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Radiogrammetry of the Femoral Neck Shaft Angle and the Angles of the Hip Joint of Nigerians

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ABSTRACT
Radiogrammetry of the axial relationship of the articulating bones of the normal hip joint has important clinical and medicolegal implications. This study is aimed to measure and provide normative values of the angular morphometric parameters needed to understand the relationship between the articulating bones of the normal hip joint among the people of South-southern Nigeria. Centre edge angle (CEA) and acetabular angle of sharp (AAS) and Femoral neck shaft angle (FNSA) were evaluated and measured from standard anteroposterior (AP) radiograph of 954 (432 males and 522 females) adults with normal hip using X-ray viewing box, Pencil, Ruler, and goniometer. The mean±Standard deviation values of the CEA, AAS and FNSA obtained from this study are 31.30±2.50° and 33.01±2.56°, 40.82±0.86° and 39.23±0.99°, and 135.00±3.91° and 132.16±4.06° for males and females respectively. The mean values of the all measured parameters were higher in males than females except for the center edge angle which was higher in females. There was a statistically significant difference ($p<0.05$) between sexes in all the measured parameters. We conclude therefore that inter-population and intra-population based differences exist in the studied parameters. Besides, sexual dimorphism and correlation exist in these parameters. We recommend the utilization of the normative values of the measured parameters stated in this study to forensic anatomist, radiologic anatomist and orthopaedic surgeons for the study population.

Keywords: Radiogrammetry, Articulating bones of the Hip joint, South- southern Nigeria

INTRODUCTION
Measurement from radiographs (radiogrammetry) of the axial relationship of the articulating bones of the normal hip joint has important clinical and medicolegal implications. It is useful to radiologist and orthopaedic surgeons. A thorough knowledge of what should be considered normal of the X-ray of the hip joint of Nigerians will help in the differentiation of the pathologic hip joint from the normal. Besides, knowledge about the normal radiographic appearance of the hip joint could be used in forensic medicine and anthropology for sexing.

To understand the hip joint mechanics the knowledge of anatomy of proximal femur is a pre-requisite. Also, knowledge of various bony components of hip joint will not only help the radiologists but will also be of immense importance to the orthopaedic surgeon and makers of orthopaedic implants and screws of the femur and acetabulum. To the best of our Knowledge there is a paucity of literature on what could be considered normal in an X-ray of hip joint and what is considered pathological for south-south Nigerian population. It should be known how far normal standards deviate and where pathological values can be expected[1]. More information is needed on the radiographic measurement of the hip joint, including its shape, its width at precise locations and influence of age, sex and race. These normal values are needed to set the limits of significant early radiographic alteration in patients with osteoarthritis[2].

Different authors have suggested that difference in parameters of bone exists among different races and have tried to figure out the relationship of these variations to increased development of hip osteoarthritis, femoral neck fracture and slipped capital femoral epiphysis[2,3,4,5]. Such parameters cited in literatures include femoral neck shaft angle, centre edge angle and acetabular angle of shape amongst others. The normal values of these parameters for our population (Nigerians) are largely unknown.

The method of measuring the femoral neck shaft angle (collo-diaphyseal angle) from x-ray films was first adopted by Keats and Lusted in 1966[6]. The angle is varies with growth of bone been wider in younger people[7] and is said to be smaller in females[8]. Several authors have examined the femoral neck shaft angle (FNSA) and most authors agree that there is considerable individual variation and wide standard deviation in this angle[9]. Also, previous workers have reported that femoral neck shaft angle or collo-diaphyseal angle show racial, sexual and regional variation[2,9,10]. Besides, researchers in Nigeria have shown that regional variations exist in collo-diaphyseal angle[11-13].

Wiberg[14] first described the centre edge angle (CE angle) and subsequently by many authors[9,15-18]. Values greater than 25 are considered normal whereas values less than 20 are considered dysplastic[9]. Osteoarthritis is rare in Africans and Indians and fairly common in Caucasians. Mandal *et al.*[15] reported similar acetabular measurements in adult hips in these three races and suggested that acetabular dysplasia may not have a significant role in the development of osteoarthritis. The CE angle was reported as significantly higher (P = 0.002) in Caucasoids than the mongoloids, however, they were unable to correlate whether this higher value of CE angle in Caucasoid has an influence in the predisposition to osteoarthritis[9]. The mean centre-edge angle has been reported on Swedish population[14,23], British population[24], Indian population[6], Japanese population[21,25], Korean populations[22] and Singaporean population[18]. However, no published literature on centre edge angle of Nigerian population was found in the course of this study. Data from these population based studies reveal differences in the mean values of the centre edge angle.

First described by Sharp[19], the acetabular angle of Sharp (AAS) is frequently used to determine the presence of dysplasia, values of greater than 43° are considered dysplastic while values below 43° are considered normal. Since its introduction, several studies have been carried out on different population by different researchers. Stuberg and Harris[20] reported on white population, Nakamura *et al.*[21] researched on the Japanese population, Han *et al.*[22] studied the Korean population, Umer *et al.*[18] worked on the Singaporean population, and Saikia *et al.*[9] on the Indian population. These studies revealed that race, climate, heredity and geographical areas have strong influence over this anthropometric parameter of the hip joint.

This radiogrammetric study is aimed to measure and provide normative values of the angular morphometric parameters needed to understand relationship between the articulating bones of the normal hip joint among the people of South-southern Nigeria.

MATERIALS AND METHODS

Standard anteroposterior (AP) radiograph of 954 adults (432 males and 522 females) with normal hip were evaluated and measured using X-ray viewing box, Pencil, Ruler, and Protractor. The radiographs were collected from the Radiology Department of University of Port Harcourt Teaching Hospital, Port Harcourt, Braithwaite Memorial Hospital, Port Harcourt, and University of Benin Teaching Hospital, Benin within the South Southern Nigeria.

The Femoral neck shaft angle (FNSA) of the proximal end of the os femoris, Centre edge angle of Wiberg (CEA), and Acetabular angle of Sharp (AAS) of the hip joint were measured directly from the obtained antero-posterior radiograph of the hip joint.

Definitions of parameters that were used are as follows:

(i) *Femoral neck shaft angle (FNSA):*

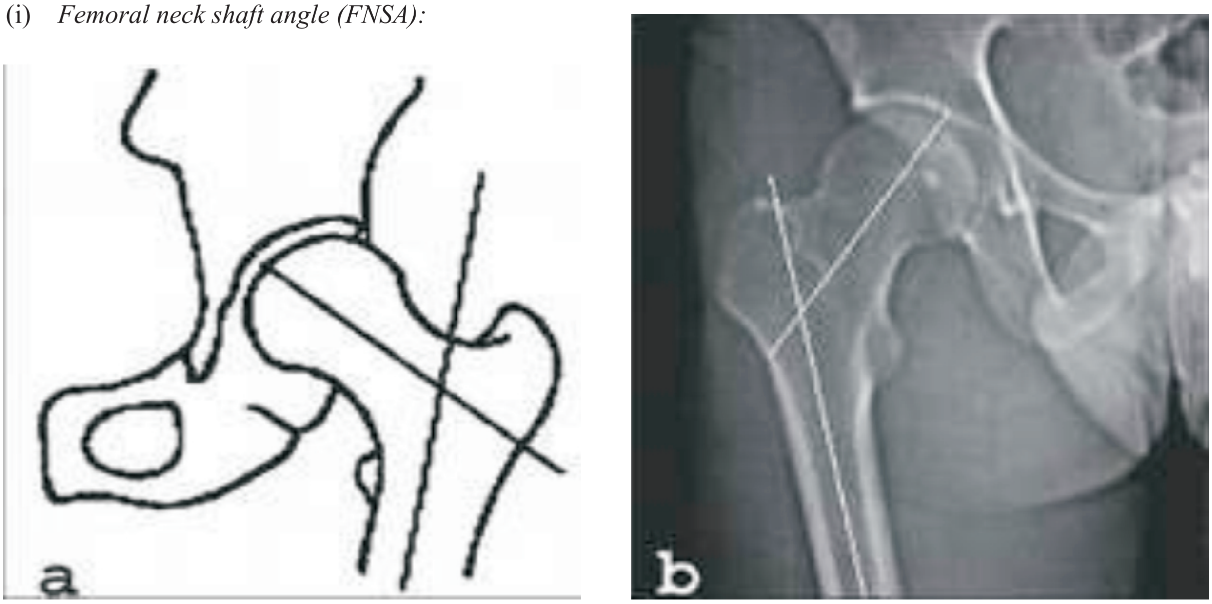

Figure 1: Line diagram (a) and radiograph (b) of femoral neck shaft angle
FNSA is the angle between the femoral shaft axis and the femoral neck axis (Figure 1a & b). The femoral shaft axis is determined by a line drawn through the centre of the medullary canal along the axis of the femur. The neck axis is drawn in the centre of the femoral neck by joining two points equidistant from the superior and inferior surface of the femoral neck and parallel to the neck of the femur.

(ii)CE angle of Wiberg (CEA):

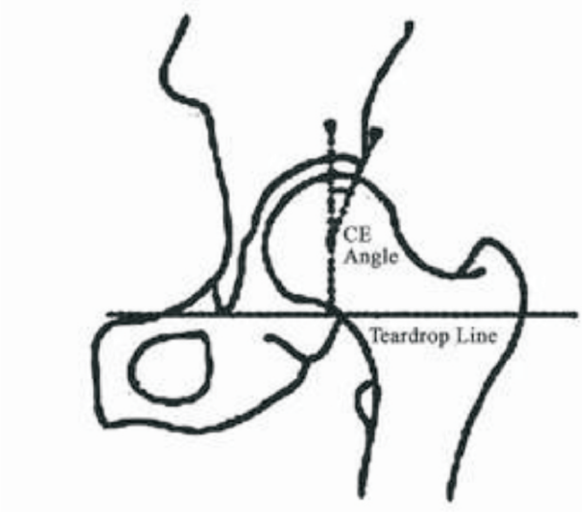

***Figure 2:** Line diagram showing CE angle of Wiberg*
CEA is the angle between a line drawn vertically through the centre of the femoral head and a second line drawn from the centre of the femoral head to the anterior edge of the acetabulum[14] (Figure 2).

(iii) *Acetabular angle of Sharp (AAS)*:

Figure 3: Line diagram of acetabular angle.
AAS is the angle between the horizontal line drawn through the tip of pelvic tear drop and a line from the tip of the tear drop to the anterior edge of the acetabulum[19] (Figure 3).
The morphometric data obtained were statistically analyzed using SPSS and Microsoft Excel data processor to provide descriptive statistical values, significant values for sexual dimorphism and correlation values.

RESULTS

The results of this study are presented in the tables below.

Table 1: Mean values, standard deviation (SD) and range of the 3 measured parameters for both sexes

	CEA (°)	AAS (°)	FNSA (°)
Mean	32.23	39.93	133.42
SD	2.49	0.81	3.88
Range	24 – 44	31 – 50	123 – 146

Center edge angle (CEA), Acetabular angle of Sharp (AAS), femoral neck shaft angle (FNSA) Standard deviation (SD).

Table 2: Comparison of means of the 3 measured morphometric parameters between sexes

Parameters	Sex	Mean	SD	Range	Z calculated	Z critical	Inference (0.05 level)
CEA (°)	Males	31.30	2.50	24 -42	4.31	1.96	Significant (p<0.05)
	Females	33.01	2.56	25 -44			
AAS (°)	Males	40.82	0.86	31 – 51	26.53	1.96	Significant (p<0.05)
	Females	39.23	0.99	32 – 50			
FNSA (°)	Males	135.00	3.91	126 – 146	10.97	1.96	Significant (p<0.05)
	Females	132.16	4.06	123 – 145			

Center edge angle (CEA), Acetabular angle of Sharp (AAS), femoral neck shaft angle (FNSA), Standard deviation (SD).

The mean values of the all measured parameters were higher in males than females except for the center edge angle which was higher in females. There was a significant difference (p<0.05) between sexes in all the measured parameters (tables 2).

Table 3: Correlation coefficient, r of the measured parameters

	AAS	FNSA
CEA	-0.11	0.58
AAS		0.52

Center edge angle (CEA), Acetabular angle of Sharp (AAS), femoral neck shaft angle (FNSA)

Table 4: Measured parameters in different populations and sex.

AUTHOR, YEAR & COUNTRY	SEX	MEASURED MORPHOMETRIC PARAMETERS (°)		
		FNSA	CEA	AAS
Wiberg, (1939), Sweden	Both		36.00	
Fredensborg, (1976), Sweden	Both		35.00	
Massie and Howorth, (1950), USA	Both		35.00	
Yoshimura et al., (1998), Britain	Both		36.20	
Fujii et al., (1994), Japan	Both		30.00	
Han et al., (1998), Korea	Both		32.60	37.00
	Males			36.50
	Females			37.50
Umer et al., (2006), Singapore	Both		31.20	39.46
	Males			39.85
	Females			38.25
Stuberg and Haris (1974), Whites	Males			32.20
Nakamura et al., (1989), Japan	Both		32.20	38.00
	Males			37.30
	Females			38.60
Sakia et al., (2008), India	Both	139.50	32.70	39.20
	Males			39.00
	Females			39.40
Hoaglund and Low, 1980 (Chinese)	Both	135.00		
Hoaglund and Low, 1980 (England)	Both	136.00		
Tahir et al (2001), North-eastern Nigeria	Males	136.70		
	Females	126.65		
Udoaka and Agi (2010), South-southern Nigeria	Males	132.00		
	Females	130.20		
Singh et al., (1986), South-eastern Nigeria	Males	132.80		
	Females	126.65		
Present study (South- south Nigeria)	Both	133.42	32.23	39.93
	Males	135.00	31.30	39.23
	Females	132.16	33.30	40.82

DISCUSSION

Anatomical variations in the parameters of the articulating bones of the hip joint do exist among different races. The development of radiography has helped in detailed anatomic study of the hip joint. Radiographs were used to make quantitative analysis of three angular parameters (Center edge angle (CEA), Acetabular angle of Sharp (AAS) and femoral neck shaft angle (FNSA) of the adult hip joint in this radiogrammetric study.

The mean value of the femoral neck shaft angle obtained in this south-southern Nigerian study varies with that obtained by researchers on Non-Nigerian populations showing considerable racial variation in this angle. This finding is in accord with outcome of earlier researchers[3,9-13] which stated the existence of population based differences. Besides, the mean value of FNSA reported in this study varies with that reported by other researchers on different regions (South-east[11] and North-east[12]) of Nigeria. The difference therefore suggest that regional variation exist in femoral neck shaft angle, which could be due to several factors including hereditary, dietary, climatic and other cultural attitudes affecting postures. Sexual dimorphism has been reported by several authors[9-13] in the mean values of the femoral neck shaft angle (FNSA) with the females having a smaller angle. In the present south-southern Nigerian study, the mean femoral neck shaft angle observed was higher in males. The difference in mean was statistically significant ($p<0.05$). This is in agreement with those of earlier workers[9-13] that have also shown higher values in males than females. The smaller femoral neck shaft angle observed in females has been adduced to their wider pelvis, greater bicondylar angle and shorter length of femur[7]. Moderate correlation was found to exist between neck shaft angle and the centre edge angle, acetabular angle.

In this study, the mean centre edge angle for the south-southern Nigeria population obtained varies with that of other populations. The difference in the mean value of the center edge angle in this study and others stated in this study reveal that racial variations exist. This conforms to the findings of Saikia *et al.*[9]. The CE angle was significantly higher ($P<0.005$) in females than in males, showing this angle as sexually dimorphic. The CE angle correlated positively with the neck shaft angle of the femur.

In the present south-southern Nigerian study, the mean value of the acetabular angle of sharp obtained varies with that stated by other researchers[18,20-22] for other populations thus buttressing the existence of population based variation in articulating bones of the hip joint. Results from this study also reveal that males have higher values than females. The difference in mean acetabular angle of males and females was found to be statistically significant ($p< 0.05$). This is in line with findings of other researchers[9,20,22] confirming the existence of sexual dimorphism. The acetabular angle showed small positive correlation with the femoral neck shaft angle and negative correlation with the centre edge angle.

In conclusion, we state that inter-population and intra-population based differences exist in the femoral neck shaft angle, centre edge angle, and acetabular angle of sharp. Besides, sexual dimorphism and correlation exist in the parameters studied. We recommend the utilization of the normative values provided in this study by anthropologic and forensic anatomist, radiologist, orthopaedic surgeons and makers of orthopaedic implants and screws when considering the study population. Besides, we recommend the findings of this study as a research tool for further research and to investigate the effectiveness of these parameters in sex determination. This study has provided normative values of the measured parameters for the south-southern Nigerian population.

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