD | Right | Males | 0.70 | 10.78 | 1.96 | Positive Correlation | FHD= 0.298(11.) + 1.390 |
| | | Fema Les | 0.71 | 11.08 | 1.96 | Is significant ($p<0.05$) Positive correlation is significant ($p<0.05$) | FHD= 1.244(IL) + 1.448 |
| \|tfD Vs LD | Left | Male S | 0.69 | 14.52 | 1.96 | Positive correlation | FIID= 1.268(11.) + 1.548 |
| | | Fema | 0.71 | 15.70 | 1.96 | Is significant ($p<0.05$) Positive | FI-ID= 1.290(IL) |

## Discussion

The relationship between FHD and ILD was investigated in this study. Our findings were similar to earlier studies done in South-East, South-West and North-East of Nigeria. The FHD was found to be 52.02 mm for males and 46.80 mm for females in South-East Nigeria[18], 50.35mm and 47.08 for males and females in South-West of Nigeria[19], and 54.16mm for males and 47.00mm for females in North-East of Nigeria[20]. FHD is higher in Nigerians when compared to studies from other countries. Among black Malawians, the average FHD was 48.30 mm for males and 44.56mm for females[21]. Indians of Eastern Uttar Pradesh Region had FHD of 41.59 ± 3.25mm[21]. Another study on India population found the vertical head diameter to be 40.89 ±2.05 on the right side and 41.46 ±2.77 on the left side. The transverse vertical diameter was 41.05±2.15 on the right side and 41.54±2.69 on the left side[22]. Hasimoto[23] using the antero-posterior diameter for sex determination, reported an average of 46.8mm for Chinese femora. The average diameters reported for males is 45.26mm and in females is 40.37mm by Javadekar[24]. It was documented by Prasad *et al*.[25] that the vertical diameter of the head of dry femora had an average value of 43.0mm in males and 39.1mm in females in South Indian population. In our investigation, FHD were greater males than females and the difference was statistically significant ($p<0.05$). This showed there is shows sexual dimorphism. The lack of significant difference when both sides where compared showed similarity in dimensions.

Femoral head dimension is of importance in clinical diagnosis and treatment plan especially in orthopaedic conditions, also in forensic anatomy for stature estimation and biomedical engineering for the design of prostheses. The femoral head articulates with the acetabulum of the pelvis to form the hip joint. One major factor in the functionality and stability of the joint is the articulating bones. The dimensions of the femoral head plays an important role in the range of movement and stability that could be achieved especially when an artificial hip joint replaces a damaged one. In diagnostic imaging, knowledge of dimensions of the head on AP view of the pelvis is a useful indicator of direction of dislocation. In anterior dislocation, the femoral head is larger than the contralateral side while it in posterior dislocation, the femoral head is smaller than the contralateral side[26]. The dimensions of the femoral head has also been shown to be adequate for sex determination during biological profiling of skeletal remains for identification[18,20,24,27,28,29,30,31,32]. Parsons[33] reported that if the vertical diameter of the head of the femur was greater than 48.00mm, the bone belonged to a male and when below 44.00mm, it indicated a female bone. From Indian femurs, Singh and Singh[28] reported figures of above 45.45mm for a male bone. The variations in the mean value of these studies suggest the femoral head dimension may be affected by racial variations necessitated by diet, heredity, climate and other geographical factors. Luo[32], postulated that the gross shape of long bones could be caused by intrinsic factors, while the specific details were determined by the bone adaptation to the functional environment. It is therefore likely that heredity is a major factor in the formation of the shape of long bones in different races. The data generated in this study would help prosthetic designers produce prosthesis tailored to suits Nigerians. Currently, there are several types

and designs of femoral head prostheses. For example, in modular hip resurfacing system prostheses, the common sizes used are 42mm, 46mm, 50mm, 54mm and 58mm[34].

The intertrochanteric line is a ridge on the anterior aspect of the femoral neck and shaft and transverses between the greater and lesser trochanters. In our study, we found it was 8.56mm and 8.60mm for the right and left sides in males and 7.67cm and 7.65cm for the right and left side in females. In Eastern Uttar Pradesh Region the ILD was reported to be 41.92±3.9mm[1]. A study among Turkish estimated the ILD to be 56.78±5.22 mm for the left side and 57±9.97mm for the right side[35]. The mean value of the intertrochanteric line diameters were similar on both sides but differ significantly in both sexes. Therefore this parameter is sexually dimorphic. Intertrochanteric line is subject of interest in determining bipedal locomotion[36] because the iliofemoral ligament attached to it help to stabilize the trunk on the hip joint by limiting mainly extension, rotation and adduction. Hu et al.[10] revealed there is intertrochanteric line expression is influenced by sex, age and body size while cross sectional geometric properties of the diaphysis is showed little correlation.

FHD was well correlated with the right intertrochanteric line diameter ILD in both sexes. (males r=0.70 and females r=0.71). This the correlation was positive and significant ($p<0.05$). The left femoral head diameter (FHD) was also correlated with the left intertrochanteric line diameter (ILD) in both sexes (males, r=0.69 and females r=0.71). The correlation was positive and significant ($p<0.05$). Regression model for estimating these FHD from ILD the studied population was also formulated in this study. The implication is that as the femoral head diameter increases, the intertrochanteric line diameter also increases.

## Conclusion

There is a positive and significant correlation between FHD and ILD. An increase in FHD corresponds to an increase in ILD. This information is valuable to forensic anthropologists in estimation of stature for human identification, orthopaedic surgeons and prosthetists to deliver excellent performance in their respective specialties.

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