ORIGINAL ARTICLE

Use of fetal biometry in the assessment of gestational age in South East Nigeria: Femur length and biparietal diameter

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Abstract

Background: Fetal growth is influenced by many factors such as race, socioeconomic status, genetics, geographical location, maternal diseases, and number of babies. Consequent upon these, fetal growth charts may vary from one location to another even within the same geographical entity.

Objective: This study was designed to establish the fetal growth chart in antenatal women who had ultrasound scanning at the University of Nigeria Teaching Hospital, Enugu, South East Nigeria.

Patients and Methods: This is a descriptive analysis of fetal biometric measurement of antenatal women. Four hundred and seventy pregnant women were studied.

Results: The nomogram for the femur length (FL) and biparietal diameter (BPD) for the different weeks of gestation (from 13th to the 40th week) were established. Correlation coefficients between gestational age and the various fetal parameters were also reported. Growth charts using both FL and BPD were plotted. A regression model for prediction of fetal age using the fetal biometry was also deduced for the studied population.

Conclusion: The fetal parameters used in this study were consistently smaller than reported values from European studies up to the 34th week of gestation after which a catch-up growth till the 40 weeks was observed. Fetal parameters observed in this study were larger than most of the reported Asian values.

Key words: Fetal biometry, gestational age, intrauterine growth curve, South East Nigeria, ultrasound

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Introduction

Monitoring of intra-uterine growth has remained a very important fetal surveillance tool in the care of pregnant women. Growth monitoring helps to pick out early cases of abnormal intrauterine growth pattern. This helps the clinician to institute timely interventions with a view to optimizing fetal outcome.

The introduction of ultrasound in Obstetrics made it easy for various fetal biometric parameters to be used to assess the fetus *in-utero* in different trimesters. The parameters include crown-rump length, abdominal circumference, femur length (FL) and biparietal diameter (BPD) amongst others. These parameters singly[1-5] or preferably in conjunction[6-9] are used to monitor intra-uterine growth, generate growth curves and as well, date pregnancies.

Accurate gestational age (GA) estimation will help the obstetrician avert cases of inadvertent premature delivery or to anticipate the delivery of a premature baby when it becomes inevitable. It also makes it easier to pick out cases

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of postmaturity. This will go a long way in reducing perinatal morbidity and mortality. Many pregnant women are either uncertain about their menstrual dates or have irregular menstrual cycles. Medico-legal implications of delivering premature, low birth weight and macrosomic babies can be far-reaching.

The aim of this study, therefore, was to establish reference charts and equation for BPD and FL from 13 to 40 weeks of gestation in South East Nigeria and compare them with published data from other population. Dependence on figures and equations from other parts of the world in our practice may lead to wrong estimation of GA in our babies.

Patients and Methods

This was a prospective cross-sectional study of pregnant women seen at the antenatal clinic and who had ultrasound scan at the Radiology Department of the University of Nigeria Teaching Hospital (UNTH), Enugu, a referral center for South East Nigeria. Data collection was from April 2009 to March 2010.

Four hundred and seventy pregnant women who met the inclusion criteria were selected for the study out of a total of 500 women recruited for this study. Only pregnant women at GAs 13–40 weeks and with singleton pregnancies were included in the study. Mothers with diseases likely to affect fetal growth such as hypertensive diseases, renal pathology, hemoglobinopathy, and diabetes mellitus were excluded as well as those unsure of their last menstrual date and babies with congenital malformations. Informed consent was gotten from all the participants. Ethical clearance was obtained from the ethical committee of the hospital.

Methods

Pregnant women attending antenatal clinic at the UNTH Enugu were sent for obstetric scan. Each patient was scanned once for the purpose of the study. The scan was done using a linear array real time ultrasound machine Siemens Sonoline 1 with a 3.5 MHz transducer. Two senior consultant staff did all the scanning.

Fetal head measurements were made in the plane where the continuous mid-line echo is broken by the cavum septi pellucidi, and taken from outer leading edge to the inner leading edge of the fetal skull (outer-inner).[10]

The FL was obtained by identifying the femur and aligning the transducer along the longest axis of the femur. A minimum of three measurements of FL from the greater trochanter to the femoral condyles was made. In the third trimester, care was taken not to include the distal femoral epiphysis.[1,2,11]

Cubic polynomial regression model ($y = a + b \times GA + c \times GA2 + d \times GA3$) was fitted to the two measurements (FL and BPD) as a function of GA. The models were chosen based on the correlation coefficient, R^2. We were able to assess the variability in measurements by computing the standard deviation (SD) at each week of gestation and SD values were regressed on GA using a simple linear equation ($y = a + b \times GA$). The 3rd, 5th, 10th, 50th, 90th, 95th, and 97th percentiles were generated from the data using the Software Package for Social Sciences (SPSS) software (SPSS Inc., Chicago, IL, USA).

To enable us compare our new biometric measurements with previously published studies from UK,[2] France,[12] Italy,[13] China,[14] and India,[15] we used the method described by Salomon *et al*.[12] By following this method, the 50th percentiles of these published works were calculated for each of the GAs 14–40 weeks by using their reference equations. The data were then expressed as Z-scores calculated with our reference equations using the formula: Z-score = (XGA − MGA)/SDGA, where XGA is data from these other population at a known GA, MGA is the mean value for our population calculated from the reference equations at this GA, and SDGA is the SD associated with the mean value at the same GA from our population. To enable visual comparison on these works, the results were presented graphically across the different GAs.

Data analysis

The resulting data were compiled, and descriptive and comparative analyses were carried out using the SPSS statistical package version 15.0 (SPSS Inc., Chicago, IL, USA). The statistical difference among groups was studied using Chi-squared tests.

Results

Out of the total of 500 participants recruited for the study, 6% (30) were excluded from the study and out of the 470 participants that met the inclusion criteria, only 460 pregnant women with complete data were used in the analysis of this work. The raw data were satisfactorily fitted to the GA in weeks (GA) using a cubic polynomial model [Figure 1]. Regression formula and their correlation coefficient (R^2) for both FL and BPD were derived as

$$FL = -48.449 + 5.705 \times GA - 0.105 \times GA^2 + 0.001 \times GA^3 \ (R^2 = 98.6).$$

$$BPD = -26.383 + 4.292 \times GA - 0.032 \times GA^2 + 0.00002375 \times GA^3 \ (R^2 = 98.8).$$

To illustrate the variability in measurement, the SDs of each week were computed and regressed on GA using a simple

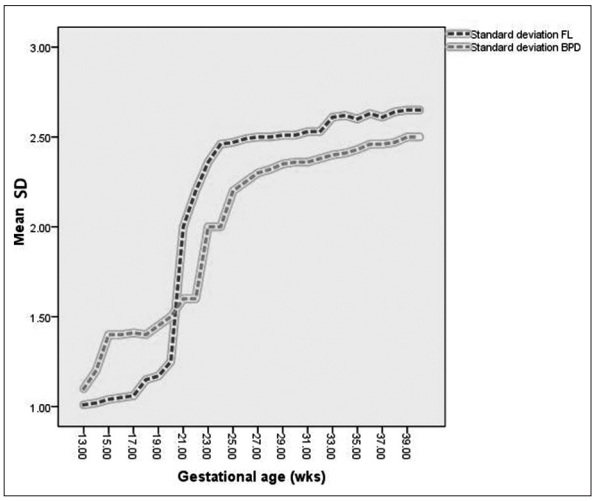

Figure 1: Plot showing the variability of the biometric parameters with gestational age in weeks

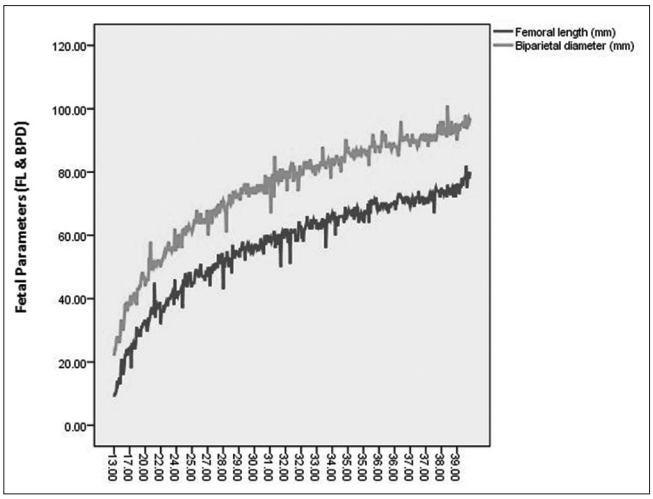

Figure 2: A graph of the raw data with gestational age fitted for both femoral length and biparietal diameter

Table 1: Fitted percentiles of BPD (outer-inner) (mm)

GA	*n*	SD	3rd	5th	10th	50th	90th	95th	97th
13.0	4	0.1	22.0	22.2	22.4	23.0	22.7	23.5.0	25.0
14.0	6	1.1	26.0	26.0	26.0	28.0	28.0	28.0	28.1
15.0	7	1.4	30.0	30.0	30.0	33.0	33.0	33.0	33.0
16.0	7	1.4	30.0	30.0	31.0	33.0	33.0	34.0	34.2
17.0	7	1.0	35.7	36.0	36.0	38.0	39.0	39.0	39.0
18.0	9	1.4	38.0	38.0	38.0	40.0	42.0	42.0	42.2
19.0	5	1.5	42.8	43.0	43.0	43.0	44.0	44.0	44.1
20.0	10	1.5	44.0	44.0	44.0	46.0	48.0	48.0	48.0
21.0	9	1.6	49.0	49.0	49.0	51.0	58.0	58.0	58.0
22.0	14	1.6	50.0	50.0	50.0	52.0	55.0	55.0	55.5
23.0	12	1.7	55.0	55.0	55.0	56.0	60.8	62.0	62.3
24.0	9	1.7	55.8	56.0	56.0	58.0	62.0	62.0	62.4
25.0	15	1.7	60.0	60.0	60.0	62.0	63.8	65.0	65.0
26.0	15	1.7	63.7	64.0	64.0	64.0	67.4	68.0	68.2
27.0	14	2.0	64.0	64.0	64.4	67.0	68.0	68.0	68.2
28.0	18	2.0	64.0	64.0	64.4	67.0	68.0	68.0	68.5
29.0	10	2.1	70.0	70.0	70.2	72.0	73.9	74.0	74.0
30.0	31	2.3	71.0	71.7	73.0	74.0	76.0	76.0	76.0
31.0	22	2.3	67.0	67.5	72.3	78.0	80.7	84.4	85.0
32.0	28	2.3	74.0	74.0	74.9	80.0	82.0	82.5	83.0
33.0	31	2.5	79.0	79.6	80.2	82.0	83.0	85.6	88.0
34.0	22	2.6	78.0	78.3	80.6	84.0	85.0	86.0	88.0
35.0	31	2.5	82.0	83.7	85.0	86.0	87.0	88.9	90.0
36.0	36	2.6	85.0	85.9	86.0	88.0	90.4	92.1	92.2
37.0	45	2.6	88.0	88.0	88.0	90.0	92.0	92.0	94.0
38.0	22	2.5	90.0	90.3	91.0	93.0	96.0	100.0	101.0
39.0	13	2.6	90.0	90.0	90.8	95.0	95.6	100.0	101.1
40.0	8	2.4	94.0	94.0	94.0	96.0	98.0	100.0	101.2

GA=Gestational age, BPD=Biparietal diameter, SD=Standard deviation

Table 2: Fitted percentiles of FL (mm)

GA	*n*	SD	3rd	5th	10th	50th	90th	95th	97th
13	4	1.02	9.6	9.6	9.8	10.0	10.1	10.4	11.2
14	6	1.09	14.0	14.0	14.0	14.5	15.0	15.0	15.0
15	7	1.06	15.7	16.0	16.0	18.0	21.0	21.0	21.0
16	7	1.05	18.0	18.0	18.0	20.0	21.0	23.0	23.0
17	7	1.06	22.0	22.0	22.0	24-0	24.0	24.0	24.3
18	9	1.13	23.5	24.0	24.0	25.0	28.0	28.0	30.0
19	5	1.00	27.6	28.0	28.0	29.0	30.0	30.0	30.4
20	10	1.25	30.0	30.0	30.0	32.0	33.9	34.0	34.2
21	9	1.30	34.0	34.0	34.0	36.0	45.0	45.0	45.4
22	14	1.20	32.0	32.0	34.0	37.0	46.0	47.0	47.0
23	12	1.19	37.8	38.0	38.0	40.0	44.8	46.0	46.3
24	9	1.74	37.0	37.0	37.0	42.0	45.0	45.0	45.1
25	15	1.67	44.0	44.0	44.0	45.0	48.0	48.0	48.0
26	15	1.65	44.0	44.0	46.0	48.0	49.8	51.	51.
27	14	1.91	44.0	44.0	46.5	47.0	50.0	52.0	52.2
28	18	2.0	44.7	45.0	47.5	52.0	54.1	55.5	55.5
29	10	2.25	53.0	53.0	53.0	54.0	56.8	57.0	57.0
30	31	2.35	53.0	53.3	55.0	56.0	59.7	66.2	66.5
31	22	2.35	53.9	54.0	56.0	58.5	60.7	67.0	67.1
32	28	2.51	54.0	54.1	58.0	61.0	63.1	67.7	67.7
33	31	2.61	59.6	59.6	62.0	64.0	66.8	70.0	70.0
34	22	2.62	60.4	60.4	63.3	66.0	67.0	67.0	67.0
35	31	2.50	64.0	64.0	64.2	67.0	69.0	69.4	69.6
36	36	2.53	67.0	67.0	68.0	70.0	71.2	72.1	72.1
37	45	2.72	68.4	68.4	69.0	72.0	73.0	73.6	73.6
38	22	2.73	71.9	72.0	72.0	74.0	75.0	80.6	80.6
39	13	1.71	72.0	72.0	72.4	76.0	78.0	81.0	81.0
40	8	2.85	74.7	75.0	75.0	78.5	82.0	82.0	82.4

FL=Femur length, SD=Standard deviation

linear equation ($y = a + b \times GA$). Our fits for SDs were as follows (all SD in mm and GA in exact weeks):

For FL: $SD = 0.225 + 0.071 \times GA$ ($R^2 = 76.9$).

For BPD: $SD = 0.551 + 0.55 \times GA$ ($R^2 = 88.6$).

Figure 1 illustrates the increase in variability of the measurements with GA. Tables 1 and 2 show the frequency table of the number of observations at each week and the percentile charts fitted for BPD (outer-inner) and femoral length, respectively. Table 3 shows a comparative analysis of the mean fetal parameters noted in this study with earlier documented reports.

Table 3: Comparative analysis of fetal femoral length and BPDs values

GA	FL this study	FL (Nigerian) Osinusi[3]	FL (Nigerian) Mador *et al.*[16]	FL (Indian) Shehzad *et al.*[15]	FL (UK) Chitty *et al.*[2]	FL (French) Salomon *et al.*[12]	FL (Chinese) Leung *et al.*[14]	BPD this study	BPD (Chinese) Leung *et al.*[14]	BPD (French) Salomon *et al.*[13]	BPD (Indian) Shehzad *et al.*[15]	BPD (Italian) Tinelli *et al.*[14]
13.0	10.00		14.60	9.50	11.00	12.09	9.12	24.00	23.01	29.66	22.50	32.02
14.0	14.21	15.20	16.30	12.38	14.10	15.08	12.46	27.20	26.32	31.75	25.25	35.22
15.0	18.25	17.40	19.00	15.18	17.10	18.05	15.71	32.00	29.65	34.04	28.09	38.46
16.0	20.25	20.50	22.90	18.73	20.50	21.00	18.85	33.07	33.00	36.52	32.36	41.74
17.0	23.14	24.60	25.00	21.90	22.70	23.92	21.91	38.00	36.36	39.15	36.00	45.04
18.0	25.11	27.30	29.00	24.80	26.90	26.81	24.87	39.78	39.72	41.92	37.87	48.35
19.0	29.00	30.70	31.60	27.55	29.80	29.67	27.74	43.00	43.07	44.81	40.73	51.67
20.0	31.00	33.70	33.50	30.20	32.20	32.48	30.53	46.30	46.40	47.79	44.10	54.96
21.0	37.80	36.40	36.70	33.10	35.40	35.25	33.23	51.78	49.69	50.85	47.90	58.24
22.0	38.36	40.10	38.70	35.13	37.20	37.98	35.86	55.00	52.95	53.95	50.19	61.47
23.0	40.40	42.00	41.10	38.31	40.60	40.66	38.40	57.00	56.15	57.08	55.06	64.64
24.0	41.44	44.50	43.80	41.50	43.50	43.28	40.87	58.67	59.30	60.21	58.25	67.76
25.0	45.67	47.50	46.20	43.63	46.10	45.85	43.26	62.07	62.37	63.33	61.38	70.79
26.0	47.87	50.10	49.10	45.42	46.90	48.35	45.58	64.87	65.37	66.41	63.50	73.73
27.0	49.14	52.30	50.90	47.70	50.20	50.80	47.84	66.53	68.28	69.42	66.00	76.57
28.0	51.61	54.50	53.60	49.86	52.40	53.17	50.03	67.00	71.08	72.35	67.86	79.30
29.0	54.30	55.20	55.40	52.40	56.30	55.48	52.15	72.30	73.78	75.18	70.60	81.89
30.0	56.94	57.40	58.30	54.79	56.00	57.70	54.22	74.38	76.36	77.88	73.93	84.34
31.0	58.32	58.90	60.30	57.50	59.70	59.85	56.23	77.41	78.81	80.42	75.71	86.64
32.0	60.21	61.10	62.10	60.40	61.30	61.92	58.18	79.50	81.13	82.80	77.33	88.77
33.0	63.80	63.00	64.10	62.14	62.80	63.91	60.07	82.19	83.29	84.98	81.10	90.72
34.0	65.41	64.20	66.20	63.08	64.30	65.80	61.92	83.32	85.30	86.94	82.02	92.48
35.0	67.00	66.5	68.50	65.85	66.20	67.60	63.72	86.13	87.14	88.66	84.20	94.03
36.0	68.00	68.2	68.50	66.59	68.30	69.31	65.47	88.41	88.80	90.12	84.80	95.36
37.0	70.47	69.9	70.60	68.14	69.90	70.91	67.18	89.77	90.28	91.30	87.07	96.47
38.0	75.00	71.3	71.70	69.14	70.80	72.41	68.85	93.33	91.55	92.17	85.86	97.33
39.0	75.46	72.6	73.90	71.78	71.70	73.80	70.47	94.08	92.62	92.71	88.17	97.93
40.0	78.79	74.8	76.70	72.00	74.70	75.09	72.07	96.0	93.48	92.90	89.75	32.02

GA=Gestational age, FL=Femur length, BPD=Biparietal diameter, SD=Standard deviation

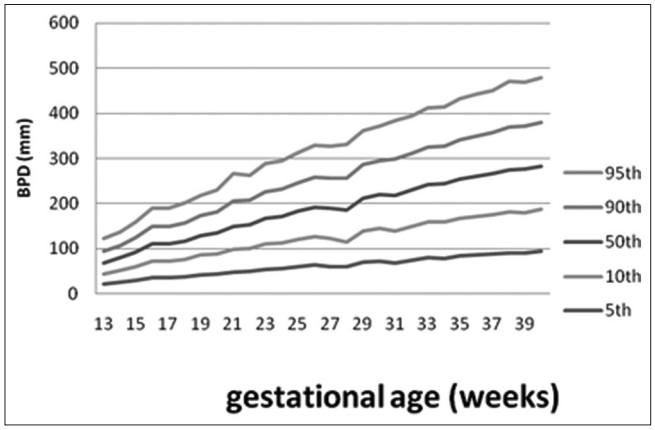

Figure 3: Raw data with fitted 5th, 10th, 50th, 90th, and 95th percentiles of gestational age by biparietal diameter

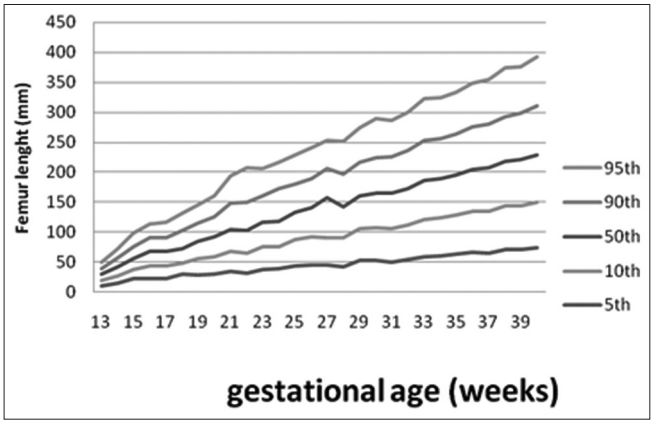

Figure 4: Raw data fitted with 5th, 10th, 50th, 90th, and 95th percentile of gestational age by femur length

Figure 2 shows a graph of the raw data with GA fitted for both femoral length and BPD. Figures 3 and 4 show the raw data for BPD (outer-inner) and femoral length, respectively, fitted with 5th, 10th, 50th, 90th and 95th percentile. The 5th, 10th, 50th, 90th, and 95th percentiles of BPD and FL were calculated from the reference equations of earlier published works.[2,3,12-16] Both biometric parameters were expressed as Z-scores. The Z-scores were plotted against GA in week, and the results have been presented graphically in Figures 5 and 6 for BPD and FL, respectively.

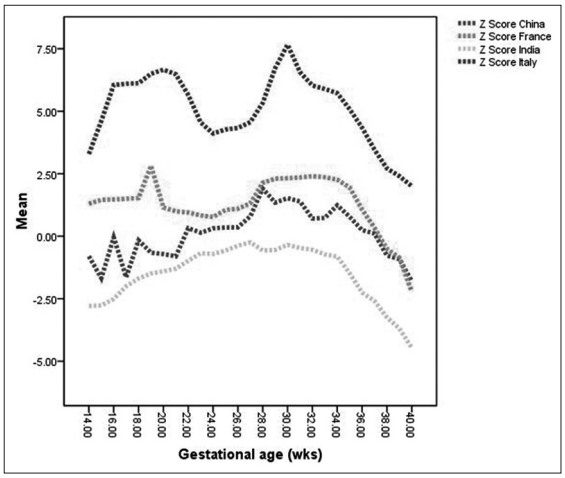

Figure 5: Comparison of our new equations on biparietal diameter with reference equations of previously published reports

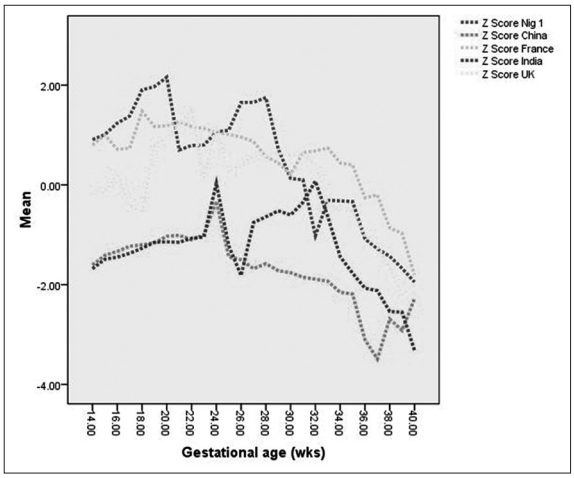

Figure 6: Comparison of our new equations on femur length with reference equations of previously published reports

Discussion

Fetal biometric measurements provide reliable information about fetal well-being, fetal growth, weight, and age. Growth of the fetus is a time-dependent change in body dimensions that occur through pregnancy.[15] Monitoring fetal growth is made easier when a reference interval is available. This study was undertaken to establish a reference interval and equation for our environment and compare our values with previously published works.

The frequency distribution of the participants [Tables 1 and 2] shows a low turnout in a number of pregnant women even up to the second trimester. This reflects unwillingness among the pregnant women in our environment to engage in early antenatal practices. The patients in this study were within 13–40 weeks of pregnancy. This interval corresponds to the period when most pregnant women in our environment start seeing their doctors and other health workers to start antenatal care. The fetal parameters that can reliably be measured at this time include FL and BPD.

The BPD measurement is most useful from 12th week of gestation upwards.[17-19] Its value is affected by the shape of the head. In abnormal head shapes, the cephalic index (CI) defined by the equation BPD × 100/occipito-frontal diameter is used. The CI ranges from 75% to 85%. It is lower in dolichocephalic fetuses and higher in brachycephalic fetuses. The accuracy of BPD in determining GA between 14 and 26 weeks is + 9 days is 95% of cases.[15] A biparietal growth chart has been produced by measuring from the outer leading edge to the inner leading edge (outer-inner) [Table 2 and Figure 1].

This study noted lower BPD and FL when compared to the reports of studies done in Uk,[2] in Italy,[13] in France,[12] but large fetal parameters in comparison with studies done in China[14] and India[15] [Table 3, Figures 5 and 6]. Our mean values compared with a similar British study[20] except that it appeared that fetuses in our study have bigger BPDs in early second trimester and late 3rd trimester. Variations in the growth of BPDs and femoral length have been reported by other researchers.[17] Racial as well as geographical factors may have some influence on these[14,21-24] as the methodology was similar in all these studies.

Femur length measurement is a useful parameter in the 2nd and 3rd trimesters of pregnancy. It increases linearly throughout pregnancy.[20,25-27] It is best measured after 14 weeks of pregnancy. The accuracy of GA determined from FL from 6 to 7 days of menstrual age is at 95% confidence level.[1]

The mean femoral length values in this study are similar to two earlier Nigerian studies done in two cities (Lagos and Jos) with different demographic characteristics.[3,16]

From our figures, we generated the charts and tables with a regression equation. For a given GA, this formula will also help to detect intra-uterine growth restriction and macrosomia and enable the obstetrician intervene appropriately.

Conclusion

We have been able to generate growth charts and an equation for monitoring growth and estimating GA based on a large sample of fetuses in South East Nigeria where many mothers are unsure of the date of their last menses and might be at risk of intra-uterine growth restriction. This we believe will guide antenatal caregivers from under-estimation or over-estimation of GA of our babies. We also observed that fetuses in our study have accelerated growth of their parameters in the last 4 weeks of gestation. Accuracy in measurement and resolution in these parameters are of immense importance.

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