INTRAUTERINE GROWTH CHARTS FOR FETAL BIPARIETAL DIAMETER BETWEEN 12 AND 40 WEEKS OF PREGNANCY AND ITS CORRELATION WITH GESTATIONAL AGE

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ABSTRACT

Objective: The objective of this study is to derive intrauterine growth charts for fetal biparietal diameter (BPD) at weekly intervals between 12 and 40 weeks of gestation and to correlate BPD with the gestational age (GA).

Methods: In a prospective observational study, a total of 100 women underwent periodic ultrasound examination between 12 and 40 weeks of gestation. Using Microsoft Excel trend line feature, polynomial regression was performed for each of this patient and weekly BPD values were extrapolated. For each week of gestation, we obtained 100 data points, and these were entered into SPSS software to obtain means, standard deviations (SD), and percentile charts for BPD. Relationship between GA and BPD was also established using curvilinear regression. Z scores were used to compare the findings of the present study with Indian, Asian, and non-Asian regions. The incremental growth of BPD per week was also established for the same GA range.

Results: The mean ± SD of BPD value at 12 weeks was 20.4±0.94 mm, which gradually increased to 92.5±2.89 mm at full term. There was a strong relationship between BPD and GA as indicated by polynomial regression analysis. As gestation advanced, BPD growth rate slowed down from 3.5 mm from mid-pregnancy to around 1 mm at term. Our BPD charts resembled closely Chinese and US growth charts.

Conclusion: There was a good mathematical relationship between fetal BPD and GA. The BPD charts and percentile tables derived from the present study help to establish customized growth charts for the local population.

Keywords: Biparietal diameter, Gestational age, Intrauterine growth chart.

INTRODUCTION

It is a standard practice to estimate the duration of pregnancy using patient's recalled 1st day of last menstrual period (LMP) [1]. LMP itself is subjected to poor recall and is influenced by several factors such as irregular cycles, lactational amenorrhea, usage of oral contraceptive pills, and implantation bleeding [2]. In the modern era, measurement of fetal biometric parameters can be helpful in the determination of gestational age (GA) and the error can be minimized when ultrasound is performed in early in pregnancy. Biparietal diameter (BPD) is one such parameter which has been used to estimate GA for the past four decades [3]. Knowledge of correct GA is of utmost importance in present-day obstetric practice, as many interventions are based on accurate dating, such as steroid administration, preventing preterm and post-term births, planning timing of delivery, and preventing untimely induction of labor [4].

BPD is not only used for calculation of GA but also it can diagnose aberrant fetal growth and many central nervous system anomalies can also be detected while measuring BPD in its correct plane [5]. There are two types of BPD growth abnormalities: First one is slow growth profile and the second is late trimester flattening [6]. However, this requires comparison to standard BPD growth chart which has been previously studied and customized for the local population.

In India, there are few publications which focus on the relationship between GA and BPD and vice versa. There is a wide variation in BPD measurements in different places, as it is influenced by maternal nutritional status, demographic pattern, and racial differences. BPD of one population may either underestimate or overestimate GA, and hence, it is very important to have BPD charts customized for local population [7]. In this study, we have correlated bidirectionally GA and BPD from 12th week of gestation to 40 weeks of pregnancy in South Indian population.

METHODS

This was a prospective observational study conducted at a tertiary care hospital which is attached to medical college between August 2014 and August 2016 in the Department of Obstetrics and Gynaecology, KMC, Manipal, which is a tertiary care center. The study was approved by the Institutional Ethics Committee (ref no: IEC: 465/2014) and all participating women gave informed consent. We included only those women who had singleton uncomplicated pregnancies with BPD measurement values between 12 and 40 weeks and who delivered at term. Their reliability of LMP was correlated with first trimester dating scan using crown rump length (CRL) measurements. If they found to have fetal growth restriction, medical complications such as congenital anomaly, gestational diabetes, pre-eclampsia, and intrauterine fetal demise during the follow-up, they were excluded from the study. The most important criterion was the availability of patients through the entire period between 12 and 40 weeks.

We used Philips HD 11XE machine for BPD measurements using 3.5 MHz curvilinear probe. We first determined the lie of the fetus and spine curvature. The transducer was turned at right angles to the fetal spine and by gradual sliding motion; transverse section of the fetal head was obtained. The correct plane for BPD measurement was defined as transthalamic plane, which showed oval-shaped head circumference, midline falx, and septum cavum pellucidum dividing the brain into two equal hemispheres and thalamic structures slightly posteriorly [8].

Our ultimate objective was to obtain at least 5–6 scan results between 12 and 40 weeks to plot growth charts. Rather than calling them on

specified GA, we recorded BPD values whenever they were called for routine antenatal visits. All the patients had an initial scan at 12–14 weeks (early anomaly scan), 18–20 weeks (targeted scan), 28–32 weeks (growth scan), and between 32 and 40 weeks (at least 2–3 interval scans).

We used Microsoft Excel graph feature to plot the growth points using X-axis for GA and Y-axis for BPD measurements. The data points were further smoothened using Excel trend line feature, which also gave polynomial equation between GA and BPD. Having obtained the regression equation, we further extrapolated BPD values at weekly intervals from 12 to 40 weeks of gestation. The details of this procedure can be obtained by author's publication on Microsoft Excel non-linear curve fitting [9].

Sample size determination

In a study by Lai and Yeo from Singapore, BPD (in mm) at term was found to be 93.09±3.1 [10]. Using sample size equation "$n=2(z\alpha+z\beta)^2\sigma^2/\Delta\mu^2$," we found that sample size of 37 would be adequate. We recruited 148 patients for the study keeping in mind (dropout rate due to onset of pregnancy complications where in early delivery would have been required, patient who changed the institution for their delivery). The final sample of study size was 100 which was 3 times more than the actual sample size required, thereby increasing the power of the study.

Statistical analysis

We obtained BPD values for all 100 patients between 12 and 40 weeks of gestation at weekly interval by the method which has been already discussed, and this information was entered into SPSS version 16 statistical package. Descriptive analysis was used to find the mean and standard deviation (SD) at specified intervals. Centile charts were also prepared using inbuilt tool in the same package. We used Z statistics to compare our values with the published values across various GAs.

- Z-scores were calculated using the formula.
- **Z**-score = $(X^{GA}-M^{GA})/SD^{GA}$, where in
- X^{GA} - mean BPD from reference population at a specified GA.
- M^{GA} - mean BPD from study population for the same GA.
- SD^{GA} -SD associated with the mean value at this GA in the current study.

RESULTS

We had initially recruited 148 pregnant women for the current study. Of them, 14 patients developed gestational diabetes, 13 had hypertension, 8 went into preterm labor, 6 women defaulted for regular check-ups, and 7 patients changed the institution. The BPD data were collected for remaining 100 pregnant women, and detailed descriptive analysis was done using SPSS package and Microsoft excel program as detailed in materials and methods section.

Table 1 shows mean, SD, and percentile values for BPD obtained in our study. The mean ± SD of BPD value at 12 weeks was 20.4±0.94 mm, which gradually increased to 92.5±2.89 mm at full term. The relationship between BPD and GA was established by the following polynomial regression equation.

$$BPD = (-6.64414+[1.280198\times GA]+0.103147\times[GA^2]-0.0018296\times GA^3)$$

Fig. 1 shows that BPD percentiles for GA range between 12 and 40 weeks at weekly intervals. This figure can be used for charting BPD values at a particular GA and this will help us identification of pregnancies affected by intrauterine growth restriction and macrosomic babies.

Table 2 summarizes GA in weeks for the corresponding BPD values in mm (from 20 mm to 95 mm). The relationship between GA and BPD is explained by 4th degree polynomial equation as follows:

$$GA = ([0.0000000706676825481\times BPD^4]+[0.0000499804240801\times BPD^3]-[0.008278133232336 8\times BPD^2]+[0.70632536575\times BPD]+0.113912991506)$$

Fig. 2 shows relationship between GA and BPD graphically. From Table 2 and Fig. 2, one can estimate the gestational age for the given BPD value.

Fig. 3 shows BPD growth velocity in mm per week of gestation. It can be seen that as the gestation advances, BPD growth rate slows down (from

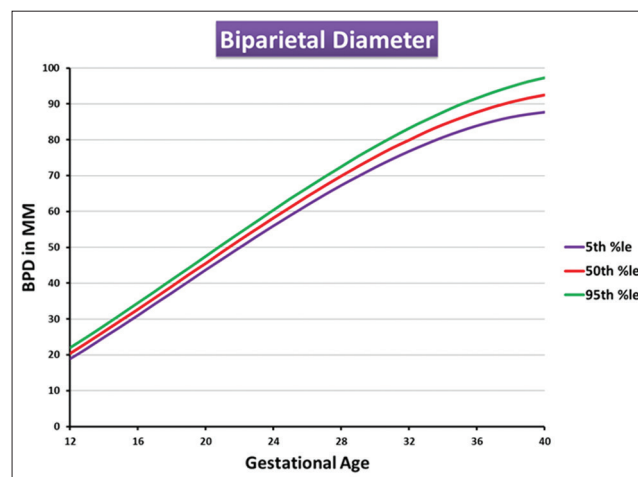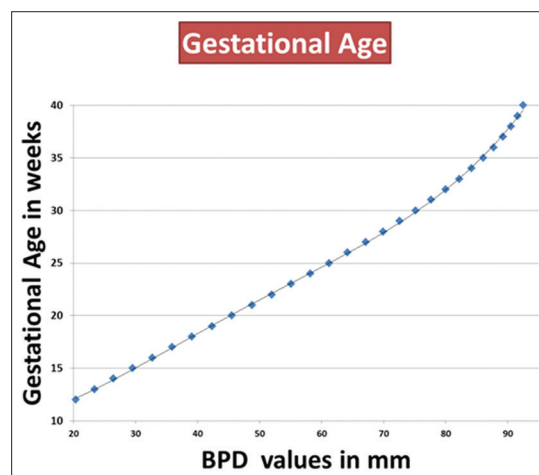**Fig. 1: Centile values for biparietal diameter at various gestational ages**

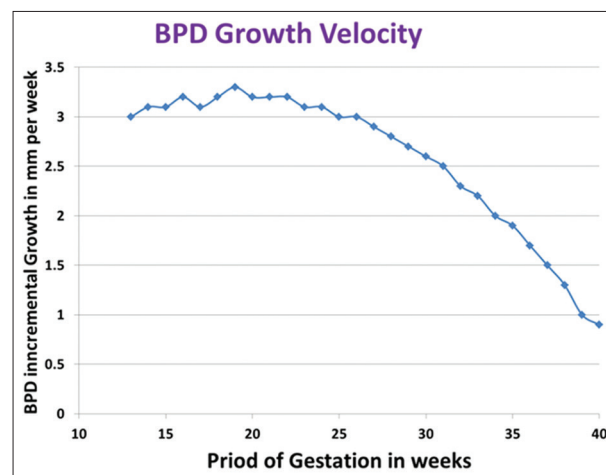**Fig. 2: Graphical relationship between gestational age and biparietal diameter**

Fig. 3: Biparietal diameter growth velocity across various gestational ages

Table 1: Descriptive statistics of BPD parameters between 12 and 40 weeks

GA	Mean±SD	5th %le	10th %le	25th %le	50th %le	75th %le	90th %le	95th %le
12	20.4±0.94	18.9	19.2	19.8	20.4	21	21.6	22
13	23.4±0.96	21.8	22.2	22.8	23.4	24.1	24.6	25
14	26.5±0.99	24.9	25.2	25.8	26.5	27.1	27.7	28.1
15	29.6±1.01	27.9	28.3	28.9	29.6	30.3	30.9	31.3
16	32.8±1.04	31	31.4	32.1	32.7	33.5	34.1	34.5
17	35.9±1.07	34.2	34.6	35.2	35.9	36.7	37.3	37.7
18	39.1±1.1	37.3	37.7	38.4	39.1	39.9	40.6	41
19	42.4±1.13	40.5	40.9	41.6	42.4	43.1	43.8	44.2
20	45.6±1.17	43.7	44.1	44.8	45.5	46.4	47.1	47.5
21	48.8±1.21	46.8	47.2	48	48.8	49.6	50.3	50.8
22	52±1.25	49.9	50.4	51.1	52	52.8	53.6	54
23	55.1±1.3	53	53.4	54.2	55.1	56	56.8	57.2
24	58.2±1.35	56	56.5	57.3	58.2	59.1	59.9	60.4
25	61.2±1.41	58.9	59.4	60.3	61.2	62.2	63	63.6
26	64.2±1.47	61.8	62.3	63.2	64.2	65.2	66.1	66.6
27	67.1±1.53	64.6	65.1	66.1	67.1	68.1	69.1	69.6
28	69.9±1.6	67.3	67.9	68.8	69.9	71	72	72.5
29	72.6±1.68	69.8	70.5	71.5	72.6	73.7	74.8	75.4
30	75.2±1.76	72.3	72.9	74	75.2	76.4	77.4	78.1
31	77.7±1.84	74.6	75.3	76.4	77.7	78.9	80	80.7
32	80±1.93	76.8	77.5	78.7	79.9	81.3	82.5	83.2
33	82.2±2.03	78.8	79.6	80.8	82.2	83.5	84.8	85.5
34	84.2±2.13	80.7	81.5	82.8	84.2	85.6	86.9	87.7
35	86.1±2.24	82.4	83.2	84.6	86	87.6	88.9	89.8
36	87.8±2.36	83.9	84.7	86.2	87.7	89.3	90.8	91.6
37	89.3±2.48	85.2	86.1	87.6	89.2	90.9	92.4	93.3
38	90.6±2.61	86.3	87.2	88.8	90.5	92.3	93.9	94.8
39	91.6±2.75	87.1	88.1	89.8	91.6	93.5	95.2	96.2
40	92.5±2.89	87.7	88.8	90.6	92.5	94.5	96.2	97.3

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

Table 2: Calculation of GA (in weeks and days) based on BPD measurements in mm

BPD (mm)	GA (W and D)	BPD (mm)	GA (W and D)	BPD (mm)	GA (W and D)	BPD (mm)	GA (W and D)
20	11W2D	39	18W1D	58	23W5D	77	30W5D
21	11W5D	40	18W4D	59	24W1D	78	31W1D
22	12W1D	41	18W6D	60	24W3D	79	31W4D
23	12W4D	42	19W1D	61	24W5D	80	32W1D
24	13W0D	43	19W3D	62	25W0D	81	32W4D
25	13W3D	44	19W5D	63	25W3D	82	33W1D
26	13W6D	45	19W7D	64	25W5D	83	33W4D
27	14W1D	46	20W2D	65	26W0D	84	34W1D
28	14W4D	47	20W4D	66	26W3D	85	34W5D
29	14W6D	48	20W6D	67	26W5D	86	35W2D
30	15W2D	49	21W1D	68	27W1D	87	35W6D
31	15W4D	50	21W3D	69	27W3D	88	36W3D
32	15W7D	51	21W5D	70	27W6D	89	37W0D
33	16W2D	52	22W0D	71	28W2D	90	37W5D
34	16W4D	53	22W2D	72	28W4D	91	38W2D
35	16W7D	54	22W4D	73	29W0D	92	39W0D
36	17W2D	55	22W6D	74	29W3D	93	39W5D
37	17W4D	56	23W1D	75	29W6D	94	40W3D
38	17W6D	57	23W3D	76	30W2D	95	41W1D

BPD: Biparietal diameter, GA: Gestational age

3.5 mm from mid-pregnancy to around 1 mm at term). BPD-based GA calculation in third trimester is prone to error because of its slow growth late gestation.

DISCUSSION

The ultrasound measurement of BPD was first described by Donald and Brown in 1967 [11]. Initially, "A" mode scan was used to obtain the BPD, but later Campbell described B mode scan for fetal head measurement [12]. Subsequently, Griffit and Henry showed that BPD can be imaged in real-time mode [13]. The best predictor of fetal age is CRL correlation, but its limitation is that it cannot be measured after 14 weeks of pregnancy. BPD is the next best fetal parameter to assess the GA after 12 weeks of gestation and it can be measured throughout the gestation, but only limitation is that as the trimester advances, its accuracy falls [14].

There is a wide variation in BPD values of South Indian fetuses compared to western standards. This is because fetal biometry is influenced by several factors such as maternal nutritional status, race, ethnicity, parental height, and even for that matter, the fetal sex [15]. Table3 shows comparative analysis of BPD values in various Indian hall mark studies.

We compared our values with published values using Z score (also known as standard score). This helps us to find how close are published

mean values of BPD compared to our mean values and fall within what range of SD as observed from our study. The method of obtaining Z score has been already explained in materials and method section. We can consider that published value is very close to our values if they fall within 1 SD. A positive Z score will mean that particular value is more than our value and vice versa, and if the score is negative, then they are lesser than our observations. A Z score toward zero implies that there are no differences in two studies.

Fig. 4 shows Z statistics for other Indian studies. We can conclude that Chennai and Gujarat studies (observations fall within ± 0.5 SD) are closed to our study. However, the Pune study showed significant differences in mean BPD value still 36weeks, but thereafter, BPD in all three studies came close to our study.

Table 4 shows a comparison of BPD values in the present study with other Asian population. The similarities and differences in the different studies have been analyzed and Fig. 5 shows the differences graphically. Although there were differences in the values in the initial part of pregnancy, it is well seen that all the studies showed comparable values in the second half of pregnancy. Of all the South Asian regions, observations from China were very close to the present study.

We also compared the results of our study with non-Asian countries (Table 5). Surprisingly by Z score analysis (Fig. 6), we found that our values did not differ much from the USA-based study. The BPD values from Netherland population appeared to be higher compared to our study, indicating that their fetuses had high growth profile.

The strength of the present study is that it provides a detailed GA wise percentile descriptive for BPD, calculation of GA for the known BPD, and also the incremental growth rate for BPD in different trimesters of pregnancy. The regression equations are also computed. The size of fetal head in terms of BPD will also throw light on cephalopelvic proportions which otherwise earlier was only relied on subjective clinical assessment or radiopelvimetry before the advent of ultrasound technology [29,30].

To summarize, there is a good mathematical relationship between fetal BPD and GA. We are of the opinion that the methodology used in the present study, percentile tables, and charts of BPD will serve as a good reference source and database for future studies in this field of research. The customized growth charts will also help us to monitor pregnancies complicated by pregnancy hypertension [31], maternal diabetes, hypothyroidism [32], and other medical disorders which influence the intrauterine fetal growth.

CONCLUSION

In the current obstetric practice, the accurate assessment of GA is of critical importance, especially in situations such as fetal growth restriction, postdated pregnancy, placenta previa, medical disorders complicating pregnancy such as pre-eclampsia, diabetes, and more so ever in management of pre-term labor. Ultrasound becomes handy in such conditions, as by measuring various fetal parameters, approximate
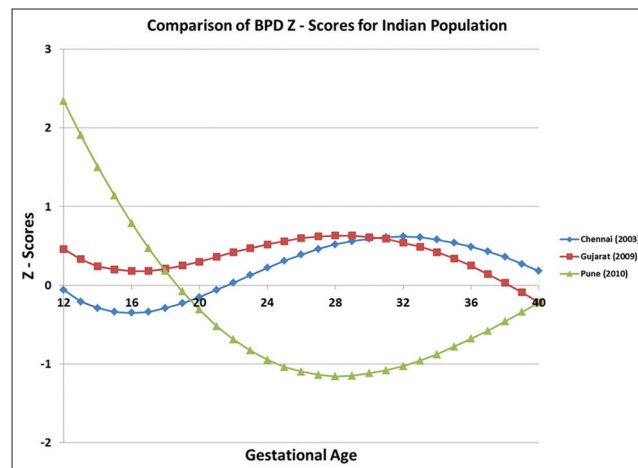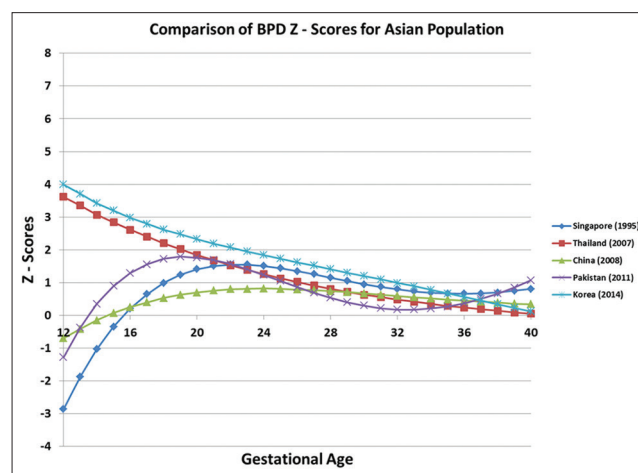

Fig. 4: Z score comparison with Indian studies

Fig. 5: Z score comparison with Asian studies

Table 3: BPD parameters of the present study compared with other Indian studies

GA	Chennai (2003) [16]	Gujarat (2009) [17]	Pune (2010) [18]	Present study	GA	Chennai (2003) [16]	Gujarat (2009) [17]	Pune (2010) [18]	Present study
12	20.3	20.8	22.6	20.4	27	67.8	68.1	65.4	67.1
13	23.2	23.7	25.2	23.4	28	70.7	70.9	68.1	69.9
14	26.2	26.7	28	26.5	29	73.6	73.7	70.7	72.6
15	29.2	29.8	30.7	29.6	30	76.2	76.3	73.2	75.2
16	32.4	32.9	33.6	32.8	31	78.8	78.7	75.7	77.7
17	35.6	36.1	36.4	35.9	32	81.2	81	78	80
18	38.8	39.4	39.3	39.1	33	83.4	83.2	80.2	82.2
19	42.1	42.6	42.3	42.4	34	85.5	85.1	82.3	84.2
20	45.4	45.9	45.2	45.6	35	87.3	86.8	84.3	86.1
21	48.7	49.2	48.2	48.8	36	88.9	88.3	86.2	87.8
22	52	52.5	51.1	52	37	90.3	89.6	87.8	89.3
23	55.3	55.7	54	55.1	38	91.5	90.6	89.3	90.6
24	58.5	58.9	56.9	58.2	39	92.4	91.4	90.7	91.6
25	61.7	62	59.8	61.2	40	93	91.9	91.9	92.5
26	64.8	65.1	62.6	64.2					

BPD: Biparietal diameter, GA: Gestational age

Table 4: BPD parameters of the present study compared with other Asian studies

GA	Singapore (1995) [10]	Thailand (2007) [19]	China (2008) [20]	Pakistan (2011) [21]	Korea (2014) [22]	Present Study
12	17.7	23.8	19.8	19.2	24.2	20.4
13	21.6	26.6	23	23.1	27	23.4
14	25.5	29.5	26.3	26.8	29.9	26.5
15	29.2	32.5	29.7	30.5	32.8	29.6
16	33	35.5	33	34.1	35.9	32.8
17	36.6	38.5	36.4	37.6	38.9	35.9
18	40.2	41.6	39.7	41	42	39.1
19	43.8	44.7	43.1	44.4	45.2	42.4
20	47.2	47.7	46.4	47.6	48.3	45.6
21	50.6	50.8	49.7	50.8	51.4	48.8
22	53.9	53.9	53	53.9	54.6	52
23	57.1	56.9	56.2	56.9	57.6	55.1
24	60.2	59.9	59.3	59.9	60.7	58.2
25	63.3	62.8	62.4	62.7	63.7	61.2
26	66.2	65.7	65.4	65.5	66.6	64.2
27	69	68.5	68.3	68.2	69.4	67.1
28	71.8	71.2	71.1	70.8	72.2	69.9
29	74.4	73.8	73.8	73.3	74.8	72.6
30	76.9	76.3	76.4	75.7	77.3	75.2
31	79.3	78.7	78.8	78.1	79.7	77.7
32	81.5	80.9	81.1	80.3	81.9	80
33	83.7	83	83.3	82.5	84	82.2
34	85.7	85	85.3	84.6	85.9	84.2
35	87.6	86.7	87.2	86.7	87.6	86.1
36	89.3	88.3	88.8	88.6	89.1	87.8
37	90.9	89.7	90.3	90.5	90.4	89.3
38	92.4	90.9	91.6	92.3	91.4	90.6
39	93.7	91.9	92.6	94	92.3	91.6
40	94.9	92.6	93.5	95.6	92.9	92.5

Table 5: BPD parameters of the present study compared with non-Asian countries

GA	France (2006) [23]	Netherlands (2008) [24]	Italy (2009) [25]	USA (2012) [26]	Egypt (2012) [27]	Brazil (2014) [28]	Present study
12	27.8	19.3	25.2	21.6	20.9	16.2	20.4
13	29.7	23.1	27.7	24.4	24.3	20.4	23.4
14	31.7	26.8	30.4	27.4	27.7	24.6	26.5
15	34	30.6	33.2	30.4	31.1	28.6	29.6
16	36.5	34.2	36.1	33.5	34.5	32.6	32.8
17	39.2	37.8	39.1	36.6	37.8	36.4	35.9
18	41.9	41.4	42.1	39.8	41.1	40.1	39.1
19	44.8	44.9	45.2	43	44.4	43.8	42.4
20	47.8	48.4	48.4	46.2	47.6	47.3	45.6
21	50.8	51.8	51.6	49.4	50.8	50.7	48.8
22	53.9	55.1	54.8	52.6	53.9	54	52
23	57.1	58.4	58	55.8	56.9	57.2	55.1
24	60.2	61.6	61.1	58.9	59.9	60.3	58.2
25	63.3	64.7	64.2	62	62.8	63.3	61.2
26	66.4	67.8	67.3	65	65.6	66.1	64.2
27	69.4	70.8	70.2	67.9	68.4	68.9	67.1
28	72.4	73.7	73.1	70.8	71.1	71.6	69.9
29	75.2	76.5	75.8	73.5	73.6	74.1	72.6
30	77.9	79.2	78.4	76.2	76.1	76.6	75.2
31	80.4	81.8	80.9	78.7	78.5	78.9	77.7
32	82.8	84.4	83.1	81	80.7	81.2	80
33	85	86.8	85.2	83.2	82.9	83.3	82.2
34	86.9	89.2	87.1	85.3	84.9	85.4	84.2
35	88.7	91.4	88.8	87.1	86.8	87.3	86.1
36	90.1	93.5	90.2	88.8	88.6	89.1	87.8
37	91.3	95.6	91.4	90.3	90.2	90.8	89.3
38	92.2	97.5	92.3	91.5	91.7	92.4	90.6
39	92.7	99.3	92.9	92.5	93.1	93.9	91.6
40	92.9	101	93.2	93.3	94.3	95.3	92.5

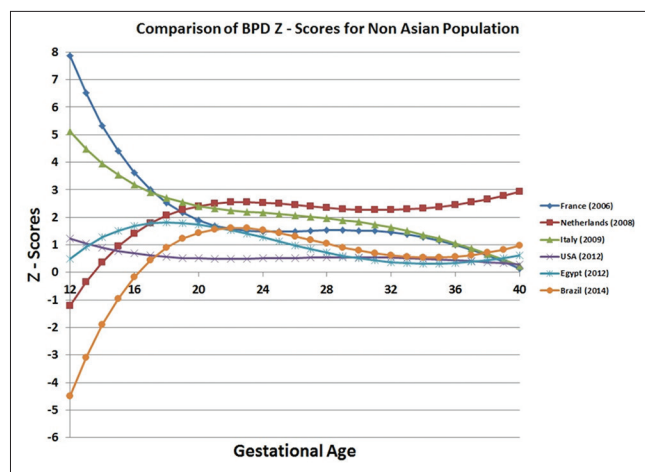BPD: Biparietal diameter, GA: Gestational age

Fig. 6: Z score comparison with non-Asian studies

age of the fetus can be determined. BPD is easier to obtain and it can be a useful tool at term for the purpose of ultrasound cephalometry. It is recommended that each local population should have its own nomograms of BPD so that there is no need to refer to other charts and errors in GA estimation can be thus minimized.

CONFLICT OF INTEREST

None.

AUTHOR'S CONTRIBUTION

Shripad Hebbar: Data analysis and draft preparation, Tracy Khuraijam: Data collection and compilation.

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