On The Determination of Gestational Age of Foetuses In-Utero

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***Abstract*: Background: Accurate measurements of bi-parietal diameter (BPD) and femoral length (FL) is key to developing acceptable nomograms for assessing gestation age (GA).**

Aim and Objective: To determine which sonographic biometric parameters, BPD and FL gives a more accurate GA of foetuses in-utero.

Methodology: Linear regression models were fitted to the BPD, FL and GA data obtained in-utero with ultrasound scanner. The models were tested for equality. The GA obtained in second and third trimester using BPD and FL respectively, were compared for significant difference. BPD and FL nomograms were generated.

Results: The difference in mean GA using BPD and FL is not significant in second trimester (p = 0.612) but significant in third trimester (p = 0.001). The nomograms showed GA of 13 weeks when BPD is 25.4 mm, 40.0 weeks when BPD is 101.9 mm; 13 weeks when FL is 11.6 mm and 40.0 weeks when FL is 82.1 mm.

Conclusion: FL is more accurate for GA determination especially, in third trimester. BPD and FL are useful for assessing foetal growth/anomalies, and determining GA of foetuses with high degree of accuracy.

***Keywords*: Accurate measurement, equality test, gestational age, bi-parietal diameter, femoral length, nomogram.**

I. INTRODUCTION

Determining gestation age is an integral part of antenatal care. Knowledge of gestational age gives one an idea of the expected date of delivery and helps one to better manage the pregnancy and plan for the delivery of the baby. It also helps the gravid mother to better prepare for the arrival of the baby. Sonography is the diagnostic tool of choice for in-utero assessment of foetal wellbeing and gestational age (GA). This is largely owing to the fact that it is relatively safe, it is reliable, cost effective, available and easily accessible. Although issues of concern regarding damage to tissues from heat or cavitation from ultrasound energy have been raised, randomized clinical trials show no significant difference in developmental, neurological, or psychosocial outcome [1]. In-utero foetal assessment involves measurement of some biometric parameters. The biometric parameters commonly used in assessing fetal wellbeing and gestational age (GA) include Biparietal diameter (BPD), Head Circumference (HC), Occipito-Frontal Diameter (OFD), Cephalic Index (CI), Femur Length (FL), Abdominal Circumference (AC), Gestational Sac Diameter (GSD), and Crown-Rump Length (CRL). These parameters are used, singly or preferably in conjunction, to monitor intrauterine growth, generate growth curves and date pregnancies [2].

Five primary sonographic measures of foetal growth are HC, BPD, OFD, AC, and FL [3]. Although there are standard measurements, factors such as geographical location, physical and genetic differences influence foetal biometric parameters such that there exist slight variations in these measurements. It is established in the literature that FL charts are ethnic/country specific [2, 4, 5, 6, 7 and 8]. BPD is useful for estimating gestational age [9]. The estimation of GA is of great value as most patients, often times, do not remember their Last Menstrual Period (LMP), an information so crucial in obstetrics. Nomogram of FL is useful in diagnosing some skeletal related foetal anomalies such as Trisomy 21 [8].

Although it is common to see Sonographers and clinicians use nomogram or charts generated from BPD and FL measures respectively, biometric ratios are also useful as obstetric diagnostic guide in evaluating foetal age, growth and anomalies. The useful biometric ratios include "Cephalic index given as BPD/OFD x 100 [with normal value range of 70 – 82 (ovoid-shaped head), values above 82 signifies brachycephalic (round head) while values less than 70 signifies dolicocephalic (elongated head)]; FL/AC (with normal values of 18 – 24, values above 24 signifies small foetus while values less than 18 signifies big foetus). Other morphometric ratios are HC/AC ratio (used to assess foetal growth) and FL/AC ratio (used to assess foetal growth). Note that AC tends to shrink more in foetal growth retardation. The other valuable ratios are FL/BPD and BPD/FL. The FL is usually spared in asymmetrical Intra Uterine Growth Retardation (IUGR)" [10].

Many authors have reported the use of BPD/FL ratio as being very useful for in-utero detection of trisomy 21 - Down Syndrome and in the diagnoses and management of some other foetal disorders such as skeletal dysplasia [1; 11]. Recent works show that sonographic estimation of GA in late pregnancy was better when some of the biometric parameters were combined [12]. Using BPD/FL ratio would help reduce anxiety of pregnant mothers who may have to undergo follow-up for short FL and IUGR. It was reported that 50% of the women undergoing follow-up for short FL and IUGR developed preeclampsia [13]. 60% of neonatal deaths, annually, are associated with foetal growth problems and foetal anomalies [14]. Hence, accurate measurements of BPD and FL is key to developing acceptable nomograms of BPD, FL and BPD/FL ratio respectively, for assessing

foetal growth, foetal anomalies and clinical management of pregnancy.

Evidence from literature show that there are variations in the estimated gestational age of foetuses determined, in-utero, sonographically using the biometric parameters, BPD, FL, AC, HC etc. [12, 15, 16, 17]. Accuracy of measurement of these parameters is also an issue in gestational age determination. Against the backdrop that variations and error of measurements of these parameters exists, the search for a more accurate method of determining gestational age of foetuses in-utero is not out of place.

The aim of this study is to determine, in the framework of linear regression analysis, which of the two biometric parameters, BPD and FL gives a more accurate gestational age of foetuses measured in-utero by comparing the regression models developed from the GA, BPD and FL data collected, so as to be able to make informed decision on which biometric parameter is more appropriate for GA determination or to confirm the need for a combination of biometric parameters as had been suggested in the literature.

II. METHODOLOGY

2.1 The linear regression model

It had been shown that a linear relationship exists between gestational age (GA) and biparietal diameter (BPD); and between gestational age and femur length (FL) [10].

Let this linear relationship be represented by:

$$y = \propto_0 + \propto_1 x \qquad (1)$$

where, y represents the dependent variable, gestational age (GA) and x represents the independent variable, biparietal diameter (BPD) [or femur length (FL)]. Model (1) is a deterministic mathematical model. Once a value of x is chosen, the value of y is automatically determined by the specific values of $\propto_0$ and $\propto_1$. However, no such exact relationship exist between the measured biometric parameters. Other factors such as visual acuity and experience of the sonographer, geographical location, physical and genetic differences influence foetal biometric parameters such that there exist slight variations. These variations must be taken care of in the modelling process.

If the true effect of y on x is a straight line, and the observation y at each level of x is a random variable, then the expectation of Y given X is [18]

$$E(Y/X) = \propto_0 + \propto_1 x \qquad (2)$$

where the parameters, $\propto_0$ and $\propto_1$ are estimable. Assuming that Y can be described by the model

$$y_i = \propto_0 + \propto_1 x + e \qquad (3)$$

where e is the error term (i.e., error of measurement due to the variations earlier mentioned) then,

$$e = y_i - y \qquad (4)$$

Let the general form of the regression model for the data of GA against BPD and that of GA against FL respectively be:

$$y_1 = \propto_{0,1} + \propto_{1,i} x_1 + e_{1,i} \qquad (5)$$

$$y_2 = \propto_{0,2} + \propto_{2,i} x_2 + e_{2,i} \qquad (6)$$

Mathematical models (5) and (6) are not deterministic because they contain random errors, $e_{1,i}$ and $e_{2,i}$ respectively.

2.2 The Procedure

The data consists of measurements of biometric parameters BPD, FL and GA of 97 pregnant women in their second and third trimesters within age range 19 – 37years obtained from Image Diagnostics, Port Harcourt, Rivers State. Regression models were fitted to this set of data. For each model, the residual and sum of the squared residuals were determined. The number of degrees of freedom and the residual mean square (i.e., the random experimental error in each measurement) were also determined. A pooled single regression model and its sum of squared residuals was obtained from the data set. The difference between the sum of squared residuals for the pooled regression model and the combined sum of squared residuals for the regression models GA against BPD and GA against FL was obtained. The number of degrees of freedom for this difference was calculated (i.e., the number of individual regression models minus 1). The residual mean square from the difference and degrees of freedom computed was obtained and the F-ratio was calculated. Using the F-ratio, we tested the hypothesis:

H_0: There is no difference between the regression models

H_1: There is difference between them

Paired difference t- test was used to check if the difference in mean gestational age using BPD and FL respectively, is statistically significant. This comparison was done for the second and third trimesters respectively and for both trimesters combined.

Nomograms of GA for second and third trimesters using BPD and FL respectively, were generated from regression models developed from the data set.

Minitab 17 statistical software for windows was used for the analysis.

III. RESULTS

For measurement using BPD, the regression model fitted to the data is

$$y = 16.052 + 0.206x_1 \qquad (7)$$

where, y represents GA and x_1 represents BPD

Hence,

$$\sum_{i=1}^{97} {e_1}^2 = (y_1 - y)^2 = 1018.18$$

For measurement using FL, the regression model fitted to the data is

$$y = 14.917 + 0.283x_2 \qquad (8)$$

where, y represents GA and x_2 represents FL

$$\sum_{i=1}^{97} {e_2}^2 = (y_2 - y)^2 = 555.18$$

$$\sum_{i=1}^{97} {e_1}^2 + \sum_{i=1}^{97} {e_2}^2 = 1573.99$$

Degree of freedom from the two regression models is (97-2) + (97-2) = 190

The mean squared error is (1573.99/190) = 8.28

For the pooled data, the regression model is

$$y^1 = 15.485 + 0.245x_{1,2} \qquad (9)$$

where, y^1 represents GA and $x_{1,2}$ represents the pooled BPD and FL measurements

$$\sum_{i=1}^{97} \varepsilon_1^2 + \sum_{i=1}^{97} \varepsilon_2^2 = 220178.30 \quad \text{(Appendix A).}$$

Difference in residual sum of squares is (220178.30 – 1573.99) = 218604.31

The degree of freedom for this difference is 1. And the mean squared error is 218604.31.

The null hypothesis was rejected as the calculated F-ratio of 26401.487 is greater than the tabulated F-ratio [i.e. $F_{1,\ 190\ (0.05)} = 3.84$].

Table 1: Paired mean difference of GA measured using BPD and FL in the second, third and both trimesters combined.

	GA using BPD Mean (S.D)	GA using FL Mean (S.D)	Difference (95% CI)	*p*-value
2nd trimester	22.38 (4.66)	22.33 (4.89)	0.05 (- 0.149, 0.249)	0.612
3rd trimester	34.83 (3.48)	34.69 (3.51)	0.14 (0.055, 0.216)	0.001
Both 2nd and 3rd trimesters	30.72 (7.05)	30.61 (7.07)	0.11 (0.024, 0.190)	0.012

Table 1 shows that the difference in mean GA using BPD and FL is not significant in the second trimester (p = 0.612) but significant in the third trimester (p = 0.001) and when both trimesters are taken together (p = 0.012).

Tables 2 and 3 respectively, show nomograms of GA for second and third trimesters foetuses generated using linear regression models:

$$GA = 4.027 + 0.3529*BPD \qquad (10)$$

$$GA = 8.513 + 0.3832*FL \qquad (11)$$

Using model (10), the result showed a GA of 13 weeks when the BPD is 25.4 mm and GA of 40.0 weeks when the BPD is 101.9 mm. Using model (11) GA of 13 weeks when the FL is 11.6 mm and GA of 40.0 weeks when the FL is 82.1 mm.

Table 2: Nomogram of GA for 2nd and 3rd trimester using regression model, GA = 4.027 + 0.3529*BPD

BPD (mm)	GA (wks.)	BPD (mm)	GA (wks.)	BPD (mm)	GA (wks.)	BPD (mm)	GA (wks.)	BPD (mm)	GA (wks.)
25.4	13.0	42.3	19.0	59.3	25.0	76.3	31.0	93.3	37.0
28.2	14.0	45.2	20.0	62.2	26.0	79.2	32.0	96.2	38.0
31.0	15.0	48.0	21.0	65.0	27.0	82.1	33.0	99.0	39.0
33.8	16.0	50.8	22.0	67.8	28.0	84.8	34.0	101.9	40.0
36.7	17.0	53.7	23.0	70.7	29.0	87.7	35.0	104.8	41.0
39.5	18.0	56.5	24.0	73.5	30.0	90.5	36.0	107.6	42.0

Table 3: Nomogram of GA for 2nd and 3rd trimester using regression model, GA = 8.513 + 0.3832*FL

FL (mm)	GA (wks.)	FL (mm)	GA (wks.)	FL (mm)	GA (wks.)	FL (mm)	GA (wks.)	FL (mm)	GA (wks.)
11.6	13.0	27.3	19.0	42.9	25.0	58.6	31.0	74.3	37.0
14.2	14.0	29.9	20.0	45.6	26.0	61.2	32.0	76.9	38.0
16.8	15.0	32.5	21.0	48.2	27.0	63.8	33.0	79.5	39.0
19.5	16.0	35.1	22.0	50.8	28.0	66.4	34.0	82.1	40.0
22.1	17.0	37.7	23.0	53.4	29.0	69.0	35.0	84.7	41.0
24.7	18.0	40.3	24.0	56.0	30.0	71.6	36.0	87.3	42.0

IV. DISCUSSION

Our interest in this work is to ascertain the truth value of the claims that FL is a better biometric parameter for determining gestational age of foetuses in-utero as recorded in the literatures. The importance of accurate measurement of GA in utero cannot be over emphasized. It helps in the early detection of foetal anomalies which would enable the obstetrician to make informed decision on the line of management of the pregnancy for safe delivery of the baby. [13, 19, 20, 21] note that ultrasonography detection of a femur length (FL) below the expected value may be a pointer to the presence of a malformation, particularly a skeletal dysplasia, or marker of an aneuploidy. [13] went further to suggest that the finding of a short FL at mid-

trimester ultrasonography should be followed by further ultrasound testing to exclude foetal malformations.

Linear regression is a method for assessing the relationship between gestational age (GA) and the biometric parameters (e.g. HC, BPD, OFD, AC, and FL) as GA varies with the sizes of the biometric parameters respectively. Several nomograms of GA have been produced using these relationships and studies (e.g. [12]) have shown positive linear correlation between gestational age and femur length.

The results of the analysis show that GA has positive linear relationship with BPD and FL respectively as shown by the value of the slope of both regression lines (7) and (8). The results also showed that there is no significant difference in the GA of foetuses measured using BPD and FL in the second trimester of pregnancy but there is significant difference in the third trimester measurements thus, agreeing with the findings of Okoye *et al*. [9]; Chris-Ozoko and Akinnoye [15]; MacGregor and Sabbagha [16]. It was observed that "between 12 and 26 weeks' gestation, the BPD is accurate to within ±10 to 11 days. After 26 weeks' gestation, the accuracy of BPD measurement progressively decreases and is ±3 weeks near term" [16]. Biologic variation or inaccuracy due to differences in maternal age, parity, pre-pregnancy weight, geographic location, and specific population characteristics as well as technical factors including inter-observer error, different techniques of measurements, and single versus multiple measurements have been identified as possible factors influencing the accuracy of BPD in assessing gestational age and this variability greatly increases with advancing pregnancy [16, 17].

The null hypothesis of no difference in the regression models was rejected. Indeed, the regression models cannot be the same because the parameters used for each of the GA measurements are different. The implication of this is that each of the biometric parameters, BPD and FL can be used independently to assess foetal gestational age. However, many authors have recommended the use of both parameters for a more accurate assessment of gestational age [12; 15; 16; 17]. Here, the mean gestational age is considered. The nomogram generated from the mean gestational age data using BPD and FL compares favourably well with values published in the literature [16].

Whereas this study has established that FL yields more accurate GA in the third trimester and that both BPD and FL can conveniently be used to assess, in-utero, foetal wellbeing and growth, foetal anomalies, and to determine the gestational age (GA) of foetuses with some high degree of accuracy despite biologic and technical factors which could influence the results, in the framework of linear regression analysis, it is important to note that other biometric parameters such as Head Circumference (HC), Occipito-Frontal Diameter (OFD), Cephalic Index (CI), Abdominal Circumference (AC), Gestational Sac Diameter (GSD), and Crown-Rump Length (CRL) are also important determinants of GA though they are not frequently used in practice. Also, GA determination in-utero can be achieved via other statistical analysis methods e.g. use of the Z score, Reference intervals (RIs) and centile charts, and Centile curves based on direct centile estimates [22].

V. CONCLUSION

This study has shown that a positive linear relationship exists between GA and BPD and, between GA and FL respectively. Both biometric parameters, BPD and FL can be used independently for in-utero gestational age determination though, using FL, especially in the third trimester yields more accurate GA. The study was also able to show the efficacy of using both the BPD and FL combination for gestational age determination. We therefore, conclude that FL yields more accurate GA in the third trimester and, both BPD and FL can conveniently be used to assess, in-utero, foetal wellbeing and growth, foetal anomalies, and to determine the gestational age (GA) of foetuses with some high degree of accuracy despite biologic and technical factors influencing the results.

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Appendix A

Results of the Data analysis using measurements of biometric parameters, BPD and FL, and the pooled data

BPD	GA	e_1	e_1^2	FL	GA	e_2	e_2^2	ε_1	ε_1^2	ε_2	ε_2^2
20.00	13.20	-6.97	48.61	10.00	13.00	-4.75	22.53	2.62	6.84	-0.03	0.00
23.00	13.40	-7.39	54.61	12.00	13.60	-4.71	22.21	3.55	12.60	1.06	1.11
24.00	14.00	-7.00	48.94	14.00	14.00	-4.88	23.80	4.40	19.32	1.95	3.78
29.00	15.20	-6.83	46.59	14.80	14.20	-4.91	24.06	6.82	46.51	2.34	5.48
30.60	15.40	-6.96	48.38	16.00	15.00	-4.45	19.76	7.41	54.94	3.44	11.80
34.40	16.40	-6.74	45.41	18.60	15.30	-4.88	23.82	9.34	87.29	4.37	19.11
39.60	18.00	-6.21	38.56	23.70	17.20	-4.42	19.57	12.22	149.26	7.52	56.57
39.60	18.00	-6.21	38.56	28.00	18.20	-4.64	21.54	12.22	149.26	9.58	91.68
41.60	18.50	-6.12	37.47	27.40	18.30	-4.37	19.11	13.21	174.42	9.53	90.78
43.00	19.90	-5.01	25.10	27.40	18.30	-4.37	19.11	14.95	223.50	9.53	90.78
51.30	21.60	-5.02	25.20	36.30	21.20	-3.99	15.92	18.68	349.07	14.61	213.41
53.00	22.10	-4.87	23.72	39.00	22.10	-3.85	14.85	19.60	384.16	16.17	261.47
56.00	23.10	-4.49	20.14	41.00	23.20	-3.32	11.02	21.34	455.18	17.76	315.42
56.00	23.10	-4.49	20.14	43.60	24.00	-3.26	10.60	21.34	455.18	19.20	368.52
57.80	23.50	-4.46	19.88	43.00	24.00	-3.09	9.52	22.18	491.77	19.05	362.90
58.80	24.10	-4.06	16.52	43.00	24.00	-3.09	9.52	23.02	529.97	19.05	362.90
59.00	24.10	-4.11	16.86	43.40	24.10	-3.10	9.61	23.07	532.22	19.25	370.49
59.80	24.30	-4.07	16.57	45.60	25.00	-2.82	7.96	23.47	550.65	20.69	427.95
61.00	24.60	-4.02	16.14	41.60	25.20	-1.49	2.22	24.06	578.88	19.91	396.29
61.90	25.10	-3.70	13.72	49.80	25.20	-3.81	14.52	24.78	614.07	21.92	480.31
68.20	25.40	-4.70	22.10	46.80	25.60	-2.56	6.56	26.62	708.84	21.58	465.74
63.80	25.50	-3.69	13.65	48.50	26.10	-2.54	6.46	25.65	657.72	22.50	506.14
64.30	25.50	-3.80	14.42	49.00	26.10	-2.68	7.20	25.77	664.02	22.62	511.66
65.00	26.10	-3.34	11.17	49.00	26.10	-2.68	7.20	26.54	704.37	22.62	511.66
65.50	26.20	-3.35	11.19	49.00	26.10	-2.68	7.20	26.76	716.23	22.62	511.66
69.00	26.40	-3.87	14.95	49.50	26.40	-2.53	6.38	27.82	773.95	23.04	530.96
66.00	26.40	-3.25	10.55	50.30	27.00	-2.15	4.63	27.09	733.60	23.84	568.27
67.10	27.00	-2.87	8.26	50.70	27.10	-2.17	4.69	27.95	781.45	24.04	577.75
67.30	27.30	-2.62	6.84	50.10	27.20	-1.90	3.59	28.30	801.09	23.99	575.50
51.00	27.30	0.74	0.55	51.00	27.20	-2.15	4.62	24.31	590.98	24.21	586.12
68.60	27.50	-2.68	7.20	51.80	27.30	-2.28	5.18	28.82	830.71	24.51	600.54
70.10	28.10	-2.39	5.72	51.80	27.40	-2.18	4.74	29.79	887.41	24.61	605.46
70.40	28.10	-2.45	6.02	53.60	28.10	-1.99	3.94	29.86	891.80	25.75	662.91
70.80	28.40	-2.24	5.00	53.20	28.10	-1.87	3.51	30.26	915.73	25.65	657.87
71.50	28.50	-2.28	5.20	53.00	28.10	-1.82	3.30	30.53	932.23	25.60	655.36
73.00	29.20	-1.89	3.57	53.30	28.20	-1.80	3.24	31.60	998.56	25.77	664.27
73.00	29.20	-1.89	3.57	56.40	29.00	-1.88	3.53	31.60	998.56	27.33	747.09
76.30	29.50	-2.27	5.15	65.00	29.00	-4.31	18.59	32.71	1069.85	29.44	866.71
73.50	29.50	-1.69	2.87	57.00	30.20	-0.85	0.72	32.02	1025.44	28.68	822.54
74.00	29.50	-1.80	3.23	58.00	30.20	-1.13	1.28	32.15	1033.30	28.93	836.66
77.30	30.60	-1.38	1.89	57.50	30.40	-0.79	0.62	34.05	1159.64	29.00	841.15
77.40	31.00	-1.00	0.99	60.30	31.20	-0.78	0.61	34.48	1188.73	30.49	929.55
77.80	31.20	-0.88	0.77	55.60	31.20	0.55	0.30	34.78	1209.37	29.34	860.66
78.00	31.20	-0.92	0.85	60.10	31.20	-0.73	0.53	34.83	1212.78	30.44	926.56
77.80	31.20	-0.88	0.77	60.00	31.20	-0.70	0.49	34.78	1209.37	30.42	925.07
79.00	31.50	-0.83	0.68	59.00	31.20	-0.41	0.17	35.37	1251.04	30.17	910.23
87.80	31.70	-2.44	5.95	60.10	31.20	-0.73	0.53	37.73	1423.25	30.44	926.56
80.00	32.10	-0.43	0.19	62.00	32.00	-0.46	0.21	36.22	1311.53	31.71	1005.21
80.00	32.10	-0.43	0.19	61.60	32.00	-0.35	0.12	36.22	1311.53	31.61	999.00

80.40	32.20	-0.41	0.17	61.80	32.10	-0.31	0.09	36.41	1325.91	31.76	1008.44
82.00	32.40	-0.54	0.30	61.20	32.10	-0.14	0.02	37.01	1369.37	31.61	999.13
82.30	32.60	-0.41	0.16	62.00	32.20	-0.26	0.07	37.28	1389.69	31.91	1017.93
82.10	32.60	-0.36	0.13	65.90	33.00	-0.57	0.32	37.23	1386.04	33.66	1133.03
82.00	33.00	0.06	0.00	63.00	33.00	0.25	0.06	37.61	1414.14	32.95	1085.70
82.60	33.20	0.13	0.02	65.90	33.00	-0.57	0.32	37.95	1440.35	33.66	1133.03
82.60	33.20	0.13	0.02	65.50	33.10	-0.35	0.12	37.95	1440.35	33.66	1133.16
83.00	33.30	0.15	0.02	64.90	33.30	0.02	0.00	38.15	1455.42	33.72	1136.73
84.00	33.60	0.24	0.06	70.40	33.30	-1.54	2.37	38.70	1497.30	35.06	1229.41
84.40	33.60	0.16	0.03	65.50	33.50	0.05	0.00	38.79	1504.90	34.06	1160.25
85.40	34.20	0.56	0.31	66.70	34.00	0.21	0.04	39.64	1571.17	34.86	1214.98
86.10	34.50	0.71	0.51	65.90	34.00	0.43	0.19	40.11	1608.77	34.66	1201.35
86.40	34.60	0.75	0.56	66.20	34.00	0.35	0.12	40.28	1622.72	34.73	1206.45
88.90	35.00	0.63	0.40	67.00	35.00	1.12	1.26	41.30	1705.32	35.93	1290.96
88.40	35.50	1.24	1.53	69.00	35.00	0.56	0.31	41.67	1736.64	36.42	1326.42
88.30	35.50	1.26	1.58	69.40	35.40	0.84	0.71	41.65	1734.60	36.92	1362.94
89.00	36.00	1.61	2.60	68.50	35.50	1.20	1.43	42.32	1790.98	36.80	1354.06
89.10	36.10	1.69	2.87	70.20	36.00	1.22	1.48	42.44	1801.54	37.71	1422.35
90.10	36.30	1.69	2.85	71.60	36.10	0.92	0.85	42.89	1839.51	38.16	1455.96
96.30	36.30	0.41	0.17	70.50	36.10	1.23	1.52	44.41	1972.11	37.89	1435.46
89.90	36.30	1.73	2.99	70.50	36.20	1.33	1.77	42.84	1835.31	37.99	1443.05
90.00	36.30	1.71	2.92	71.30	36.30	1.21	1.45	42.87	1837.41	38.28	1465.63
89.90	36.30	1.73	2.99	70.10	36.30	1.54	2.39	42.84	1835.31	37.99	1443.20
96.40	36.40	0.49	0.24	70.30	36.30	1.49	2.21	44.53	1983.19	38.04	1446.93
90.30	36.40	1.75	3.05	71.00	36.30	1.29	1.66	43.04	1852.31	38.21	1460.00
90.60	36.50	1.78	3.18	72.00	36.30	1.01	1.01	43.21	1867.28	38.46	1478.79
91.00	36.60	1.80	3.25	72.10	36.60	1.28	1.64	43.41	1884.43	38.78	1503.85
90.90	36.60	1.82	3.32	72.10	36.60	1.28	1.64	43.39	1882.30	38.78	1503.85
91.00	36.60	1.80	3.25	72.10	36.60	1.28	1.64	43.41	1884.43	38.78	1503.85
90.80	36.70	1.94	3.78	72.30	37.00	1.62	2.63	43.46	1888.86	39.23	1538.88
92.50	37.00	1.89	3.58	72.30	37.00	1.62	2.63	44.18	1951.65	39.23	1538.88
93.60	37.30	1.97	3.87	76.40	37.10	0.56	0.32	44.75	2002.29	40.33	1626.75
93.00	37.50	2.29	5.24	75.00	37.20	1.06	1.12	44.80	2007.04	40.09	1607.21
93.50	38.00	2.69	7.22	72.90	37.20	1.65	2.73	45.42	2063.20	39.58	1566.22
94.00	38.20	2.78	7.75	75.60	37.30	0.99	0.98	45.75	2092.61	40.34	1627.07
95.00	38.50	2.88	8.28	74.30	38.00	2.06	4.23	46.29	2142.76	40.72	1658.00
95.00	38.50	2.88	8.28	74.90	38.20	2.09	4.35	46.29	2142.76	41.07	1686.38
95.00	38.50	2.88	8.28	75.00	38.30	2.16	4.66	46.29	2142.76	41.19	1696.62
95.80	39.10	3.31	10.98	96.90	39.30	-3.04	9.24	47.09	2217.09	47.56	2261.53
96.60	39.30	3.35	11.21	77.00	39.30	2.59	6.72	47.48	2254.54	42.68	1821.58
97.60	39.60	3.44	11.85	77.00	39.30	2.59	6.72	48.03	2306.59	42.68	1821.58
97.40	39.60	3.48	12.14	78.00	39.40	2.41	5.80	47.98	2301.89	43.03	1851.15
97.40	39.60	3.48	12.14	77.30	39.50	2.71	7.33	47.98	2301.89	42.95	1845.00
97.80	40.00	3.80	14.45	79.80	40.00	2.50	6.25	48.48	2349.92	44.07	1941.81
98.00	40.00	3.76	14.14	78.50	40.00	2.87	8.22	48.53	2354.68	43.75	1913.84
98.00	40.00	3.76	14.14	81.00	40.00	2.16	4.67	48.53	2354.68	44.36	1967.81
99.00	40.00	3.55	12.63	78.70	40.10	2.91	8.47	48.77	2378.51	43.90	1926.90
98.10	40.10	3.84	14.74	81.00	41.00	3.16	9.99	48.65	2366.77	45.36	2057.53
$\sum(\cdot)$			1018.81				555.18		123947.00		96231.30

Appendix B

Raw Data of Age of Mother and the Foetal Parameters of BPD, BPDGA, FL, FLGA, BPD/FL and Average GA

S/N	Age of Mother (Years)	BPD (mm)	BPD GA (weeks)	FL (mm)	FL GA (weeks)	BPD/FL	Average GA (weeks)
1	19.00	67.30	27.30	50.70	27.10	1.30	27.20
2	34.00	65.00	26.10	48.50	26.10	1.30	26.10
3	30.00	91.00	36.60	72.10	36.60	1.30	36.60
4	33.00	24.00	14.00	14.00	14.00	1.70	14.00
5	25.00	20.00	13.20	10.00	13.00	2.00	13.10
6	29.00	80.00	32.10	62.00	32.20	1.30	32.20
7	32.00	51.00	27.30	50.30	27.00	1.00	27.10
8	33.00	43.00	19.90	28.00	18.20	1.50	18.50
9	28.00	84.00	33.60	62.00	32.00	1.40	32.80
10	35.00	23.00	13.40	12.00	13.60	1.90	13.50
11	32.00	85.40	34.20	66.70	34.00	1.30	34.10
12	23.00	76.30	29.50	57.50	30.40	1.30	30.00
13	36.00	34.40	16.40	18.60	15.30	1.80	15.80
14	32.00	93.60	37.30	76.40	37.10	1.20	37.20
15	34.00	58.80	24.10	43.40	24.10	1.40	24.10
16	37.00	90.80	36.70	70.20	36.00	1.30	36.30
17	24.00	63.80	25.50	46.80	25.60	1.40	25.50
18	29.00	90.60	36.50	72.30	37.00	1.30	36.80
19	29.00	65.50	26.20	49.50	26.40	1.30	26.30
20	23.00	82.00	32.40	64.90	33.30	1.30	32.90
21	28.00	90.10	36.30	70.40	33.30	1.30	34.80
22	28.00	71.50	28.50	51.80	27.40	1.40	28.00
23	35.00	82.30	32.60	65.50	33.50	1.30	33.10
24	33.00	86.40	34.60	38.50	35.50	2.20	35.10
25	35.00	92.50	37.00	74.30	38.00	1.20	37.50
26	29.00	97.60	39.60	79.80	40.00	1.20	39.80
27	32.00	96.30	36.30	71.60	36.10	1.30	36.20
28	32.00	97.80	40.00	78.00	39.40	1.30	39.70
29	36.00	82.10	32.60	65.50	33.10	1.30	32.90
30	23.00	70.10	28.10	56.40	29.00	1.20	42.30
31	30.00	57.80	23.50	43.60	24.00	1.30	23.80
32	28.00	79.00	31.50	61.80	32.10	1.30	31.30
33	26.00	98.10	40.10	75.60	37.30	1.30	37.70
34	29.00	89.10	36.10	71.30	36.30	1.20	36.20
35	32.00	68.20	25.40	41.60	25.20	1.60	25.30
36	27.00	67.10	27.00	51.80	27.30	1.30	27.10
37	30.00	86.10	34.50	65.90	34.00	1.30	34.20
38	28.00	84.40	33.60	61.20	32.10	1.40	32.90
39	27.00	73.50	29.50	53.60	28.10	1.40	28.80
40	26.00	70.80	28.40	50.10	27.20	1.40	27.80
41	27.00	77.30	30.60	60.30	31.20	1.30	30.90
42	32.00	98.00	40.00	96.90	39.30	1.01	39.60
43	28.00	41.60	18.50	23.70	17.20	1.80	17.80
44	29.00	68.60	27.50	53.20	28.10	1.30	27.80
45	25.00	88.40	35.50	70.50	36.10	1.30	35.80
46	35.00	70.40	28.10	53.30	28.20	1.30	28.10
47	29.00	89.00	36.00	70.50	36.20	1.30	36.10
48	23.00	97.40	39.60	78.50	40.00	1.20	39.80

49	34.00	93.50	38.00	74.90	38.20	1.20	38.10
50	34.00	97.40	39.60	78.70	40.10	1.20	37.80
51	32.00	51.30	21.60	36.30	21.20	1.40	21.40
52	22.00	88.90	35.00	66.20	34.00	1.30	34.50
53	26.00	61.90	25.10	45.60	25.00	1.40	25.00
54	34.00	96.40	36.40	75.00	37.20	1.30	36.80
55	28.00	93.00	37.50	72.90	37.20	1.30	37.30
56	20.00	77.40	31.00	55.60	31.20	1.40	31.10
57	33.00	96.60	39.30	77.30	39.50	1.20	39.40
58	35.00	30.60	15.40	14.80	14.20	2.10	14.80
59	33.00	88.30	35.50	69.40	35.40	1.30	35.40
60	31.00	82.60	33.20	65.90	33.00	1.30	33.10
61	25.00	39.60	18.00	27.40	18.30	1.40	18.20
62	35.00	89.90	36.30	72.10	36.60	1.20	36.40
63	26.00	77.80	31.20	60.10	31.20	1.30	31.20
64	33.00	90.90	36.60	70.10	36.30	1.30	36.40
65	25.00	64.30	25.50	49.80	25.20	1.30	25.20
66	32.00	87.80	31.70	70.30	36.30	1.20	35.80
67	30.00	80.40	32.20	61.60	32.00	1.30	32.10
68	31.00	90.30	36.40	72.30	37.00	1.20	36.70
69	32.00	73.00	29.20	57.00	30.20	1.30	29.70
70	27.00	74.00	29.50	53.00	28.10	1.40	28.80
71	25.00	73.00	29.20	58.00	30.20	1.30	29.80
72	26.00	95.00	38.50	75.00	38.30	1.30	38.40
73	25.00	83.00	33.30	63.00	33.00	1.30	33.10
74	30.00	98.00	40.00	81.00	40.00	1.20	40.00
75	29.00	69.00	26.40	49.00	26.10	1.40	26.10
76	28.00	90.00	36.30	67.00	35,00	1.30	35.70
77	27.00	82.00	33.00	60.00	31.20	1.40	32.10
78	26.00	56.00	23.10	51.00	27.20	1.10	25.20
79	29.00	99.00	40.00	81.00	41.00	1.20	40.50
80	30.00	91.00	36.60	71.00	36.30	1.30	36.40
81	33.00	66.00	26.40	49.00	26.10	1.30	26.20
82	29.00	61.00	24.60	39.00	22.10	1.60	23.40
83	30.00	95.00	38.50	72.00	36.30	1.30	38.90
84	30.00	53.00	22.10	41.00	23.20	1.30	22.70
85	3300	95.00	38.50	77.00	39.30	1.20	38.90
86	27.00	78.00	31.20	65.00	29.00	1.20	30.10
87	23.00	59.00	24.10	43.00	24.00	1.40	24.50
88	24.00	94.00	38.20	69.00	35.00	1.40	36.60
89	28.00	80.00	32.10	59.00	31.20	1.40	31.70
90	29.00	29.00	15.20	16.00	15.00	1.80	15.10
91	30.00	56.00	23.10	43.00	24.00	1.30	23.10
92	31.00	82.60	33.20	65.90	33.00	1.30	33.10
93	37.00	95.80	39.10	77.00	39.30	1.20	39.40
94	25.00	39.60	18.00	27.40	18.30	1.40	18.10
95	35.00	89.90	36.30	72.10	36.60	1.20	36.40
96	26.00	77.80	31.20	60.10	31.20	1.30	21.20
97	23.00	59.80	24.30	49.00	26.10	1.20	26.20