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Ultrasonographic Assessment of the Asymptomatic Neonatal Hip Joint at the University of Benin Teaching Hospital, Benin City

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Abstract

Background

The hip joint is a major weight-bearing joint that enables standing, walking, and running. In neonates, Hip abnormalities in neonates can reflect neuromuscular or intrauterine problems. Improper positioning can deform the acetabulum and predispose to developmental dysplasia of the hip (DDH). Early asymmetry or instability warrants further evaluation. The aim of this study was to determine the acceptable normal ranges of acetabular angles (α and β) and percentage femoral head coverage in neonates for clinical practice in our environment, and to note variations between the left and right neonatal hip joints.

Methods

This study investigates the sonographic characteristics of the normal neonatal hip joint, conducted at the Department of Radiology, University of Benin Teaching Hospital, Benin City. A prospective analysis was performed on the hip joints of 384 randomly selected neonates, who were examined with a 6.5 MHz sector-array transducer on a Sonoace ultrasound scanner. Measurements of the alpha (α) and beta (β) angles, as well as femoral head coverage, were obtained and analyzed.

Results

The mean α angles for the right and left hips were 51.7 ± 0.3° and 51.9 ± 0.3°, respectively, while the mean β angles for the right and left hips were 47.3 ± 0.33° and 48.1 ± 0.3°, respectively. The mean percentage femoral head coverage was 46.3%±0.4% for the right hip and 46.9% ±0.4% for the left hip. This study also found a positive correlation between birth weight and gestational age, and between both acetabular angles and femoral head coverage. In contrast, the mode of delivery and birth presentation showed no significant correlation.

Conclusion

This study has established the upper and lower threshold values for the α and β angles and the percentage of femoral head coverage. These values were found to be consistent with Caucasian reference values used for comparison. Additionally, the correlative analysis revealed a positive correlation between acetabular angles and femoral head coverage, whereas a negative correlation was observed between the α and β angles.

1 Introduction

The hip joint is a major weight-bearing joint essential for standing, walking, and running [1]. In neonates, proper alignment of the femoral head and acetabulum is crucial for normal mechanical development [1]. Early abnormalities in this alignment can disrupt gait and posture, potentially leading to long-term complications in adulthood [1]. Hip abnormalities in neonates may indicate underlying neuromuscular or intrauterine issues, such as cerebral palsy, oligohydramnios, or breech presentation [2]. Improper positioning during gestation can deform the acetabulum and predispose the infant to developmental dysplasia of the hip (DDH) [2]. Early detection of hip joint asymmetry or instability warrants further evaluation to prevent long-term functional impairment [2]. The transformation of the neonatal cartilaginous acetabulum into an osseous cavity is dependent on the coordinated growth of the metaphysis and proper positioning of the femoral head. Any defects in the acetabular roof, coupled with femoral head displacement, result in an abnormal anatomical relationship that can lead to additional deformities. Timely identification of incoordinate hip joints in neonates is essential for effective management and improved prognosis. In many settings, including our own, neonatal hip ultrasound is not routinely used in clinical practice, and there are currently no established reference values for this procedure. Nonetheless, there is a pressing need to standardise this diagnostic tool and establish normal reference values to ensure reliable, reproducible assessments. Ultrasonography is a safe, non-invasive method, suitable for both initial evaluation and repeated follow-up examinations [3–6]. In the early 1980s, hip ultrasound emerged as a diagnostic tool for assessing the neonatal hip, and it is now widely employed to obtain detailed images of both the bony and cartilaginous structures of the hip joint, including its dynamic movements [3–6]. Ultrasound is particularly valuable for evaluating cartilaginous structures, making it ideal for studying conditions specific to the developing child [3–6]. Additionally, it avoids the use of ionising radiation, contrast media, or sedation, and follow-up imaging can be performed even when the infant is wearing corrective devices such as traction, a cast, or a Pavlik harness [3–6]. Despite the widespread adoption of ultrasound for neonatal hip joint assessment, there remains no universal agreement on its role in clinical practice [7]. This study aims to provide baseline data on neonatal hip joint characteristics specific to the West African subregion, thereby encouraging the routine use of ultrasound in assessing neonatal hip health.

2 Materials and Methods

2.1 Study designs and settings

This prospective study was conducted to assess the sonographic findings of the normal neonatal hip joint at the Immunisation Clinic, Postnatal Lying-in Wards, and the Ultrasound Unit of the Radiology Department at the University of Benin Teaching Hospital, Benin City, Edo State, from January 2010 to December 2010.

2.2 Study Population and Inclusion/Exclusion Criteria

A total of 384 neonates were examined during the study period. The study participants were randomly selected normal-term neonates aged 1 to 28 days, born at the University of Benin Teaching Hospital. Both male and female neonates from mothers residing in neighbouring states (Edo, Delta, Ondo, and Ekiti) were included. Only neonates whose parents provided written informed consent were included in the study. Neonates with abnormal physical findings on hip examination, such as positive Ortolani or Barlow signs, limitation of hip movements, lower limb anomalies, or neurological defects affecting locomotion (e.g., cerebral palsy), were excluded from the study.

2.3 Sample Size Calculation

The sample size was calculated using Cochran's formula: N = (Z/E) ²(P)(1-P), where a confidence level of 95% (Z = 1.96) and a tolerable error (E) of ± 0.05 were assumed. Since the incidence (p) was unknown, a maximum value of p = 0.5 was used to maximise p(1-p), yielding a sample size of 384. Given that the estimated annual number of neonates born at the University of Benin Teaching Hospital is approximately 2,200, and the total population of neonates delivered annually is less than 10,000, finite population correction was applied using the formula: Nf = n/ (1 + n/N). This yielded a minimum required sample size of 327, with 384 subjects selected to enhance precision, account for potential non-responses, and expand the study's scope.

2.4 Data Collection

Before the ultrasound examination, biometric parameters, including age, sex, and weight, were recorded. A detailed perinatal history, including gestational age at delivery, mode of delivery, and presentation at birth, was obtained. A thorough physical examination was performed to exclude hip instability.

2.5 Ultrasonographic Assessment

Ultrasonographic assessments were conducted by the researcher under supervision to minimise inter-observer variability. A 6.5 MHz sector transducer of a Sonoace 1500 ultrasound machine (Medison Inc., Korea, 1994) was used to perform the scans. The neonates were placed in the supine position on the examination couch, with assistance from the parents or an assistant to ensure immobility. Static scans were performed using Graf's technique, with both hips examined. The infant's pelvis was aligned flat, and the coronal/neutral view of the hip joint was obtained with the hip and knee extended, and the transducer positioned at a 90-degree angle to the femur. Acetabular angle measurements (α and β angles) were taken from static images using a protractor. Each measurement was repeated three times, and the average value was used to minimise error. The acetabular depth and labral position were assessed by drawing a line parallel to the ossified lateral wall of the ilium (iliac line or baseline), extending through the head of the femur. The α angle, formed by the intersection of the baseline and the bony roof line, and the β angle, formed by the intersection of the baseline and the cartilage roof line, were measured. Two additional straight lines were drawn parallel to the iliac line: one tangent to the lateral part of the femoral head and the other tangent to the junction of the medial part of the femoral head and the acetabular fossa. Femoral head coverage was calculated using the formula: $100D_1/D_2$, where D_1 is the distance between the iliac line and the deepest point of the acetabular fossa, and D_2 is the distance between the deepest point of the acetabular fossa and the most lateral point of the femoral head (Figs. 1 and 2).

2.6 Statistical Analysis

Descriptive statistics were calculated for all variables. Pearson's correlation coefficient was used to assess relationships between birth weight, gestational age, and the measured parameters. Chi-square tests were used to evaluate associations between categorical variables and hip measurements.

3 Results

3.1 Demographic Characteristics

The age and sex distribution of the 384 neonates included in this study is presented in Figure 3. Of the total subjects, 206 (53.6%) were male, and 178 (46.4%) were female. The mean age was 15.2 ± 0.4 days, with a median age of 13.5 days and a mode of 11 days. The frequency

distribution of birth weights among the neonates showed that 2.6% were very low birth weight, 5.5% low birth weight, and the majority, 84.1%, had normal birth weight. Only 7.8% of the neonates were categorised as large for gestational age. The mean birth weight was 3.26 ± 0.40 kg, with a median weight of 3.00 kg and a mode of 3.00 kg.

Figure 3: Bar chart showing age-sex distribution of neonates

3.2 Acetabular Angles and Femoral Head Coverage

Table 1 presents the range, mean, median, and standard deviation of the right acetabular angles for male and female neonates across different age groups. Table 2 presents the same measurements for the left acetabular angles. Table 3 presents the femoral head coverage measurements for both right and left hips across age groups.

Age group (days)	RIGHT ALPHA ACETABULAR ANGLES (DEGREES)							
	Range		Mean		Median		Standard Deviation	
	Male	Female	Male	Female	Male	Female	Male	Female
0-5	45.0-60.0	45.0-60.0	50.2	54.5	50.0	56.0	5.4	4.5
6-11	45.0-62.0	45.0-60.0	51.6	52.0	51.0	53.0	4.9	4.3
12-17	45.0-65.0	45.0-60.0	51.2	51.0	52.0	50.0	5.4	5.5
18-23	45.0-72.0	45.0-58.0	53.8	52.1	54.0	53.5	5.7	4.4
24-29	45.0-65.0	45.0-60.0	50.6	51.4	49.0	51.0	6.0	4.9
RIGHT BETA ACETABULAR ANGLES (DEGREES)								
0-5	32.0-55.0	27.0-55.0	46.0	44.2	48.0	45.0	6.7	8.7
6-11	35.0-55.0	32.0-55.0	48.9	46.8	50.0	49.0	5.1	6.2
12-17	35.0-55.0	32.0-55.0	48.3	48.8	50.0	49.5	5.5	5.2
18-23	35.0-55.0	27.0-55.0	48.1	47.9	50.0	50.0	5.7	7.5
24-29	32.0-55.0	27.0-55.0	44.6	44.8	47.5	46.0	7.2	8.0

Table 1: The range, mean, median, and standard deviation of the left acetabular angles for male and female neonates.

Age group (days)	LEFT ALPHA ACETABULAR ANGLES (DEGREES)							
	Range		Mean		Median		Standard deviation	
	Male	Female	Male	Female	Male	Female	Male	Female
0-5	45.0-58.8	49.0-80.0	50.0	56.6	50.0	56.0	4.7	9.2
6-11	45.0-62.0	30.0-70.0	51.2	51.1	51.8	49.0	5.1	7.7
12-17	45.0-60.0	45.0-70.0	51.8	52.3	54.0	53.7	5.1	5.6
18-23	45.0-62.0	45.0-60.0	49.4	51.7	46.3	53.0	5.4	4.7
24-29	45.0-60.0	30.0-80.0	51.8	53.8	52.9	52.6	4.7	9.3
LEFT BETA ACETABULAR ANGLES (DEGREES)								
0-5	32.0-55.0	27.0-55.0	46.0	44.2	48.0	45.0	6.7	8.7
6-11	35.0-55.0	32.0-55.0	49.0	46.8	50.0	49.0	5.1	6.2
12-17	35.0-55.0	32.0-55.0	48.3	48.8	50.0	49.5	5.5	5.2
18-23	35.0-55.0	27.0-55.0	48.2	47.9	50.0	50.0	5.7	7.5
24-29	32.0-55.0	27.0-55.0	44.6	44.8	47.5	46.0	7.2	0.0

Table 2: The range, mean, median, and standard deviation of the right and left hip femoral head coverage for male and female neonates.

The range, mean, median, and standard deviation of the right and left hip femoral head coverage for male and female neonates.

Age group(days)	RIGHT HIP FEMORAL HEAD COVERAGE(PERCENTAGE)							
	Range		Mean		Median		Standard Deviation	
	Male	Female	Male	Female	Male	Female	Male	Female
0-5	38.5-59.0	27.0-53.0	47.5	42.9	48.0	42.5	6.8	7.6
6-11	36.0-75.0	38.0-64.0	48.4	45.23	50.0	44.0	8.2	6.8
12-17	36.0-75.0	36.0-64.0	48.4	45.5	47.0	44.5	10.4	6.0
18-23	38.5-80.0	27.0-64.0	48.9	45.0	45.0	43.0	10.2	8.1
24-29	36.0-58.0	27.0-55.0	46.0	41.8	47.0	43.0	6.4	5.9
LEFT HIP FEMORAL HEAD COVERAGE(PERCENTAGE)								
0-5	33.4-61.1	33.3-60.0	47.5	47.8	50.0	48.7	7.9	7.8
6-11	35.0-64.0	33.0-64.0	47.2	44.5	45.0	43.0	8.0	7.2
12-17	36.0-80.0	36.0-67.0	47.0	47.2	43.0	46.0	10.0	7.8
18-23	35.7-64.0	33.3-62.5	45.1	46.0	43.8	45.5	7.9	7.7
24-29	35.0-80.0	38.0-67.0	49.0	50.1	47.0	50.0	9.9	7.9

Table 3 summarises the mean, median, and mode values for the acetabular angles and percentage femoral head coverage of both the right and left hips in all the neonates included in the study. The mean α angles for the right and left hips were 51.7±0.3° and 51.9±0.3°, respectively, while the mean β angles for the right and left hips were 47.3±0.33° and 48.1±0.3°, respectively. The mean percentage femoral head coverage was 46.3%±0.4% for the right hip and 46.9%±0.4% for the left hip (as shown in Table 4).

Parameters	Acetabular angles (degrees)				Femoral head coverage (%)	
	Right alpha	Left alpha	Right beta	Left beta	Right	Left
Mean ± SD	51.7 ± 0.3	51.6 ± 0.3	47.3 ± 0.3	48.1 ± 0.3	46.3 ± 0.4	46.9 ± 0.4
Median	52.0	52.6	49.0	50.0	45.0	46.0
Mode	45.0	45.0	50.0	50.0	40.0	40.0

Table 4 Mean values of neonatal acetabular angles and femoral head coverage.

3.3 Correlation Analysis

Figure 4 presents a combined scatter plot illustrating Pearson's correlation coefficient (r) between birth weight and the α acetabular angles of both the right and left hips. The analysis shows a negative correlation between birth weight and the right α acetabular angle ($r = -0.055$, $p < 0.05$), while a positive correlation is observed between birth weight and the left α acetabular angle ($r = 0.032$, $p = 0.02$).

Figure 4 Scatter diagram of birth weight of neonates and right/left alpha acetabular angle

Figure 5 presents a combined scatter plot illustrating Pearson's correlation coefficient (r) between birth weight and the percentage femoral head coverage of both the right and left hips. The analysis shows a positive correlation between birth weight and the percentage femoral head coverage of the right hip ($r = 0.141$, $p = 0.005$), as well as the left hip ($r = 0.071$, $p = 0.00$).

Figure 5 Scatter diagram of birth weight of neonates and right/left femoral head coverage.

Tables 5, 6 and 7 present the relationship between acetabular angles, percentage femoral head coverage, and gestational age at delivery for both hip joints.

For α acetabular angles, most term and all post-term neonates had angles ranging between 50 and 59.9 degrees for both hips. In contrast, the majority of preterm neonates had α-acetabular angles of 30 to 39.9 degrees for the right hip and 40 to 49.9 degrees for the left hip. These findings were statistically significant ($\chi^2 = 61.50$, $p = 0.00$).

Regarding β acetabular angles, most preterm neonates had angles between 40 and 49.9 degrees, while the majority of term neonates had β angles between 50 and 59.9 degrees in both hips. Post-term neonates showed a more varied distribution, with angles spread between 30 and 39.9 degrees equally and between 50 and 59.9 degrees at the right hip. These results were also statistically significant ($\chi^2 = 22.96$, $p = 0.001$).

However, no statistically significant relationship was found between percentage femoral head coverage and gestational age at delivery (Table 7).

Table 5 NEONATES RIGHT AND LEFT ALPHA ACETABULAR ANGLE AND GESTATIONAL AGE AT DELIVERY

	Gestational age at delivery							
	Right hip			Total (%)	Left hip			Total (%)
Alpha acetabular angle (degree)	Pre-term	Term	Post-term		Pre-term	Term	Post- term	
30.00-39.99	10(40.0)	85(24.2)	0(0.0)	95(24.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
40.00-49.99	6(24.0)	76(21.6)	0(0.0)	82(21.4)	12(48.0)	119(33.9)	0(0.0)	131(34.1)
50.00-59.99	6(24.0)	148(42.2)	8(100.0)	162(42.2)	10(40.0)	207(59.0)	8(100.0)	225(58.6)
60.00-69.99	0(0.0)	41(11.7)	0(0.0)	41(10.7)	3(12.0)	24(6.8)	0(0.0)	27(7.0)
70.00-79.99	3(12.0)	0(0.0)	0(0.0)	3(0.78)	0(0.0)	1(0.3)	0(0.0)	1(0.3)
80.00-89.99	0(0.0)	1(0.3)	0(0.0)	1(0.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
Total (%)	**25(100.0)**	**351(100.0)**	**8(100.0)**	**384(100.0)**	**25(100.0)**	**351(100.0)**	**8(100.0)**	**384(100)**

c2=61.50, DF=10, P=0.00

Table 6 NEONATES RIGHT AND LEFT BETA ACETABULAR ANGLE AND GESTATIONAL AGE AT DELIVERY

BETA ACETABULAR ANGLE (DEGREE)	GESTATIONAL AGE AT DELIVERY							
	RIGHT HIP			TOTAL (%)	LEFT HIP			TOTAL (%)
	PRE-TERM	TERM	POST- TERM		PRE-TERM	TERM	POST- TERM	
20.00-29.99	0(0.0)	4(1.1)	0(0.0)	4(1.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
30.00-39.99	4(16.0)	41(11.7)	4(50.0)	49(12.8)	0(0.0)	26(7.4)	0(0.0)	26(6.8)
40.00-49.99	11(44.0)	133(37.9)	0(0)	144(37.5)	18(72.0)	134(38.2)	8(100.0)	160(41.7)
50.00-59.99	10(40.0)	173(49.3)	4(50.0)	187(48.7)	7(28.0)	188(53.6)	0(0.0)	195(50.7)
60.00-69.99	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(0.8)	0(0.0)	3(0.8)
Total (%)	**25(100.0)**	**351(100.0)**	**8(100.0)**	**384(100.0)**	**25(100.0)**	**351(100.0)**	**8(100.0)**	**384(100.0)**

2=22.96, DF=6, P=0.001

Table 7 NEONATES RIGHT AND LEFT FEMORAL HEAD COVERAGE AND GESTATIONAL AGE AT DELIVERY

Femoral head coverage (%)	Gestational age at delivery							
	Right hip				Left hip			
	Pre-term	Term	Post- term	Total (%)	Pre-term	Term	Post- term	Total (%)
20.00-29.99	0(0.0)	4(1.1)	0(0.0)	4(1.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
30.00-39.99	5(20.0)	47(13.4)	4(50.0)	56(14.6)	2(8.0)	42(12.0)	0(0.0)	44(11.4)
40.00-49.99	8(32.0)	176(50.1)	4(50.0)	188(49.0)	16(64.0)	175(49.8)	4(50.0)	195(50.8)
50.00-59.99	12(48.0)	103(29.4)	0(0.0)	115(30.0)	7(28.0)	95(27.1)	4(50.0)	106(27.6)
60.00-69.99	0(0.0.0)	15(4.3)	0(0.0)	15(3.9)	0(0.0)	36(10.2)	0(0.0)	36(9.4)
70.00-79.99	0(0.0)	4(1.1)	0(0.0)	4(1.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)
80.00-89.99	0(0.0)	2(0.6)	0(0.0)	2(0.5)	0(0.0)	3(0.9)	0(0.0)	3(0.8)
Total (%)	**25(100.0)**	**351(100.0)**	**8(100.0)**	**384(100.0)**	**25(100.0)**	**351(100.0)**	**8(100.0)**	**384(100)**

c^2=16.81, DF=12, P=0.157

There is no statistically significant difference between neonates' right and left femoral head coverage and gestational age at delivery.

Figures 6 and 7 illustrate the distribution of mean values for neonatal α angles, β angles, and percentage femoral head coverage in both hips, categorised by birth presentation and mode of delivery, respectively. Cross-tabulation analysis revealed no statistically significant differences in acetabular indices between birth presentation and mode of delivery.

Figure 6 BAR CHART SHOWING DISTRIBUTION OF MEAN VALUES OF NEONATES ALPHA ANGLES, BETA ANGLES AND PERCENTAGE FEMORAL HEAD COVERAGE WITH PRESENTATION AT DELIVERY

Figure 7 BAR CHART SHOWING DISTRIBUTION OF MEAN VALUES OF NEONATES ALPHA ANGLES, BETA ANGLES AND PERCENTAGE FEMORAL HEAD COVERAGE WITH MODE OF DELIVERY

Table 8 presents the correlation matrices for age, sex, acetabular angles, and femoral head coverage. The analysis reveals that percentage femoral head coverage is most strongly correlated with the left α angle ($r = 0.229$, $p < 0.05$) and the right β angle ($r = 0.235$, $p < 0.05$). It also shows a moderate correlation with age ($r = 0.112$, $p < 0.05$) and a weak, non-significant correlation with the left β angle ($r = 0.97$, $p > 0.05$).

Table 8 CORRELATION MATRICES OF THE VARIOUS PARAMETERS OF RESPONDENTS

Femoral Alpha angle coverage		**Beta angle head**							
		Age	**Sex**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
	Age	1							
	Sex	0.060**	1						
Alpha	**Right**	0.020**	0.022**	1					
angle									
	Left	0.320**	0.089**	0.136*	1				
Beta angle	**Right**	0.106**	0.054**	0.055**	0.257*	1			
	Left	0.150**	0.046**	0.004**	0.050**	0.167*	1		
Femoral	**Right**	0.068**	0.212*	0.200*	0.119*	0.106*	0.180*	1	
head									
coverage	**Left**	0.112*	0.044**	0.033**	0.229*	0.235*	0.097**	0.060**	1

*Correlation significant <0.05
**Correlation significant >0.05

4 Discussion

Developmental dysplasia of the hip (DDH) is the most common congenital musculoskeletal disorder of childhood and encompasses a continuum of abnormalities, including hip instability, acetabular dysplasia, and complete dislocation [10] [11]. Early recognition is critical, as untreated DDH may lead to residual dysplasia and early-onset osteoarthritis. Although routine clinical screening has effectively reduced the incidence of late-presenting DDH, it has not eliminated it entirely. In Nigeria, congenital hip dislocation is believed to be rare; however, few studies have explored the prevalence of other conditions within the DDH spectrum. Ali-Gombe et al. [12] reported that the prevalence of acetabular dysplasia among Nigerian men was comparable to that of British men (7% vs 8.2%), highlighting the need for further epidemiological data in local populations. Ultrasonography has been recommended since the early 1980s as an adjunct to clinical examination for evaluating neonatal hips. Its advantages include ease of use, absence of ionising radiation, and detailed visualisation of cartilaginous structures. Although no major differences have been noted between sector and linear scanners, higher-resolution probes (6.5–7.5 MHz) are preferable for neonates, particularly preterm infants [13]. In this study, all measurements were obtained with a 6.5 MHz sector transducer using the Graf method. Among the 384 neonates assessed, mean α-angles were 51.7° (right) and 51.6° (left), while mean β-angles were 47.3° and 48.1° respectively. Percentage femoral head coverage was 46.3% on the right and 46.9% on the left. No significant side-to-side differences were observed. Threshold values for α- and β-angles were within acceptable ranges for both sexes, with females showing slightly lower values. Femoral head coverage demonstrated a wide distribution (27–80% right; 33–80% left), consistent with findings by Morin et al. [14], who reported normal coverage between 33° and 78° with high specificity and elimination of false negatives. The α-angle values observed here were slightly lower than those reported by Zugler et al. [15] but higher than those documented by Matos et al. [16] in Brazil. Although

these variations fall within clinically acceptable limits, they may reflect interobserver variability or demographic differences between populations. Birth weight demonstrated a generally negative correlation with acetabular angles, except for a positive but likely incidental association with the left α-angle. The positive correlation between birth weight and femoral head coverage aligns with findings by Gunay et al. [17], reflecting the relationship between acetabular development and fetal maturity. As birth weight increases, so does femoral head coverage, consistent with improved maturation of the acetabulum. Gestational age also correlated positively with acetabular angles, further supporting its role as an index of fetal maturity and acetabular development. Neither mode of delivery nor fetal presentation showed a significant effect on acetabular angles or femoral head coverage in this cohort, though the relatively small number of caesarean and breech deliveries may limit this interpretation. Correlation analyses revealed that percentage femoral head coverage correlated most strongly with the left α-angle ($r = 0.229$, $p < 0.05$) and the right β-angle ($r = 0.235$, $p < 0.05$), and weaker with age and the left β-angle. These findings are consistent with those of Gunay et al. [17] and further support the interconnected relationship among acetabular morphology, femoral head coverage, and the developmental maturity of the hip joint.

5 Conclusions

This study established reference upper and lower threshold values for the α-angle, β-angle, and percentage femoral head coverage in a Nigerian neonatal population. These values showed good concordance with previously reported Caucasian data. Correlation analyses demonstrated that acetabular angles were positively associated with femoral head coverage but negatively associated with one another. Both birth weight and gestational age exhibited positive correlations with acetabular angles and femoral head coverage, whereas mode of delivery and birth presentation showed no significant influence. These findings contribute population-specific normative data that may enhance early diagnosis and evaluation of developmental dysplasia of the hip.

Declarations

Informed consent: Informed consent for treatment and open access publication was obtained or waived by all participants in this study.

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Ethical approval: All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee of the University of Benin Teaching Hospital, Benin City, Nigeria, and with the 1964 Helsinki Declaration and its later amendments, or with comparable ethical standards. Ethical approval for the study was obtained prior to commencement.

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:

Payment/services info: All authors have declared that no financial support was received from any organisation for the submitted work.

Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organisations that might have an interest in the submitted work.

Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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Figures

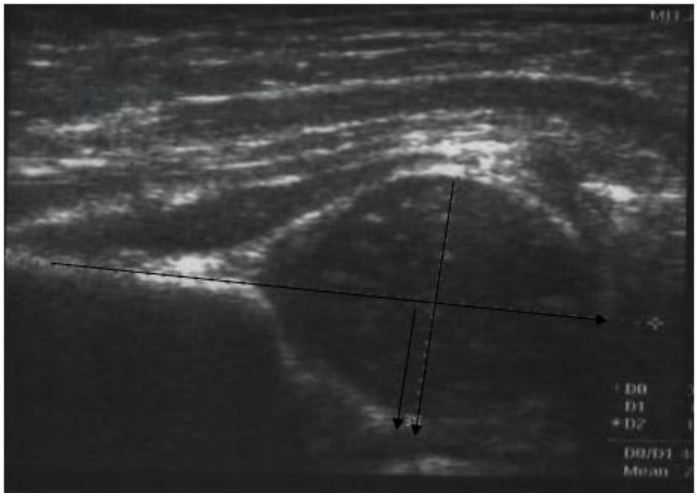


Figure 1

Figure 1 Ultrasonogram showing Femoral Head Coverage measurements

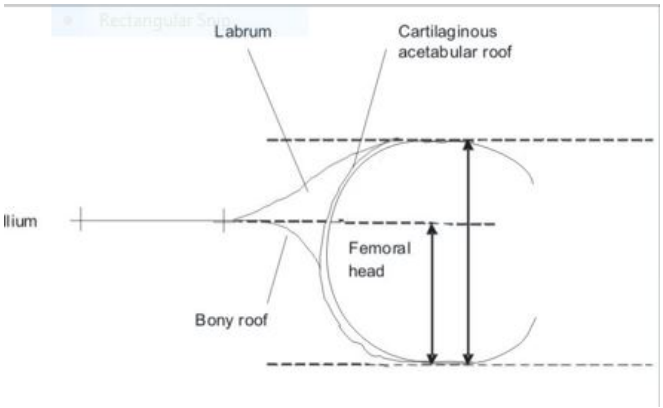


Figure 2

Figure 2: Line diagram showing Femoral Head Coverage measurements

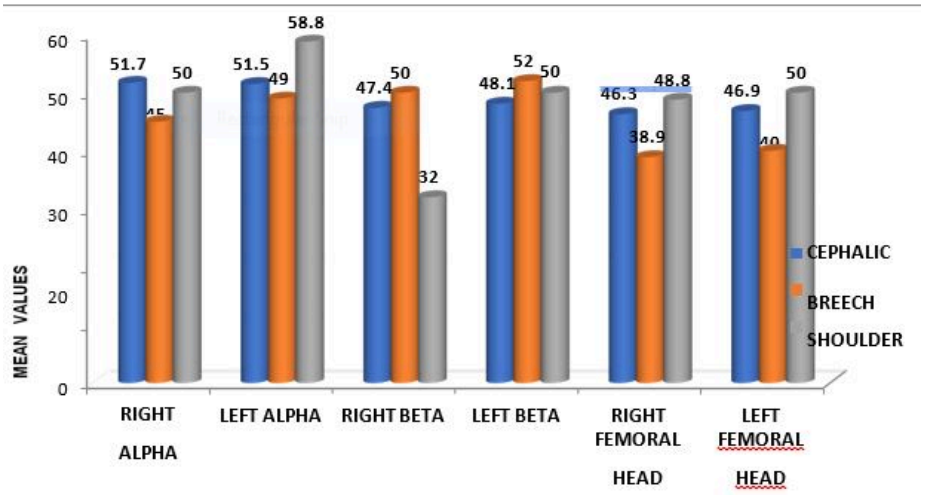


Figure 3

Figure 3: Bar chart showing age-sex distribution of neonates

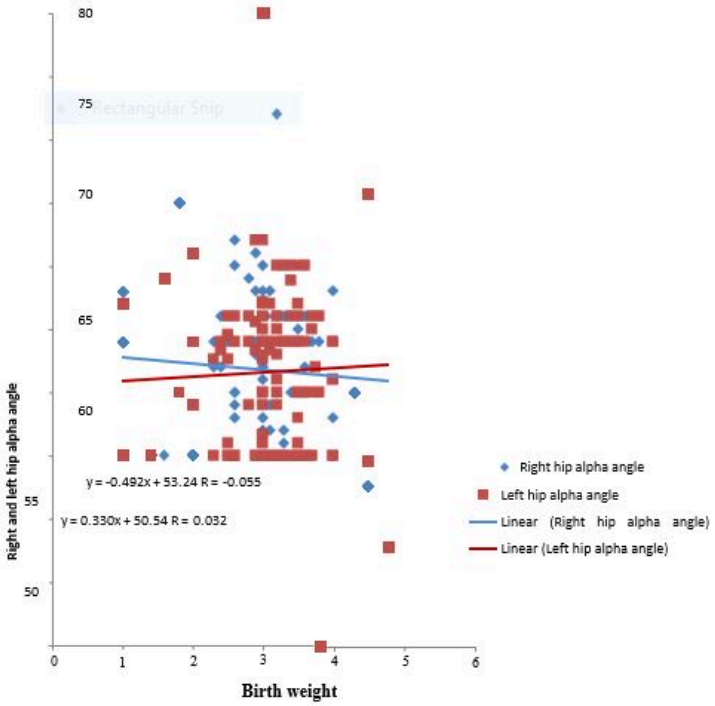


Figure 4

Figure 4Scatter diagram of birth weight of neonates and right/left alpha acetabular angle

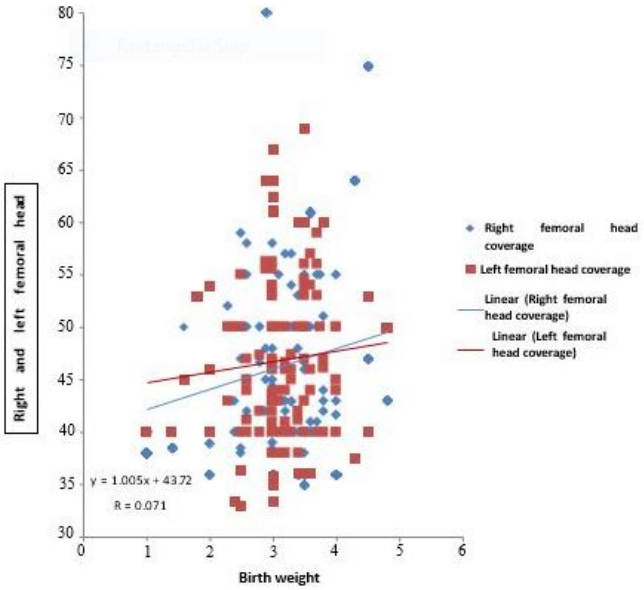


Figure 5

Figure 5 Scatter diagram of birth weight of neonates and right/left femoral head coverage.

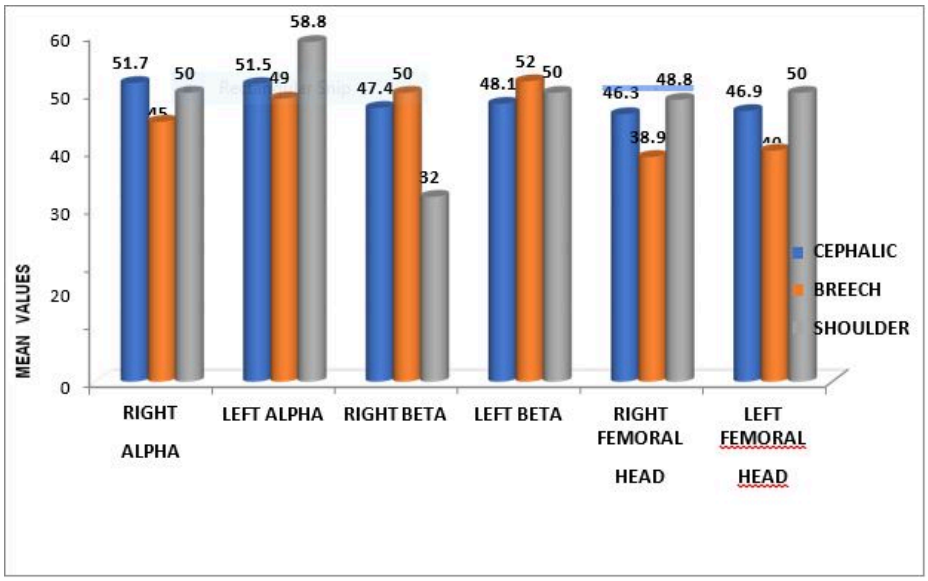


Figure 6

Figure 6 BAR CHART SHOWING DISTRIBUTION OF MEAN VALUES OF NEONATES ALPHA ANGLES, BETA ANGLES AND PERCENTAGE FEMORAL HEAD COVERAGE WITH PRESENTATION AT DELIVERY

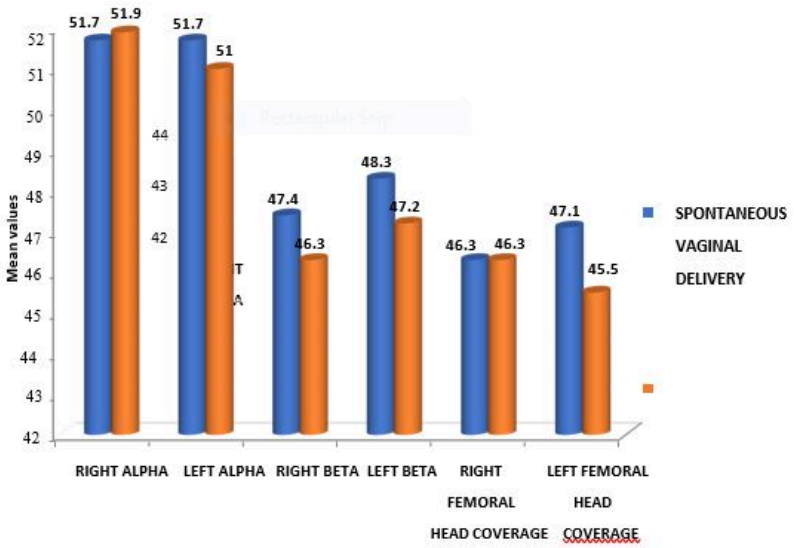


Figure 7

Figure 7 BAR CHART SHOWING DISTRIBUTION OF MEAN VALUES OF NEONATES ALPHA ANGLES, BETA ANGLES AND PERCENTAGE FEMORAL HEAD COVERAGE WITH MODE OF DELIVERY