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Reference charts of fetal biometric parameters in a group of healthy Nigerian women with singleton pregnancies

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Abstract
Background: Fetal biometric assessment is critical for optimal obstetric management as fetal growth abnormalities are associated with perinatal morbidity and mortality. We sought to ascertain normal third trimester fetal biometric parameters and develop growth charts in a Nigerian obstetric population.
Methods: A third trimester cross-sectional assessment of fetal biometric parameters at 2-weekly intervals from 28 -36 weeks and thereafter, weekly to 41 weeks' gestation. At each gestational age, 50 women were recruited and had ultrasound scan where fetal biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) were assessed and estimated fetal weight (EFW) calculated using Hadlock algorithm. SPSS version 20 was used to calculate the mean values and percentiles (5th, 10th, 50th, 90th, and 95th) for the parameters and corresponding reference charts developed using Microsoft Excel.
Results: The mean values and ranges of BPD and HC respectively among preterm fetuses were 81.6 ±2.1 mm (68.4 – 95.5) and 29.3 ± 0.7 cm (24.6 – 33.7) while that of term fetuses were 94.0 ± 2.8 mm (82.9 – 101.0) and 33.5 ± 0.8 cm (31.8 – 35.8). Mean values and ranges of AC, FL and EFW for preterm fetuses were 29.1 ± 1.1 cm (23.3 – 35.4), 63.0 ± 1.9 mm (51.4 – 74.7), 2.1 ± 0.2 Kg (1.10 – 3.48). Mean values and ranges of AC, FL and EFW for fetuses at term were 35.2 ± 1.2 cm (32.7 – 41.3), 74.4 ± 1.9 mm (69.6 – 79.5) and 3.6 ± 0.3 Kg (3.02 – 4.85). Reference charts for normal fetal growth were derived from 28 – 41 weeks' gestation.
Conclusion: Reference third trimester fetal growth charts were established and are useful tools for clinical management in this obstetric population.

Keywords: Fetal biometry, Biparietal diameter, Head circumference, abdominal circumference, Femur length, estimated fetal weight

Introduction

Fetal growth is a function of related interplay between multiple maternal, fetal and placental factors. Intra-uterine fetal growth assessment has largely been done by serial symphysiofundal height measurement which is often associated with inaccuracies and ineffective in detecting fetal growth abnormalities such as small or large for gestational age fetuses [1]. Modern obstetric imaging is mostly dependent on the use of ultrasound which is safe. Fetal biometry with the use of ultrasound provides reliable and important clinical information about the growth and wellbeing of the fetus [2, 3]. Detection of fetal growth disorders is often based on disparities between expected and actual biometric measurements at a particular gestational age [4, 5]. Hence accurate estimation of gestational age is essential in detecting growth abnormalities as well as determining the timing and mode of delivery and this help in avoiding unnecessary obstetric interventions [6]. Early and accurate detection of intrauterine fetal growth restriction and fetal macrosomia with institution of appropriate management may help in reduction of perinatal morbidity and mortality [7, 8]. Therefore, correct diagnosis of fetal growth abnormalities has implications for antenatal management of the patients as it influences determination of timing of delivery which at the end impacts on perinatal outcomes.

Fetal biometric measurement is an important part of modern obstetric care in the second and third trimesters of pregnancy. Several reference charts of fetal biometric parameters have been reported for different obstetric populations across the world [9-11]. These published charts are not applicable to all pregnant women inclusive of those in our environment as there are variations on fetal biometry in different ethnic groups [12-15]. To the best of our knowledge, no study to date has reported on normal fetal biometric parameters for singleton pregnancies in Jos, Nigeria. This research was therefore aimed at ascertaining the reference fetal biometric parameters among healthy pregnant Nigerian women attending antenatal care in our clinical setting as the outcomes may have implications for its clinical applicability in our obstetric population.

Materials and methods

This prospective observational study was conducted between January and December 2017 in the antenatal clinic of Bingham University Teaching Hospital, Jos among 500 healthy women with singleton pregnancies between 28 – 41 weeks' gestation. Fifty women each were recruited consecutively at 28, 30, 32, 34, 36, 37, 38, 39, 40 and 41 weeks of gestation after obtaining verbal consent for the study. Each woman was included once and the inclusion criteria were healthy pregnant women with singleton pregnancies who were sure of their last menstrual period and the gestational age corroborated with that of ultrasound dating done in the first half of pregnancy. Women with medical or obstetric disorders in pregnancy including hypertensive disorders, diabetes mellitus, suspected intra-uterine growth restriction, and fetal anomalies were excluded from the study. We routinely induce labor in women with pregnancy beyond 41 weeks' gestation in our center and so no woman at 42 weeks' gestation was studied.

For each woman, relevant socio-demographic and obstetric parameters were inquired, then ultrasound scan for fetal biometric assessment was done and findings documented in a proforma. All fetal sonographic assessments were done by the same Obstetrician to avoid inter-observer errors using portable Mindray(R) DP-2200 (Shenzhen Mindray Bio-medical Electronics Co Ltd, China 2010) 2-dimensional ultrasound machine with a Curvilinear 3.5 MHz transducer. The fetal biometric parameters assessed were biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) using standard published guidelines [16].

The BPD and HC were measured at the axial plane at the level where the continuous midline echo is interrupted by cavum septi pellucidi in the anterior third and both thalami could be symmetrically seen. Fetal BPD was measured as the outer-inner distance of the parietal bones in the midline. The HC was measured by placing the calipers over the landmarks for the outer-outer distance of the parietal bones in the midline and fitting a computer-generated eclipse to include the outer edges of the margins of the fetal skull. The AC was measured at the transverse section of the fetal abdomen where the stomach bubble could be seen. The antero-posterior diameter was measured with the calipers placed from the spine to the anterior abdominal wall and the computer-generated eclipse facility was used to assess the AC. FL was measured in a plane where the full femoral shaft was seen and the measurement was effected from one end of the shaft to another. The estimated fetal weight (EFW) was automatically computed from BPD, AC and FL by the ultrasound machine using Hadlock *et al* formula [Log10 Estimated Fetal Weight = 1.335 – 0.0034 × abdominal circumference × femur length + 0.0316 × biparietal diameter + 0.0457 × abdominal circumference +0.1623 × femur length] [17].

Data was analyzed with SPSS version 20 (IBM, Armonk, NY, USA), ascertaining the mean, standard deviation, and percentile values for BPD, HC, AC, FL AND EFW for each group of women (50) at the various gestational ages. Percentile values (5th, 50th and 95th) of each biometric parameter were plotted using Microsoft Excel 2010 (Microsoft, Redmond, WA, USA) for the different gestational ages. Approval for the study was granted by the Human Research and Ethics Committee of Bingham University Teaching Hospital, Jos.

Results

A total of 500 healthy pregnant women had ultrasound assessment between 28 – 41 weeks of gestation. The mean age of the women was 30.6 ± 5.4 years and about three-quarter of them were of gravidity 2-4. Most of the women were of Igbo (34.8%) ethnic group while Yoruba and Berom tribes constituted 15.9% and 14.6% respectively. Other tribes including Irigwe, Anaguta, Mwaghavul, Afizere, Idoma, Tiv, Eggon, Kataf, Sayawa, Kilba, Mupun, Ngas among others constituted 34.7% of the ethnic groups.

The mean biparietal diameter and head circumference among preterm fetuses were 81.6 ±2.1 mm and 29.3 ± 0.7 cm with ranges of 68.4 – 95.5 mm and 24.6 – 33.7 cm respectively. For fetuses at term (≥ 37 weeks), the mean biparietal diameter and head circumference were 94.0 ± 2.8 mm and 33.5 ± 0.8 cm with ranges of 82.9 – 101.0 mm and 31.8 – 35.8 cm respectively. Also, the mean abdominal circumference, femur length and estimated fetal weight for preterm fetuses were 29.1 ± 1.1 cm, 63.0 ± 1.9 mm, 2.1 ± 0.2 Kg and ranges of 23.3 – 35.4 cm, 51.4 – 74.7 mm, 1.10 – 3.48 Kg respectively. The mean abdominal circumference, femur length and estimated fetal weight for fetuses at term were 35.2 ± 1.2 cm, 74.4 ± 1.9 mm and 3.6 ± 0.3 Kg with ranges of 32.7 – 41.3 cm, 69.6 – 79.5 mm and 3.02 – 4.85 Kg respectively. Table 1 – 5 depict the means and percentiles values of the biparietal diameter, head circumference, abdominal circumference, femur length and estimated fetal weight respectively among the study population. Table 6 shows the normal reference values of the various fetal biometric parameters in the study population.

Table 1: Percentile values (mm) of fetal biparietal Diameter at various Gestational Ages

Gestational age (weeks)	Mean	Standard deviation	5th Percentile	10th Percentile	50th percentile	90th Percentile	95th Percentile
28	72.6	1.9	68.7	69.1	73.2	74.8	75.0
30	77.9	2.2	74.2	75.5	77.8	80.9	82.2
32	81.8	2.1	77.7	78.9	82.1	84.0	85.7
34	85.6	2.1	82.5	82.8	85.3	89.1	90.6
36	89.9	2.2	85.1	86.7	89.9	92.8	94.1
37	90.9	3.1	84.8	86.8	91.5	94.0	95.5
38	93.1	2.5	89.7	90.5	92.6	97.8	98.1
39	94.4	2.8	88.0	89.9	94.9	97.6	98.4
40	94.9	2.7	89.2	89.4	95.3	98.2	98.7
41	96.7	2.7	92.1	92.3	96.8	100.2	101.0

Table 2: Percentile values (cm) of fetal Head Circumference at various Gestational Ages

Gestational age (weeks)	Mean	Standard deviation	5th Percentile	10th Percentile	50th percentile	90th Percentile	95th Percentile
28	26.4	0.7	25.0	25.5	26.4	27.5	27.6
30	28.0	0.8	26.7	26.8	27.9	29.2	29.6
32	29.2	0.8	27.8	28.2	29.1	30.2	30.8
34	30.7	0.8	28.5	29.5	30.9	31.5	31.7
36	32.2	0.6	31.2	31.4	32.1	33.1	33.5
37	32.7	0.8	31.9	32.0	32.5	34.1	34.7
38	33.2	0.6	32.2	32.6	33.2	34.2	34.3
39	33.5	0.7	32.3	32.7	33.6	34.6	34.9
40	33.5	0.9	31.9	32.1	33.5	34.8	35.2
41	34.6	0.8	33.2	33.4	34.4	35.6	35.8

Table 3: Percentile values (cm) of Fetal Abdominal Circumference at various Gestational Ages

Gestational age (weeks)	Mean	Standard deviation	5th Percentile	10th Percentile	50th percentile	90th Percentile	95th Percentile
28	24.5	0.6	23.4	23.7	24.4	25.3	25.5
30	27.1	1.4	24.5	25.5	26.7	29.4	29.7
32	29.3	0.8	27.8	28.2	29.2	30.5	30.9
34	31.4	1.7	29.6	29.7	31.2	33.3	35.1
36	33.2	1.0	31.8	31.9	33.0	35.0	35.3
37	33.9	0.8	32.7	32.9	33.7	35.3	35.6
38	34.0	1.2	32.3	32.5	33.8	35.8	36.2
39	35.2	1.1	33.3	33.7	35.3	36.7	37.4
40	36.2	1.5	34.2	34.4	35.9	38.9	39.3
41	36.7	1.6	34.1	34.4	36.6	38.7	40.4

Table 4: Percentile values (mm) of fetal femur length at various Gestational Ages

Gestational age (weeks)	Mean	Standard deviation	5th Percentile	10th Percentile	50th percentile	90th Percentile	95th Percentile
28	54.5	1.6	51.6	52.3	54.6	56.6	56.9
30	59.1	2.5	53.9	56.5	59.2	63.1	64.7
32	62.8	1.7	59.3	60.7	62.7	65.1	66.2
34	67.3	2.0	63.4	64.5	67.3	70.1	70.5
36	71.1	1.9	68.4	68.7	71.0	74.4	74.6
37	73.0	2.1	70.0	70.4	72.8	75.9	77.0
38	73.0	2.0	68.8	70.7	73.1	75.7	76.3
39	74.8	1.6	72.3	72.6	74.7	76.7	78.1
40	75.1	1.9	71.8	72.2	75.4	77.7	78.4
41	75.9	2.0	72.7	73.4	76.0	78.6	79.2

Table 5: Percentile values (Kg) of Estimated Fetal weight at various Gestational Ages

Gestational age (weeks)	Mean	Standard deviation	5th Percentile	10th Percentile	50th percentile	90th Percentile	95th Percentile
28	1.28	0.09	1.11	1.15	1.29	1.39	1.42
30	1.70	0.19	1.45	1.49	1.66	2.00	2.08
32	2.05	0.20	1.64	1.85	2.04	2.32	2.48
34	2.53	0.31	2.07	2.15	2.54	2.92	3.21
36	3.04	0.21	2.68	2.79	3.02	3.36	3.44
37	3.24	0.16	3.03	3.05	3.21	3.46	3.64
38	3.35	0.25	3.02	3.06	3.28	3.80	3.83
39	3.59	0.20	3.27	3.38	3.60	3.93	3.98
40	3.72	0.32	3.26	3.33	3.64	4.25	4.41
41	3.84	0.36	3.20	3.45	3.76	4.26	4.66

Table 6: Normal ranges of fetal biometric parameters among the study population

GA	BPD (mm)	HC (cm)	AC (cm)	FL (mm)	EFW (Kg)
28	68.7 – 75.0	25.0 – 27.6	23.4 – 25.5	51.6 – 56.9	1.11 – 1.42
30	74.2 – 82.2	26.7 – 29.6	24.5 – 29.7	53.9 – 64.7	1.45 – 2.08
32	77.7 – 85.7	27.8 – 30.8	27.8 – 30.9	59.3 – 66.2	1.64 – 2.48
34	82.5 – 90.6	28.5 – 31.7	29.6 – 35.1	63.4 – 70.5	2.07 – 3.21
36	85.1 – 94.1	31.2 – 33.5	31.8 – 35.3	68.4 – 74.6	2.68 – 3.44
37	84.8 – 95.5	31.9 – 34.7	32.7 – 35.6	70.0 – 77.0	3.03 – 3.64
38	89.7 – 98.1	32.2 – 34.3	32.3 – 36.2	68.8 – 76.3	3.02 – 3.83
39	88.0 – 98.4	32.3 – 34.9	33.3 – 37.4	72.3 – 78.1	3.27 – 3.98
40	89.2 – 98.7	31.9 – 35.2	34.2 – 39.3	71.8 – 78.4	3.26 – 4.41
41	92.1 – 101.0	33.2 – 35.8	34.1 – 40.4	72.7 – 79.2	3.20 – 4.66

Figure 1 – 5 show the 5th, 50th, and 95th percentile values of the various fetal biometric parameters as well as depicting patterns of increase of each parameter with increasing gestational age. In all the parameters, there are increases as the gestational age increases and so they depict the growth pattern of the fetuses in this study population.

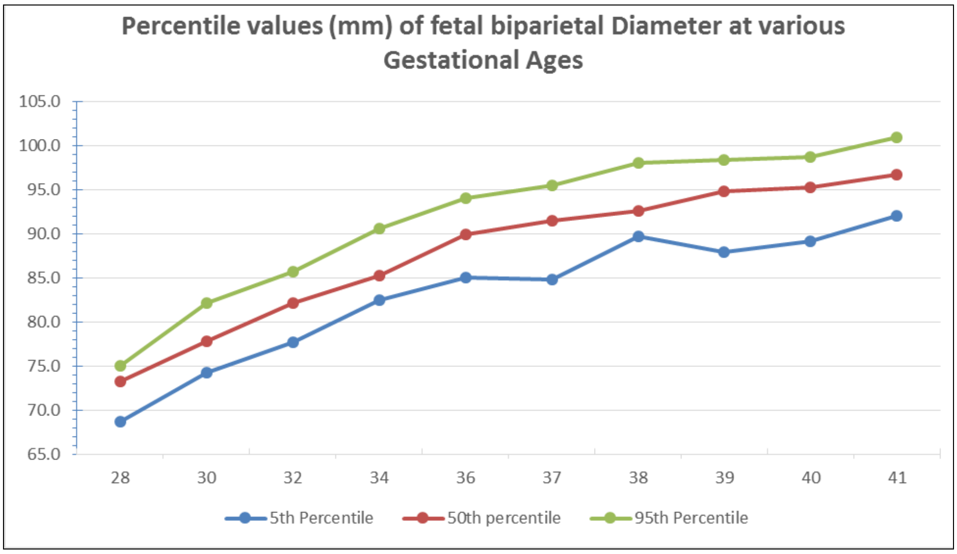

Fig 1: Pattern of increase in biparietal diameter among the study population

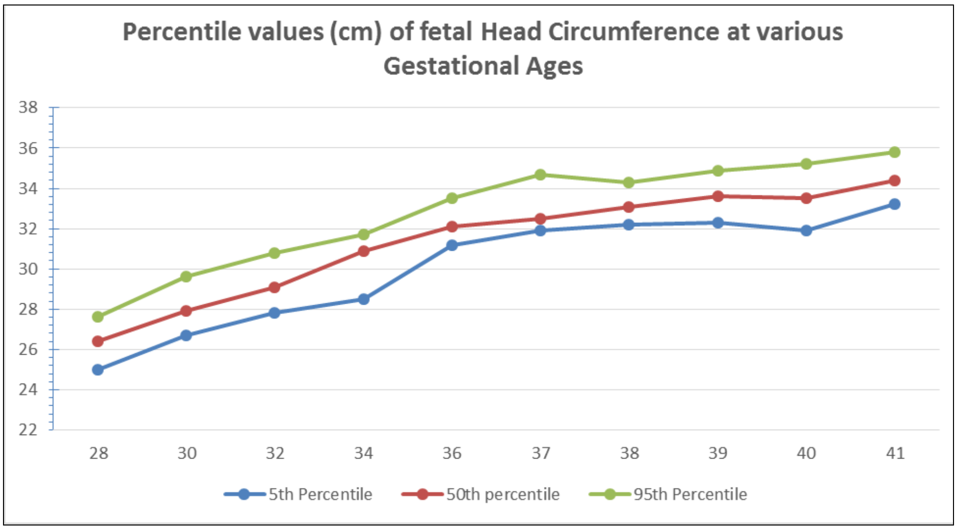

Fig 2: Pattern of increase in head circumference among the study population

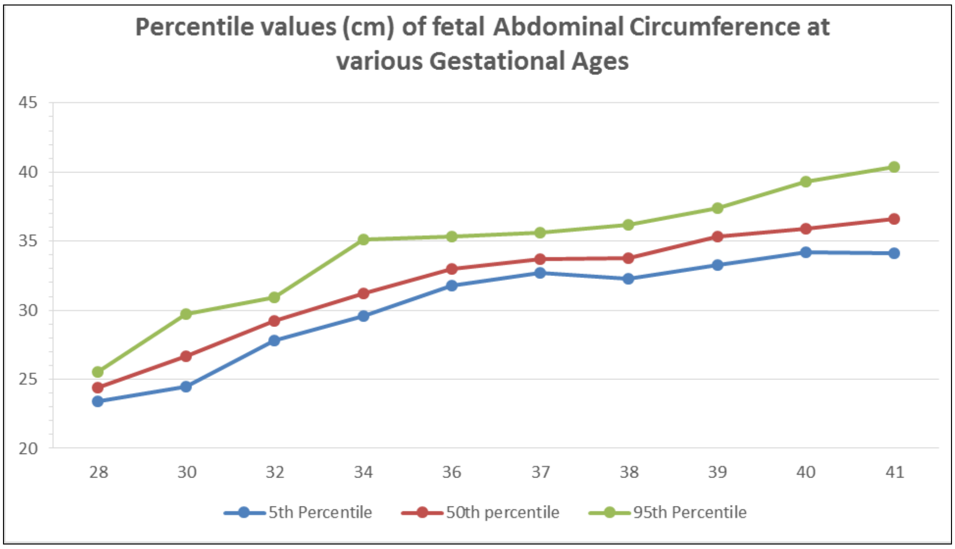

Fig 3: Pattern of increase in abdominal circumference among the study population

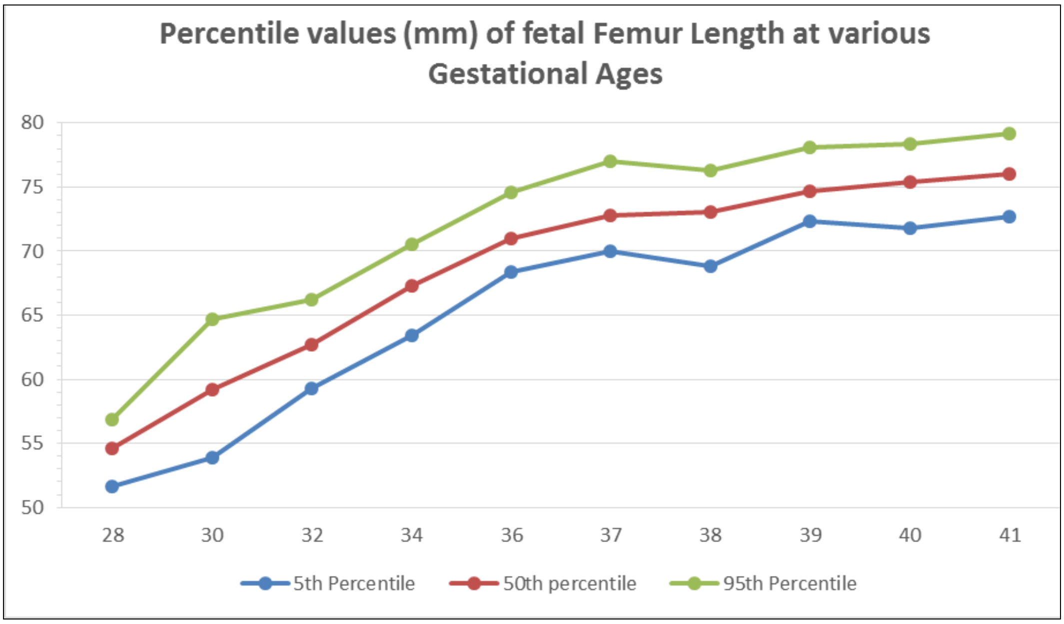

Fig 4: Pattern of increase in fetal femur length among the study population

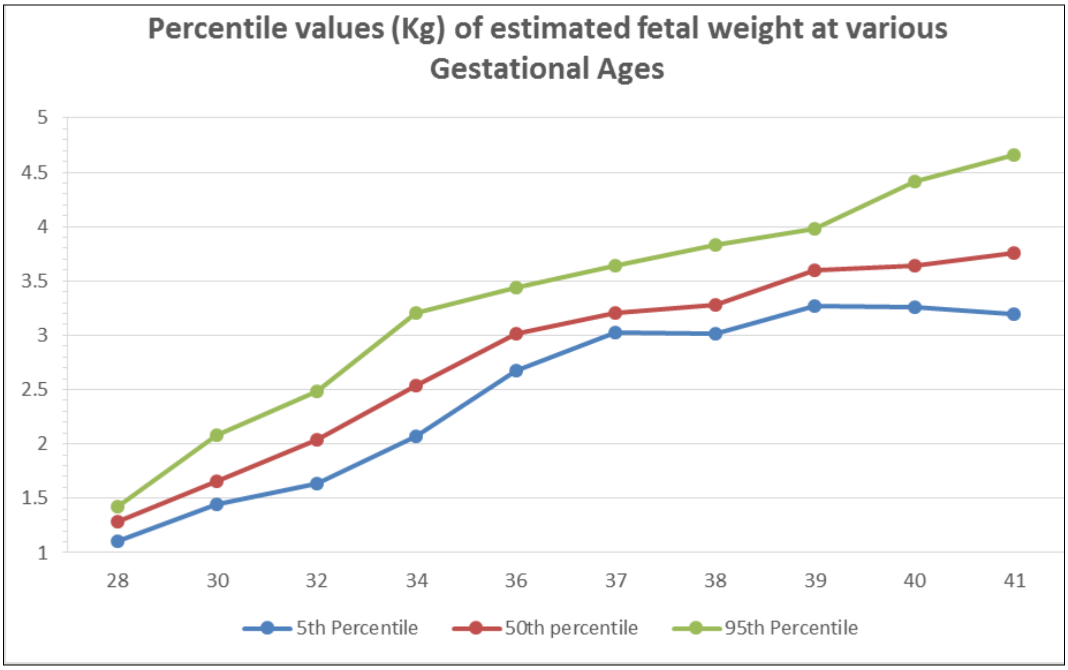

Fig 5: Pattern of increase in estimated fetal weight among the study population

Discussion

Accurate ultrasound fetal physical biometric measurements are essential in modern obstetric practice and it contributes to diagnosis of fetal growth disorders and so help in clinical decision making which positively impact on perinatal morbidity and mortality. In this study, we present the fetal growth biometric parameters in our obstetric population intended to be used as a reference in our clinical setting.

Fetal head biometric measurements are most clinically useful from second trimester of pregnancy [18]. In this study, we noted almost similar BPD values across gestational ages compared to reports from Brazilian and French obstetric populations but lower than figures reported from Italian women [9, 19, 20]. Our values are however higher across preterm gestational ages compared to the report from Enugu, Nigeria but become similar at term [21]. However, our HC values are almost similar from reported figures from Brazil and Nigeria [19, 21] across gestational ages in third trimester. These variations in fetal head biometric findings among the obstetric populations may be attributable to differences in ethnicity, races and study methodologies. Genetic variations among various ethnicity/races have been reported to play a major role in the rate of intrauterine fetal growth [12-15]. The obstetric population in Enugu, Nigeria may be more homogenous comprising mostly of the Igbo tribe compared to this study consisting of different ethnic groups. This may explain the differences in preterm fetal head biometric findings but the findings were almost similar at term, suggesting relatively same fetal growth at term among obstetric populations in Nigeria.

The 50th percentile values of AC obtained in this study at various gestational ages were generally higher compared to that in Brazilian populations [19, 22] (range 1.8 – 2.5 cm), but comparable to that of multinational study carried out by WHO [14]. Also, the values for femur length in our study were higher than that of Chinese and Brazilian populations [11, 19, 22] (range 2.3 – 2.8 cm) but slightly lower than figures reported by WHO multinational study group (range 0.8 – 1.5 cm) [14]. Racial differences in fetal biometric parameters at various gestational ages have been noted by different researchers [12, 23]. Generally, the Asian populations have smaller fetal biometric parameters compared to other populations [24, 25]. These differences could also be attributed to variations in fetal sex and parity of the obstetric populations as well as inter- or intra observer errors of the sonographers.

The estimated fetal weights (EFW) across gestational ages are noted to be higher than those reported from obstetric populations in Brazil (mean difference 230 – 490 grams) [19, 22] but closely similar across gestational ages to those reported by WHO multinational study group and figures from Binza Maternity Hospital, Kinshasha, Democratic Republic of Congo [26]. Our EFW values are slightly lower than those reported from United States of America and Norway [15, 27]. Similarities in EFW with that from DR Congo may be attributed to the fact that women in Africa have potentially same maternal health factors in pregnancy including nutritional deficiencies and infections such as malaria which in turn impacts on placental function and fetal growths. However, differences in EFW compared to Brazilian, American and European populations may be attributed to ethnic/racial factors as well as differences in study methodologies.

Limitations of the study include the use of two-dimensional imaging technique which seems to be inferior to 3-D imaging in other advanced health institutions. Also, the study was cross-sectional and probably a longitudinal assessment would have been more accurate in evaluating fetal growth. Other limitations are non-inclusion of pregnancies at 42 weeks of gestation and the fact that our study was conducted in an urban hospital-based setting and the results may not be generalizable to the general population. However, this study provides the first fetal biometric parameters for this hospital which will serve as reference for clinical management of obstetric patients in our environment.

In conclusion, we established reference fetal biometric parameters in our obstetric population and this can be used for assessment of fetuses at risk of intra-uterine growth restriction and fetal macrosomia in our clinical setting. The need for creation of local or regional fetal biometric normograms as useful clinical tools for optimal obstetric practice cannot be over-emphasized and this was accomplished for our clinical setting.

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Conflicts of interest: The authors declare no conflict of interest

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