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Fetal Biometric Charts and Reference Equations for Pregnant Women Living in Port Said and Ismailia Governorates in Egypt

Moustafa Hegab[1], Mahmoud Farouk Midan[2], Tamer Taha[3], Mamdouh Bibars[3], Khaled Helmi El Wakeel[4], Hesham Amer[3*], Osama Azmy[3]

[1]Obstetrics & Gynecology Department, Al-Azhar University, Cairo, Egypt; [2]Obstetrics & Gynecology Department, Al-Azhar University, Damietta, Egypt; [3]Reproductive Health Research Department, National Research Centre, Giza, Egypt; [4]Biological Anthropology Department, National Research Centre, Giza, Egypt

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***Correspondence:** Hesham Amer. Reproductive Health Research Department, National Research Centre, Giza, Egypt. E-mail: hesham_naguib@yahoo.com

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Abstract

AIM: To construct new fetal biometric charts and equations for some fetal biometric parameters for women between 12th and 41st weeks living in Ismailia and Port Said Governorates in Egypt.

MATERIAL AND METHODS: This cross-sectional study was carried out on 656 Egyptian women (from Ismailia and Port Said governorates) with an uncomplicated pregnancy, and all were sure of their dates. The selected group was between the 12th and 41st weeks of gestation, recruited from the district general hospital in Ismailia and Port Said to measure ultrasonographically biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL), then for each measurement separate regression models were fitted to estimate both the mean and the Standard deviation at each gestational age.

RESULTS: New Egyptian charts were reported for BPD, HC, AC, and FL. Reference equations for the dating of pregnancy were presented. The mean of the previous measurements at 12th and 41st weeks were as follows: (23.37, 98.72), (83.05, 336.12), (67.85, 332.57) and (12.50, 74.92) respectively.

CONCLUSION: New fetal biometric charts and regression equations for pregnant women living in Port Said & Ismailia governorates in Egypt.

Introduction

Appropriate intrauterine fetal growth and development are fundamental for newborn health and lifelong welfare. Both intrauterine growth restriction (IUGR) where the fetus failed to reach the recommended growth potential [1] usually as a result of placental insufficiency and macrosomia (exaggerated intrauterine growth, frequently associated with maternal obesity and/or diabetes), are associated with in utero fetal death, neonatal morbidity and mortality, and remote future risks to health [2]. IUGR is a common condition affecting about 10-15% of the general maternity population [3], while in developing countries along with Egypt it reaches up to 30% and constitutes 50-60% of low birth weight neonates (birth weight below 2500 g) [4].

Fetal growth abnormalities such as large-for-gestational-age, small-for-gestational-age, low birth weight and macrosomia are determined based on the standard growth charts taken from the growth of what we termed "normal fetuses". This issue is of specific consequences because many fetal growth references did not consider many factors that can affect the construction of such references. Furthermore, some charts are based on fetuses from normal and abnormal pregnancies, without sufficient acknowledgement of the implications for normative interpretation using percentiles [5].

Many changes affect fetal growth along with physiological and pathological changes, such as weight and height of pregnant women, drug or tobacco hazards, fetal sex [6], genetic syndromes, placental failure and congenital anomalies.

Many of published charts or curves showing the normal values of measurement in fetal biometry are established mainly depending on studies from western or American populations [7]. Such standards may be unsuitable for other populations; indeed, ethnic variations in fetal size and growth have been demonstrated in several studies [8] [9] [10]. The ethnic factor is essential in the fetal growth pattern, making it impossible for reference ranges of fetal biometric parameters from the homogeneous population to be applied in other populations, mainly heterogeneous populations [11]. In an American study with singleton pregnancies between 17 and 22.9 weeks, Afro-American fetuses have a smaller abdominal circumference (AC) than Caucasian fetuses. As AC contributes heavily to the estimated fetal weight, the Afro-American fetuses could be mistakenly underestimated [12].

Several other authors have stressed the value of using customised fetal biometry charts that consider variables such as maternal weight, parity, and race [13]. Cross-sectional and longitudinal ultrasound studies have demonstrated racial variations in fetal growth [10] [14] [15]. The fetuses of Turkish and Moroccan women had been reported having a shorter femur, smaller head and abdominal circumferences than Belgian women, and in Africa, Nigerian AC and BPD were found to be smaller than those of the British population [10] [16].

If we excluded all pathological conditions still ethnicity [10] contributes significantly to the fetal growth, and accordingly, each specific population or ethnic group should have their reference charts for the different fetal anthropometrical variables to maintain the most precise fetal assessment. Moreover, fetal nomograms need to be revised at regular intervals as fetal size has changed in the last decades [6].

Biparietal diameter provides the closest correlation with gestational age in the second trimester. Head circumference is an adequate alternative in case of presence of differences in skull shape. Abdominal circumference is the most useful dimension to evaluate fetal growth, while femur length is the best framework for evaluating skeletal dysplasia. Using multiple predictors improves the accuracy of such estimates [17].

The objective of this study is to construct new fetal biometric charts and equations for some fetal biometric parameters for women living in Ismailia and Port Said Governorates in Egypt.

Material and Methods

This cross-sectional study was carried out on 656 Egyptian women (from Ismailia and Port Said governorates) with an uncomplicated pregnancy. All those included were sure of their dates and were attending for routine antenatal care. The selected group was between the 12th and 41st weeks of gestation, recruited from the district general hospital in Ismailia and Port Said. We chose a lower gestational age limit of 12th weeks as sometimes there is difficulty in getting the ideal fetal position for measuring crown-rump length. Accordingly, BPD and FL are appropriate at such early gestational age. For each measurement, separate regression models were fitted to estimate both the mean and the standard deviation at each gestational age.

Menstrual history was recorded including last menstrual period (LMP) and regularity of the cycle. Women who came in the first trimester had their dates being confirmed by measuring crown-rump length (CRL)**.** While those attending in the second and third trimesters had their dates confirmed by the documented early first-trimester scan.

The range of each week is from week^{+0} days to week^{+6} days. The inclusion criteria for women with regular cycle (26-30 days), sure of their LMP and carrying singleton pregnancy, age between 18-40 years, without congenital fetal anomalies or maternal diseases that could affect fetal growth and not taking drugs that could affect the growth of her baby were included in the study.

Whereas, those with irregular cycles or without early ultrasound dating or a difference of more than 10 days in the GA (between their LMP and early ultrasound scan) or suffering from diseases that disturb normal fetal growth as diabetes mellitus, hypertension, autoimmune disorders or those on anticoagulant and antiplatelets were excluded from the study.

The BPD, HC, AC and, FL were measured by 3.5MHz convex abdominal probe as the standard fetal biometric profile, according to the guidelines proposed by the International Society of Ultrasound in Obstetrics and Gynecology [18] using (General Electric, LOGIQ 3, Milwaukee, Wisconsin, USA) and(Mindray DP-5, Nanshan, Shenzhen, China) ultrasound machines. BPD was measured from the outer proximal edge to the inner proximal edge of the fetal skull border in an axial plane showing the third ventricle, cavum septum pellucidum, and the thalami,

HC was measured directly by placing the ellipse of ultrasound device around the outside of the skull bone echoes. The AC measurement was taken at the widest part of the fetal abdomen, across the liver where, the transverse section should include the fetal stomach, spine and deep portion of the umbilical vein. The femur length was obtained with a linear array transducer along the long axis of diaphysis using a straight line from the tip of the greater trochanter to the lateral epicondyle.

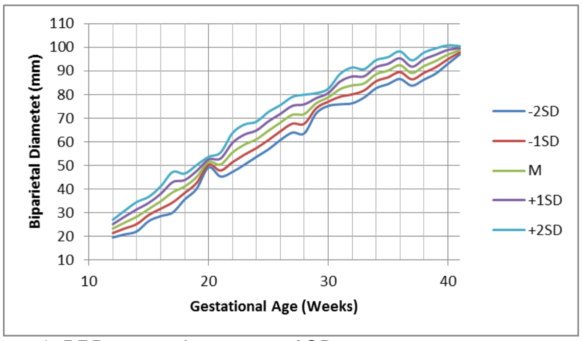

Figure 1: BPD regression curve ± 2SD

Statistical analysis was performed using SPSS program (version 14). The BPD, HC, AC, and FL measurements were expressed as mean ± SD and maximum and minimum values. A Polynomial regression model was used to obtain biometric charts for the GA from the above biometric measurements. Charts were figured out by plotting the predicted means and two SD at each week of the GA as shown in Figures 1-4.

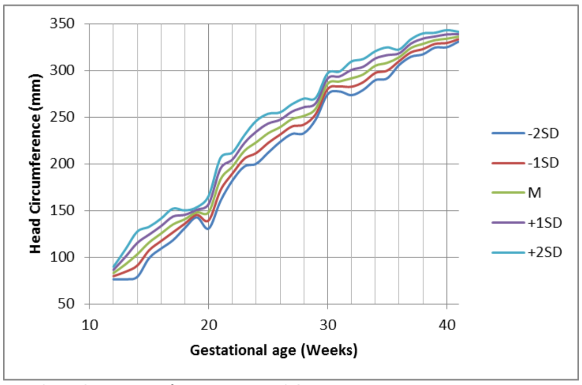

Figure 2: HC regression curve ± 2SD

Regression analysis has been used to produce an analytic description and to obtain the best-fitted model polynomial equation for the fetal biometric parameters. Quadratic functions were used to find the best interrelation between the measured fetal parameter and GA according to the least squares criteria. The goodness of fit was evaluated by measurement of the coefficient of determination r^2 (the nearer to one the better the correlation). Predicted parameter values for GA were calculated using the most appropriate models.

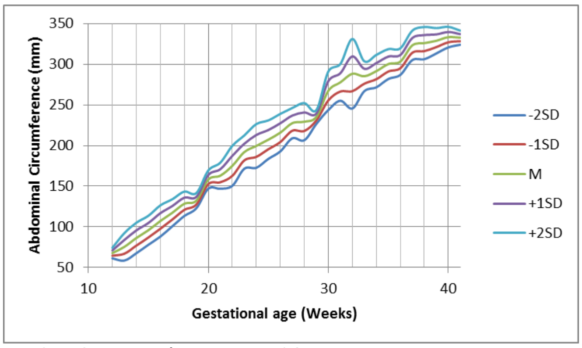

Figure 3: AC regression curve ± 2SD

We compared the results of fetal biometric measurements from our population with those from different countries as United Kingdom [19], Korea [7] and North America [20].

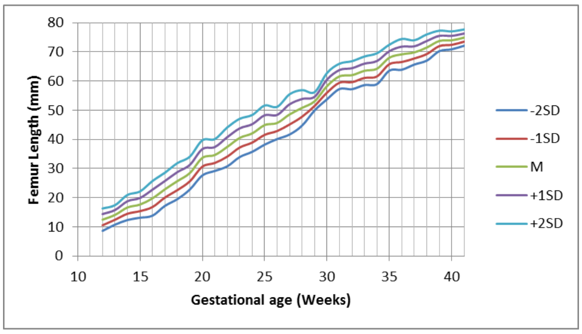

Figure 4: FL regression curve ± 2SD

Results

The mean, standard deviation (SD), minimum and maximum of BPD(mm), HC(mm), AC(mm) and FL(mm) of the study group at each gestational age were tabulated (Tables 1-4). The mean of the previous measures at 12th and 41st weeks were as follows: (23.37, 98.72), (83.05, 336.12), (67.85, 332.57) and (12.50, 74.92) respectively.

Table 1: Descriptive Statistics for BPD

GA (wks)	Ismailia & Port Said cases					GA (wks)	Ismailia & Port Said cases				
	N	Mean	SD	Min	Max		N	Mean	SD	Min	Max
12	4	23.37	1.87	21.3	25.2	27	16	71.47	3.76	64.7	77.3
13	16	25.97	2.51	22.5	30.4	28	17	71.78	4.09	61.2	80.0
14	21	28.40	3.10	22.1	34.4	29	14	76.36	2.13	72.6	79.3
15	30	31.69	2.56	27.8	36.5	30	13	78.81	1.81	76.7	83.6
16	24	34.93	3.14	30.4	41.8	31	14	82.32	3.22	78.3	87.6
17	25	38.73	4.28	32.5	47.2	32	28	83.87	3.78	77.8	89.4
18	30	41.16	2.73	37.6	48.0	33	36	84.74	3.0	79.2	90.9
19	11	45.18	2.51	41.9	50.1	34	28	88.62	2.96	81.8	93.5
20	5	51.46	1.11	50.2	53.2	35	31	90.13	2.85	85.0	96.4
21	18	50.44	2.53	46.7	54.4	36	18	92.42	2.92	88.1	99.1
22	13	55.53	4.10	50.0	63.2	37	35	89.12	2.67	85.3	96.2
23	16	58.86	4.25	53.0	65.3	38	53	92.04	2.85	86.7	98.3
24	21	61.12	3.72	55.3	67.1	39	44	94.23	2.65	88.2	98.4
25	19	64.75	3.95	58.9	71.6	40	27	96.91	1.95	93.1	99.6
26	25	68.16	3.69	62.0	74.8	41	4	98.72	0.88	98.0	99.8

The polynomial regression equations that best described the interrelation between BPD, HC, AC, FL and gestational age were as follows:

Table 2: Descriptive Statistics for HC

GA (wks)	Ismailia & Port Said cases					GA (wks)	Ismailia & Port Said cases				
	N	Mean	SD	Min	Max		N	Mean	SD	Min	Max
12	4	83.05	3.37	79.4	87.1	27	16	247.89	7.96	234.9	263.3
13	16	92.27	7.98	80.0	105.7	28	17	251.29	9.26	236.7	271.3
14	21	103.14	12.11	83.2	117.4	29	14	259.18	5.76	245.6	271.3
15	30	115.85	8.39	93.1	127.2	30	13	285.76	5.63	276.0	269.2
16	24	125.28	8.03	106.4	139.2	31	14	288.13	5.36	279.2	296.9
17	25	135.06	8.45	120.8	154.7	32	28	291.53	9.01	275.5	310.3
18	30	140.66	4.71	130.4	149.2	33	36	295.76	8.25	297.2	311.1
19	11	148.04	2.69	142.9	152.3	34	28	305.02	7.74	290.4	321.8
20	5	184.18	8.73	171.8	192.3	35	31	308.10	8.27	287.9	320.4
21	18	183.42	11.53	167.2	209.0	36	18	314.11	4.16	305.0	320.8
22	13	197.15	7.49	183.5	209.1	37	35	324.02	4.69	315.3	335.6
23	16	213.85	8.37	200.6	228.5	38	53	328.41	5.60	314.7	337.4
24	21	223.04	11.46	201.4	241.4	39	44	332.33	3.97	324.7	338.4
25	19	232.74	10.40	210.8	249.7	40	27	333.94	4.59	322.7	338.9
26	25	239.21	7.93	226.5	259.6	41	4	336.12	2.60	333.2	338.7

BPD (mm) = - 0.051(GA) ² + 5.403(GA) – 37.934

HC (mm) = - 0.174(GA) ² + 18.555(GA) – 126.302

AC (mm) = - 0.107(GA) ² + 15.6475(GA) – 115.157

FL (mm) = - 0.026(GA) ² + 3.739(GA) – 32.088

GA (days) = 0.235(BPD) + 0.061(HC) + 0.312(AC) + 1.132(FL) + 36.706

R^2 was 0.98; the mode was highly significant as $P<0.05$.

Table 3: Descriptive Statistics for AC

GA (wks)	Ismailia & Port Said cases					GA (wks)	Ismailia & Port Said cases				
	N	Mean	SD	Min	Max		N	Mean	SD	Min	Max
12	4	67.85	3.24	63.5	71.3	27	16	227.56	9.32	217.3	251.0
13	16	75.49	8.44	60.2	87.3	28	17	229.33	11.38	207.9	245.6
14	21	86.39	9.37	62.8	100.6	29	14	235.14	4.24	229.1	241.6
15	30	95.85	8.91	80.9	113.2	30	13	267.39	11.83	251.7	284.2
16	24	107.28	9.58	88.4	120.2	31	14	277.66	11.28	256.4	291.4
17	25	117.40	8.30	100.6	130.0	32	28	288.21	21.36	236.5	386.4
18	30	128.43	7.49	113.8	139.6	33	36	285.21	9.15	263.2	304.5
19	11	132.24	4.66	123.6	140.3	34	28	291.51	9.95	237.6	307.8
20	5	158.24	5.59	150.2	165.7	35	31	300.19	9.17	277.2	315.6
21	18	162.97	8.04	150.1	178.1	36	18	303.23	8.15	289.3	314.9
22	13	175.11	12.28	159.3	193.5	37	35	323.19	9.04	302.9	338.7
23	16	192.05	10.23	171.9	207.7	38	53	325.91	9.86	302.8	350.7
24	21	199.57	13.44	177.4	221.8	39	44	328.82	7.79	306.4	338.4
25	19	207.27	11.83	190.7	223.9	40	27	333.24	6.30	319.7	343.8
26	25	215.92	11.53	196.0	238.3	41	4	332.57	4.32	328.3	336.4

On comparing the mean of fetal biometric measures (BPD, HC, AC, FL) of our study population with that of other published ones from different countries as United Kingdom, Korea, and North America we found that the mean of BPD measurement appeared to be quietly larger in UK women than Egyptian ones till reaching maximum difference at 37th week with 6mm difference, as shown in (Figure 5A). While the mean of BPD appeared to be quietly bigger in Egyptian women than in Korean and North American women till reaching maximum difference at 20th week (5 mm and 4 mm respectively).

Table 4: Descriptive Statistics for FL

GA (wks)	Ismailia & Port Said cases					GA (wks)	Ismailia & Port Said cases				
	N	Mean	SD	Min	Max		N	Mean	SD	Min	Max
12	4	12.50	1.92	10.3	14.3	27	16	48.60	3.45	43.8	54.1
13	16	14.14	1.67	10.2	16.7	28	17	50.84	3.04	45.9	56.4
14	21	16.69	2.15	12.9	19.8	29	14	53.07	1.57	51.3	56.7
15	30	17.67	2.25	13.2	21.6	30	13	58.28	2.25	54.4	61.3
16	24	19.81	2.97	14.9	25.9	31	14	61.63	2.17	58.0	64.6
17	25	22.92	2.84	18.4	29.1	32	28	62.03	2.40	55.9	65.3
18	30	25.72	3.09	20.3	31.5	33	36	63.53	2.45	58.4	68.3
19	11	28.49	2.82	24.7	32.4	34	28	64.24	2.64	59.5	69.6
20	5	33.68	3.01	30.9	38.5	35	31	68.04	2.22	64.3	71.3
21	18	34.67	2.73	30.5	41.1	36	18	69.18	2.63	65.1	72.5
22	13	37.45	3.33	32.7	43.2	37	35	69.85	2.08	67.1	74.6
23	16	40.53	3.28	34.1	45.3	38	53	71.52	2.24	66.5	75.4
24	21	42.08	3.15	38.0	48.1	39	44	73.76	1.75	69.0	76.8
25	19	44.93	3.35	39.9	52.4	40	27	73.97	1.54	70.4	76.3
26	25	45.65	2.76	41.8	51.2	41	4	74.92	1.40	72.9	76.1

Also, it appeared that the mean of HC is gently higher in the UK and North American women than Egyptian ones till 25th week (Figure 5B). This difference increases after that until reaching its maximum (18 mm) at 29th week. While there was unstable variability between Korean and Egyptian women, the maximum difference was at the 19th and 29th weeks (10 mm and 11 mm, respectively).

There was unremarkable inconstancy between the mean of AC in the UK, North American and Egyptian women till 25th weak were the mean of AC was mildly higher in the UK and North American women than Egyptian ones reaching maximum difference of 21 mm at 36th week (Figure 5C), while there was unstable flippancy between those of Korean and Egyptian women with the maximum difference (15 mm) was at 29th week. Finally, in (Figure 5D), there was no remarkable variability between the mean of FL of UK, North American and Egyptian women, while regarding Korean women the mean of FL was lower than that of Egyptian women reaching maximum difference at 31st and 39th week (the difference was 5 mm).

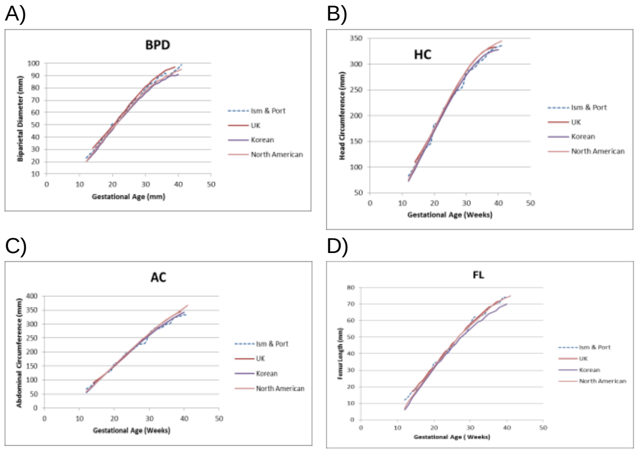

Figure 5: A) Comparison of our BPD with that of UK, Korean & North America populations; B) Comparison of our HC with that of UK, Korean & North America populations; C) Comparison of AC among the study group and that of UK, Korean & North America populations; D) Comparison of FL measurements within study group and that of UK, Korean and North America populations

Discussion

Nowadays examination and measurement of fetal biometry using ultrasound devices have become a basic part of recent obstetric care. These measurements helped in measuring the GA and assessment of fetal development. Choosing the appropriate reference charts is of great importance to guarantee an accurate diagnosis [21]. Several studies have demonstrated the influence of ethnicity on fetal biometry [10] [22].

A Pilot study was done by Zaki *et al*. (2012) in Egypt to compare the fetal biometric measurements of Egyptian women with those of other western ones. They found that Egyptian data are different from other western data and they recommended the development of a national fetal ultrasound biometric reference charts that can be used in clinical practice and the assessment of fetal growth. Unfortunately, this study was a limited pilot study applied to only 71 pregnant women between 14th & 24th weeks of gestation, not through the whole pregnancy. This study also did not include a wide and diverse range of Egyptian population from different governorates [23].

Accordingly, this study was designed to provide fetal biometric charts and regression equations for biometric measurements of pregnant women between 12th and 41st weeks of gestation living in Ismailia and Port Said Governorates in Egypt as a part of a larger project to create an Egyptian growth curve based on all governorates.

The noted difference of the BPD and HC among the UK women and the Korean and North American women than the Egyptian women may mainly be attributed to the method or the way BPD and HC measures were taken, ethnic, racial factors and the shape of the head.

AC was higher in the UK and North American women than Egyptian ones especially in the third trimester, while there was an unstable variability between Korean and Egyptian women. This may be related to women height and size as well as other epigenetic factors as the nutritional status, level of pollution and socioeconomic standards of our women.

Egyptian fetuses have almost comparable femur length as those from the UK and North American fetuses. While fetuses of Korean women had shorter femur than that of Egyptian counterparts. Fetal FL measurement can be underestimated by obtaining oblique images of the femur or overestimated by including the non-ossified portions of the femur [24]. There was no systemic bias in our study as we included only the ossified portion of the femur shaft, and all the measurements were done in the same way on all fetuses. It might be important to pay more attention to the effect of ethnic variations on fetal FL measurements as short femur has been reported as an important soft marker for Down syndrome [23].

In conclusion, the fetal growth is not uniform and varies between different groups of citizens. These differences in the various fetal biometric measurements among the dissimilar inhabitants emphasise the importance of selecting suitable charts for every population separately. Otherwise, over or underestimation of fetal growth abnormalities will include normally growing babies according to their normal population potential. This has a tremendous impact on the national health and economic resources. We endorse on the need to establish national Egyptian fetal biometric growth references.

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