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Effect of maternal pre-pregnancy body mass index and gestational weight gain on birth weight and gestational age: An observational cross-sectional study

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ABSTRACT

Background: Studies show that pre-pregnancy body mass index (ppBMI) and gestational weight gain (GWG) are associated with birth weight (BW), gestational age (GA), and neonatal morbidities. Higher BW leads to metabolic syndrome. Preterm and low BW (LBW) have short and long-term morbidities. Monitoring ppBMI and GWG is necessary as these are modifiable risk factors for obesity. In this study, we revisited these findings in an Indian scenario. **Aims and Objectives:** The primary objective is to study the association of BW and GA with ppBMI and GWG. The secondary objective is to study the association of ppBMI and GWG with cesarean section (CS), infant size, and early neonatal intensive care unit (NICU) requirement. **Materials and Methods:** This observational cross-sectional study was conducted over 1 year with 230 mothers, after Institutional Ethics Committee approval and informed consent. Data were collected using predesigned pro forma and analyzed by SPSS. Digital weighing scales, stadiometer, and fenton growth charts were used. **Results:** We found a positive linear correlation of ppBMI and GWG with BW. Obesity and excess GWG were associated with higher BW, large for GA, CS, and NICU stay. Overweight had more CS. Underweight and less GWG had a greater risk of LBW, preterm, and NICU stay. Less GWG had more small for GA. **Conclusion:** GWG and ppBMI are determinants of BW, GA, and neonatal morbidities. Further studies should focus on exercise and nutrition in pregnant and reproductive age women so that healthy babies with low-risk of obesity, metabolic syndrome, and neurodevelopmental disabilities are born.

Key words: Pre-pregnancy body mass index; Gestational weight gain; Birth weight

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INTRODUCTION

Among reproductive age women in India, 22.9% were underweight and 20.7% were overweight or obese in 2015–2016. Compared with previous data, there is a significant rise in overweight or obesity.[1] The prevalence of overweight/obesity, low gestational weight gain (GWG), and high GWG in Asia are 10%, 31%, and 37%, respectively.[2] The WHO has classified women into four pre-pregnancy body mass index (ppBMI) categories: Underweight (BMI <18.5), normal (18.5–24.9), overweight (25–29.9), and obese (≥30). For underweight, normal, overweight, and obese mothers, the Institute of Medicine (IOM) recommended GWG of 12.7–18.1 kg, 11.3–15.9 kg, 6.8–11.3 kg, and 5–9.1 kg, respectively.[3] Underweight, overweight, obesity, and less and excess GWG have been associated with various maternal and fetal abnormalities such as pre-eclampsia, gestational diabetes mellitus, cesarean section (CS), preterm, low birth weight (LBW), small for gestational age (SGA), and large for gestational age (LGA). Studies show that ultra-processed food intake is associated with maternal and neonatal weight and nutritional intervention during pregnancy might help in reducing these complications.[4]

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GWG is a modifiable risk factor for adverse neonatal outcomes.[5] Excess GWG increases birth weight (BW) and child and adult obesity, thereby increasing the risk of metabolic disorders.

At present, the prevalence of metabolic syndrome is 25% in India. About 5.2% of adolescents and 13% of young adults had either obesity, diabetes, or hypertension.[6,7] The causes are dietary habits and a sedentary lifestyle, which might be rooted in higher BW caused by maternal obesity or excess GWG. Furthermore, the prevalences of preterm and LBW in India are 13.2% and 18.2%.[8] Of the many causes of preterm delivery, maternal underweight is a modifiable cause. In this study, we have studied the association of maternal ppBMI and GWG with BW, gestational age (GA), mode of delivery, and neonatal complications requiring neonatal intensive care unit (NICU) stay in an Indian setting.

Aims and objectives

The primary objective is to study the association of BW and GA with ppBMI and GWG. The secondary objective is to study association of ppBMI and GWG with caesarean section (CS), infant size (LGA and SGA) and early NICU requirement.

MATERIALS AND METHODS

This observational cross-sectional study has been conducted over 1 year (1/4/2019-31/3/2020) in the Obstetric ward of the Department of Gynaecology and Obstetrics and NICU of the Neonatology division of the Department of Pediatric Medicine, KPC Medical College and Hospital, Kolkata. The study population includes 230 antenatal women enrolled on admission to the hospital for delivery. The pregnant women were selected by simple random sampling. Sample size calculation based on the LBW incidence rate of 17% (prevalence proportion) shows that the sample size should be 216. The considered confidence interval in sample size calculation was 95% and absolute error/precision was 5%. Mothers with known heart disease, other systemic diseases, previous abortion or childbirth, anatomical abnormalities of the reproductive system, multiple gestations, fetal congenital anomalies, addictions, requiring general anesthesia, admitted in non-ambulatory condition, and mothers whose pre-pregnancy weight or early first-trimester weight were not recorded were not eligible. Institutional ethics committee approval and prior informed consent were taken. Data collection was done according to predesigned pro forma which included variables such as age, maternal weight on admission, height, pre-pregnancy weight, mode of delivery, BW, GA, SGA/appropriate for GA (AGA)/LGA, medical and obstetric complications, and NICU requirement within 24 h after birth. Maternal weight and height were measured using a digital scale and stadiometer, respectively, immediately on admission. Pre-pregnancy weight (within 1 month before positive pregnancy urine test) or weight recorded on the first visit to the obstetrician (within a month of missed periods) was obtained from maternal records. The ppBMI was calculated using the formula BMI = weight (kg)/(height in m)^2. The antenatal mothers were classified into 4 IOM ppBMI categories underweight, normal, overweight, and obese.[3] GWG was calculated by the difference between the weight just before delivery and pre-pregnancy (first trimester) weight. Mothers were classified into 3 IOM categories as below recommended, normal, and above recommended GWG within their respective ppBMI categories. GA was calculated from LMP. Babies delivered by both spontaneous vaginal delivery and CS were included in the study. After delivery, the baby was placed on the mother's abdomen or chest for drying and initial assessment. Cord clamping and cutting were done at 30 s after birth. Babies who cried at birth or after the initial steps were kept with the mother and BW was recorded 1 h after delivery using a digital infant weighing scale. For babies requiring resuscitation, BW was recorded after stabilization, mostly after 1 h of delivery. The SGA/AGA/LGA status of the neonate was determined by plotting on the sex-specific fenton fetal growth charts.[9] The data were transferred to a Microsoft Excel spreadsheet for analysis by SPSS software. The ppBMI, GWG, BW, and GA data have been represented in terms of mean and standard deviation (SD) and analyzed using independent (unpaired) t-tests. Chi-square tests have also been used for some of the analyses. Everywhere, the 95% confidence interval was used and a $P<0.05$ was taken to be significant.

RESULTS

The mean age of all the mothers enrolled in the study is 26.4 (SD 2.64) years. The mean ppBMI is 24.78 kg/m^2 (SD 5.17). Thirty-four (14.7%) women are underweight, 85 (37.1%) women have normal ppBMI, 73 (31.7%) women are overweight, and 38 (16.5%) women are obese as per the IOM pre-pregnancy weight category. The mean GWG in all the women is 10.6 kg (SD 4.59). Figure 1 shows the distribution of GWG following IOM guidelines in all 4 weight categories.

121 (52.6%) of all 230 babies are females and 109 (47.4%) are males. The mean BW and GA of all the babies born are 2.72 kg (SD 0.55) and 36.42 (SD 1.75) weeks, respectively. The number of SGA, LGA, and AGA babies is 25 (10.9%), 25 and 180 (78.3%), respectively. Eighty-six (39.4%) babies

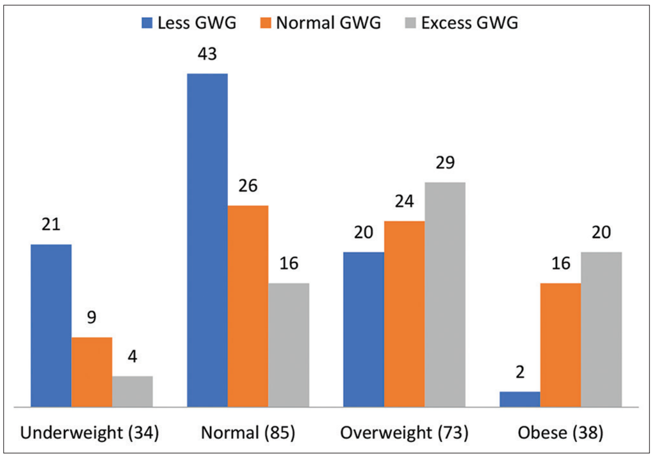

Figure 1: Distribution of gestational weight gain categories among pre-pregnancy body mass index categories

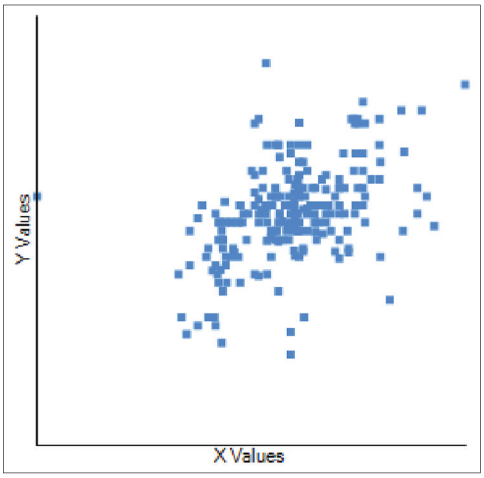

Figure 2: A scatter diagram showing the correlation between maternal pre-pregnancy body mass index (ppBMI) and birth weight of their babies, X values=ppBMI, Y values=Birth weight

were delivered normally and 144 (62.6%) by CS. Fifty-nine (25.65%) babies developed complications and needed NICU admission.

Figure 2 shows that there is a significant positive correlation between maternal ppBMI and BW of their babies (Pearson's correlation coefficient R=0.4517, *P*<0.00001), indicating that underweight mothers have a risk of delivering LBW babies, whereas overweight and obese mothers have a risk of delivering larger babies.

Table 1 shows that the results of independent t-tests comparing the BW of babies of underweight and obese mothers with that of normal BMI mothers, respectively, are statistically significant, indicating that underweight women have a risk of delivering LBW babies whereas obese women have a risk of delivering larger babies. BW of babies born to overweight mothers was not significantly higher than normal BMI mothers.

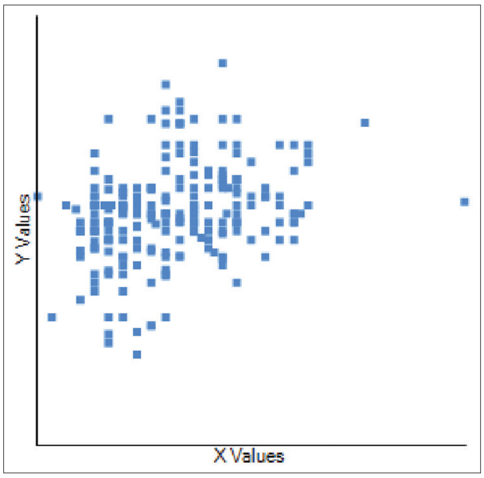

Figure 3: A scatter diagram showing the correlation between maternal gestational weight gain (GWG) and birth weight of their babies, X values=GWG, Y values=Birth weight

Table 1: The results of independent t-tests comparing the BW of babies of underweight, overweight, and obese mothers with that of normal BMI mothers, respectively

ppBMI category	t-value	P-value*
Underweight	−5.9082	<0.00001
Overweight	0.9097	1.82198
Obese	4.111	0.000036

*Results significant at *P*<0.05, BW: Birth weight, BMI: Body mass index, ppBMI: Pre-pregnancy body mass index

Figure 3 shows that there is a significant positive correlation between maternal GWG and BWs of their babies (Pearson's correlation coefficient R=0.3057, *P*<0.00001), indicating that mothers who have inadequate GWG have a risk of delivering LBW babies, whereas mothers having excess GWG have a risk of larger babies.

Table 2 shows that the results of independent t-tests comparing the BW of babies of mothers having inadequate and excess GWG with that of mothers having normal GWG, respectively, are significant, indicating that women having inadequate GWG have a risk of delivering LBW babies whereas women having excess GWG have a risk of larger babies.

The correlation between maternal ppBMI and GA of babies was studied. The results are not significant at *P*<0.05 (Pearson's correlation coefficient R=0.1065, P=0.8647), indicating that the chances of preterm or term delivery will be similar in all ppBMI categories.

However, the result of the independent t-test comparing the GA of babies of underweight mothers with that of normal BMI mothers is significant (t=−3.3682, P=0.00051), indicating that underweight women have a greater risk of delivering preterm babies. The results of the independent t-tests comparing the GA of babies born to overweight and obese mothers compared to that of normal BMI mothers are however not significant (t=0.4627, P=0.3221 and t=−1.1489, P=0.1264, respectively), indicating that lower ppBMI can affect the GA leading to preterm deliveries, but higher ppBMI does not.

The correlation between GWG and GA of babies was studied. The results are not significant at $P<0.05$ (pearson's correlation coefficient R=0.1188, P=0.7214), indicating that the chances of preterm or term delivery will be similar in all GWG categories.

The result of an independent t-test comparing the GA of babies of mothers having inadequate GWG with normal GWG is significant (t=−2.5333, P=0.0061), indicating that women having inadequate GWG have a risk of delivering preterm. However, the result of the independent t-test comparing the GA of babies of mothers having excess GWG with normal is not significant (t=−1.2152, P=0.1132), indicating that higher GWG does not seem to affect the GA unlike lower GWG.

Table 3 shows that the results of Chi-square tests comparing immediate postnatal NICU requirement in babies of underweight and obese mothers with that of normal BMI mothers are significant, indicating that neonates of underweight and obese women have a risk of developing significant early postnatal complications requiring NICU stay. NICU requirement of babies of overweight mothers was not significant compared to normal. This indicates that chances of developing significant immediate postnatal complications are greater at extremes of ppBMI categories only.

Table 2: The results of independent t-tests comparing the BW of babies of mothers having inadequate and excess GWG with that of mothers having normal GWG, respectively

GWG	t-value	P-value*
Less	−4.6658	<0.00001
Excess	5.1006	<0.00001

*Results significant at $P<0.05$, GWG: Gestational weight gain, BW: Birth weight

Table 3: The results of Chi-square tests comparing the immediate postnatal NICU requirement of babies of underweight, overweight, and obese mothers with that of mothers having normal ppBMI, respectively

ppBMI category	Chi-square statistic	P-value
Underweight	7.1853	0.0074
Overweight	0.332	0.5642
Obese	5.1738	0.2293

ppBMI: Pre-pregnancy body mass index, NICU: Neonatal intensive care unit

The results of Chi-square tests comparing the immediate postnatal NICU requirement of babies of mothers having inadequate and excess GWG with normal are significant (P=0.0445 and 0.0195, respectively), indicating that babies of women having inadequate and excess GWG have a greater risk of perinatal complications.

The result of Chi-square test comparing the occurrence of LGA in obese mothers with normal is significant (P=0.000074), indicating that LGA babies were significantly more common in obese mothers than normal. SGA was however not more frequent in other ppBMI categories compared to normal. LGA was not significantly higher in overweight mothers compared to normal.

The result of Chi-square test comparing the occurrence of SGA in mothers with less GWG with normal GWG is significant (P=0.005085), indicating that SGA babies were significantly more common in mothers with less GWG. SGA was not more frequent in babies of mothers with excess GWG compared to normal.

The result of Chi-square test comparing the occurrence of LGA in mothers with excess GWG with normal is significant (P=0.00116), indicating that LGA babies were significantly more common in mothers with excess GWG.

The result of Chi-square test comparing the occurrence of CS in mothers with excess GWG with normal is significant (P=0.026591), indicating that CS was significantly more common in excess GWG.

The results of Chi-square tests comparing the occurrences of CS in overweight and obese mothers with normal are significant (P=0.017044 and 0.002177, respectively), indicating that CS was significantly more common in overweight and obese mothers than normal.

DISCUSSION

Our study shows that BW has a positive correlation with ppBMI and women with obesity had a risk of delivering babies with higher BW. Tela et al., also showed a significant positive correlation of ppBMI with BW in their study.[10] Similar findings were obtained by Goldstein et al., Li et al., and Slack et al.[11-13] Papazian et al., McCall et al., and Chen et al., stated that neonatal macrosomia was significantly higher in obese mothers.[14-16]

Our study shows that BW has a positive correlation with GWG and women with excess GWG had a risk of delivering babies with higher BW. Tela et al., also showed a significant positive correlation of GWG with BW in their study.[10] Dahake and Shaikh found a significant association between BW and GWG.[17] Li et al., stated that weekly GWG is positively associated with the physical growth of infants of different ages.[12] Bouvier et al., showed that women with excess GWG had a risk of delivering macrosomic neonates.[18] Similar findings were obtained by Goldstein et al., Guan et al., Goldstein et al., Chen et al., and Wang et al.[2,11,16,19,20] We found that mothers with less GWG had a risk of having LBW babies, similar to Papazian et al., Guan et al., and Wang et al.[14,19,20]

We found that women with obesity had a risk of delivering babies with LGA**.** Dzakpasu et al., showed that women with obesity had a significant association with LGA, similar to our study.[21]

We also found that women with excess GWG had a risk of delivering babies with LGA. Bouvier et al., showed that women with excess GWG had a risk of delivering LGA neonates.[18] Dzakpasu et al., Guan et al., and Goldstein et al., too showed that women with excess GWG had a significant association with LGA, similar to our study.[2,19,21] Rogozinska et al., showed that there is two fold increase in odds of LGA with increasing GWG.[22]

We found that less GWG was associated with SGA. Goldstein and Dzakpasu et al., showed that less GWG was significantly associated with the risk of SGA.[11,21] Rogozinska et al., and Guan et al., showed that the risk of SGA increases significantly in inadequate GWG.[19,22] Goldstein et al., showed that low GWG is associated with SGA.[2]

We found that underweight women had a risk of delivering LBW babies but not SGA. These findings are substantiated by Papazian et al., showing that infants of underweight women have a higher risk of LBW than normal.[14] Dzakpasu et al., found that underweight had a significant association with SGA, which does not match our results.[21] This difference is probably due to the significantly higher numbers of preterm deliveries in underweight mothers.

Dahake and Shaikh found no significant association between GA and GWG, similar to our study.[17] We found that mothers with inadequate GWG had a risk of delivering preterm. Goldstein showed that less GWG was associated with the risk of preterm delivery.[11] Rogozinska et al., stated that there is two fold increase in the odds of preterm birth with decreasing GWG.[22] Guan et al., and Goldstein et al., found that the risk of preterm increases significantly in inadequate GWG.[2,19] Dzakpasu et al., indicated that excess GWG only had a significant association with preterm birth, which does not match our results.[21]

We found that underweight mothers had a risk of delivering preterm. Gennette mentioned that underweight women have a higher risk of spontaneous preterm birth.[23] Another study showed that pre-pregnancy overweight and obesity are associated with increased rates of preterm, unlike our findings.[16]

Our study found that babies of women with underweight and obesity had risk of NICU admission due to perinatal complications. Bouvier et al., stated that ppBMI was a major determinant of pregnancy outcome.[18] Similar findings were obtained by Goldstein et al., and Chen et al.[11,16] Papazian et al., showed that maternal obesity caused significantly higher rates of NICU admission.[14] McCall et al., showed that high maternal BMI is associated with low Apgar score at 5 min.[15]

Our study found that babies of women with inadequate and excess GWG had a risk of NICU admission due to perinatal complications. Similar findings were obtained by Goldstein et al.[11] Bouvier et al., stated that such perinatal complications could be reduced by controlling the GWG in the second trimester.[18]

Our study showed that mothers with overweight and obesity were more likely to deliver by CS. The same findings were established by Bouvier et al., Nkoka et al., and Chen et al.[16,18,24] According to Slack et al., in South Asian women, maternal pre or early pregnancy anthropometric measurements are associated with the mode of delivery.[13] McCall et al., showed that high maternal BMI is associated with CS.[15]

Our study showed that mothers with excess weight gain were more likely to deliver by CS. The same findings were established by Bouvier et al., Goldstein et al., Kominiarek and Peaceman, and Guan et al.[5,11,18,19] Rogozinska et al., showed that there is a 5% increase in odds of CS with increasing GWG.[22] Goldstein et al., and Chen et al., also showed that high GWG is associated with CS.[2,16]

CONCLUSION

From this study, we conclude that ppBMI and GWG are determinants of BW and perinatal complications requiring NICU stay. Obesity is associated with higher BW, LGA, higher rates of CS, and NICU admission. Underweight is associated with LBW, preterm, and a higher NICU admission rate. Less GWG is associated with SGA, LBW, preterm, and higher NICU admission rates. Excess GWG is associated with higher BW, LGA, and higher rates of CS and NICU admission. This indicates the importance of dietary interventions and exercise in reproductive age women so that they have a normal BMI at conception. The same is essential throughout pregnancy so that the pregnancy-related complications are minimized and a healthy neonate with normal BW is born. Further studies with larger samples are required to understand if there is an association between obesity, excess GWG, and preterm birth.

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SM- Literature review, concept, design, data collection, review; **AM**- Planning statistical analysis, data analysis, drawing conclusions.

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