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Early pregnancy body mass index and gestational weight gain in relation to neonatal birth weight: An observational study

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ABSTRACT

Background: The pattern of gestational weight gain (GWG) and pre-pregnancy body mass index (BMI) are indicative of maternal and fetal nutrition during pregnancy and contribute to their later health. However, there is a paucity of studies related to this association from developing countries like India.

Objective: To study early pregnancy body mass index and gestational weight gain in relation to neonatal birth weight.

Methodology: This observational study was conducted on 1031pregnant women, aged 18-35 years, from June 2014-December 2015. Data was collected by a pre-designed questionnaire. Pre-pregnancy BMI and GWG gain at antenatal visits were noted. National health mission (NHM, 2014) guidelines were used to assess weight gain. Neonatal birth weight and gestational age at birth were noted post-delivery. Statistical analysis was performed using R software (Version 3.6.0).

Results: Majority of the women were 21-25 years old (57.81%), nullipara, normal BMI (72.16%) with poor education level (61.69%) and good socio-economic status (31.91%). Neonatal birth weight was within normal range (2.5-2.99 Kg) (41.22%) with maternal GWG within NHM recommendation (71%). A significant association was observed between neonatal birth weight and maternal BMI (P>0.001). A significant difference was observed in weight gain in 1st and 2nd trimester between underweight and normal weight subjects (P <0.05). Distribution of neonatal birth weight born to women with 1-4 Kg weight gain during 1st trimester (P<0.05) and with 3-7 Kg during 2nd and 3rd trimester (P<0.001) was significantly different. A significant positive correlation existed between maternal BMI and neonatal birth weight (P<0.001); total GWG and birth weight of neonates for most demographic characters (P <0.05).

Conclusion: Maternal early pregnancy BMI and GWG are positively associated with neonatal birth weight with GWG causing an increase in birth weight.

Key words: Body mass index, Gestational weight gain, Pregnancy, Birth weight, Obesity

INTRODUCTION

Birth weight plays an essential role in infant survival, childhood development and their health status in adulthood. It is an indicator of perinatal risk and a representation of fetal nutritional exposure (1). Birth weight indicates pregnancy conditions and impacts quality of life, development and growth of a child, along with morbidity and mortality during childhood (2).

Among various factors that affect birth weight of neonates, inadequacies in pre-pregnancy and gestational nutritional status affecting pre-pregnancy body mass index (BMI) and gestational weight gain (GWG) of mother are of special concern (3).Pre-pregnancy obesity and overweight are significantly associated with gestational diabetes and hypertension, cesarean delivery, preterm birth along with high or low birth weight of neonates (2). Low birth weight and preterm birth have also been associated with a low pre-pregnancy BMI (3).

Low pre-pregnancy BMI leads to an increased risk of infants born small for gestational age (SGA) along with low birth weight. Whereas high pre-pregnancy BMI results in the risk of infants born large for gestational age (LGA) with macrosomia, high birth weight, and increased risk of obesity or overweight in future (4).Excessive GWG also causes increased newborn weight (LGA) and inadequate GWG acts as a risk factor for lower birth weight and SGA infants. Maternal pre-pregnancy BMI and GWG are also related to intrauterine growth restriction (5).

Specific to pre-pregnancy body mass index (BMI) group, the recommendations for GWG by Institute of Medicine (IOM) include recommended ranges for total GWG, rate of weight gain/ week for the first, second and third trimesters (6).However, these guide lines were made with limited evidenced resources on how the timing and pattern of GWG affects health outcomes. For example, a pregnant woman early in pregnancy might show low GWG and then later in pregnancy might have rapid GWG. Therefore, the IOM had recommended future research in this area (6).

Despite current evident interventions during pregnancy such as health education, weight monitoring, and weight management counseling, most pregnant women in developing countries lack access to these services and information (7). Thus, for antenatal care providers and pregnant women from developing countries, the pregnancy weight gain issue remains of low priority (8). Therefore, it is essential to study early pregnancy BMI and GWG in relation to birth weight in an Indian setup.

Few studies have conducted research in line with the fact that the trimester specific rate and pattern of GWG is indicative of maternal body water and body fat (9). They are highly associated with neonatal weight supporting the importance of trimester specific GWG monitoring (9).This study investigated early pregnancy body mass index and trimester specific GWG in relation to neonatal birth weight.

MATERIALS AND METHODS

Study design

With the institutional ethics committee's approval, asingle-centered, hospital-based, prospective, observational study was conducted in the Department of Obstetrics and Gynecology at a tertiary hospital in Karad (Maharashtra)over a period of 18months(June 2014-December 2015).Written informed consent was obtained from all the patients.

Selection criteria

One thousand thirty-on pregnant women agedbetween18and 35yearsand booked for regular antenatal care before 12 weeks of pregnancy with singleton pregnancy were included. Patients with multiple gestations, congenital anomaly of fetus, chronic hypertension, renal disease, or cardiac disease, preterm delivery (before 37 completed weeks), pregnancy complications like GDM (gestational diabetes mellitus), re-eclampsia, were excluded.

Data collection

Data regarding age, educational and social status [As per modified B.G. Prasad classification of socioeconomic status (Prasad, 1970)], medical history, was collectedwith the help of pre-designed questionnaire.

By using maternal weight before pregnancy and height of pregnant women, the body mass index (BMI) was calculated. Based on WHO criteria, pregnant womenwere divided into 4 groups: underweight (< 18.5 kg/m2), normal weight (18.5–24.9 kg/m2), overweight (25.0–29.9 kg/m2) and obese (> 30 kg/m2) (10). Gestational weight gain (GWG) was calculated using the pre-pregnancy weights of pregnant womenand the weights on the day of labor ward admission. GWG gain of pregnant women was also noted during every antenatal check-up visits.National health mission (NHM, 2014) guidelines were used to assess weight gain in terms of pre-pregnancy BMI. Total GWG was categorized into the following: underweight (12.7–18.4 kg), normal weight (11.5–16 kg), overweight (6.8–11.34 kg), obese (5–9.07 kg)(11).

GWGof pregnant women was noted atevery antenatal check-up visit.Newborns' birth weights and gestational age at birth were noted according to WHO growth charts post-delivery (12).

Statistical analysis

Statistical analysis was performed by using R software (Version. 3.6.0). Data wasrecorded in Microsoft excel and expressed as mean ± standard deviation along with frequency and percentage. Qualitative variables were analyzed using Chi-squaretest of independence and Kruskal-Wallis test for continuous variables. Correlation between the variables was calculated using Spearman's rank correlation.Data was considered statistically significant when $P \leq 0.05$.

RESULTS

The study was carried out in 1031pregnant women. Table 1 presents the distribution of demographicand baseline variables.Majorityof the women were young.Most of them were Hindu by religion with poor educational statusas majority of them had <12 years in school. Their socioeconomic status showed that most of them either belong to upper middle class or upper with most of them being a housewife. Majority of pregnant women were nullipara and had normal BMI. After delivery, most neonates had a healthy birth weight. Further, post-delivery, most women had their weight gain within NHM recommendations (Table 1).

A highly significant association was observed between birth weight of neonate with BMI of mother (P>0.001). h (Table 2). Distribution of GWG in 1st and 2nd trimester changes significantly over BMI. A significant difference was observed in distribution of weight gain in 1st and 2nd trimester between underweight and normal weight subjects (P <0.05). However, no significant difference was observed in distribution of GWG in 3rd trimester and total GWG over BMI (P >0.05) (Table 3).

A significant difference was observed in the distribution of birth weight of neonates born to pregnant women with 1 to 4Kg weight gain during 1st trimester (P<0.05) (Table 4). A highly significant difference was observed in the distribution of birth weight of neonates born to pregnant women with 3 to 7 Kg weight gain during 2nd trimester and during 3rd trimester (P<0.001) (Table 4),

Overall, neonates born to pregnant women with a total weight gain of 8-17 kg and weight gain according to NHM recommendations also showed a highly significant difference in their birth weight (P<0.001) (Table 4).A significant positive correlation was observed between BMI of pregnant women and birth weight of their neonates (Table 5).

A significantly positive correlation was noted between total GWG and birth weight of neonates for all education levels, socio-economic status except that of lower class, employment status, parity and BMI categories except obese (30 and above) (P<0.05) (Table 6).However, a significantly negative correlation was noted between total GWG and birth weight of neonates for weight gain above NHM recommendations (P>0.05) (Table 6).

DISCUSSION

Pre-pregnancy BMI and GWGin pregnant women are associated with early childhood growth patterns that incline children towards obesity, and various adverse outcomes such as gestational diabetes, small and large for gestational age infants, cesarean, preterm delivery, and sometimes infant death (3). Understanding the interaction among these variables is essential for analyzing the composite determinants and for developing potent interventions for various adverse maternal outcomes and childhood obesity (13).Therefore, the present prospective study was carried out to study of the relation between early pregnancy BMI and gestational weight gain with neonatal birth weight.

Majorityof the women were young, nullipara, with normal BMI and poor educational status. Most of them had good socio-economic status and were housewives. This is in line with the study conducted by Chen et alin which most of the pregnant women were in the age group of 25-29 years, nullipara, with normal BMI andpooreducational status but in contrast to our study most of the subjects had poor socio-economic status (14). This differencecould be due to different ethnic and geographical backgrounds,as present study had most of the women coming from well-off families.

After delivery, most of the neonates born to these women had a healthy birth weight as observed. This could be attributed to the fact that women with normal BMI usually give birth to normal birth weight babies. Also, women belonging to good socio-economic status tend to have good antenatal care facilities such as good nutrition and regular antenatal check-ups which affect the development and growth of foetus (15).

A significant association was observed between birth weight of neonate with BMI of mother, which is in accordance with the study performed by Yu et al (3).Neonates of women with high pre-pregnancy BMI have a phenotype responsible for rapid weight gain of neonate in the first months of his/her life, which is further followed by assisted elevation in percentile for weight-for-length throughout their first year of life. On the other hand, neonates of mothers with normal BMI prior to pregnancy can normalize over time their growth trajectory (16).

Distribution of GWG in 1^{st} and 2^{nd} trimester changes significantly over BMI. A significant difference was observed in distribution of weight gain in 1^{st} and 2^{nd} trimester between underweight and normal weight pregnant women. A high GWG was noted especially in the 2^{nd} trimester. This is in accordance with the study findings of Du et al as they noted a significant association between GWG in first two trimesters of pregnancy with the first two pre-BMI categories (underweight and normal weight of pregnant women)(17). Higher GWG especially during the 2^{nd} trimester is usually associated with higher levels of growth-promoting factors such as IGF (Insulin-like growth factor)-1, IGF-2, IGFBP-3, and high levels of leptin in cord blood (18).

Birth weight of neonates changed significantly with weight gain by their mothers in 1^{st}, 2^{nd}, 3^{rd} trimester with a total weight gain of 8-17 kg which was according to NHM recommendations. With increasing GWG the birth weight of neonates increased. Similar results have been noted in previous studies (14,16).Weight gain by the mothers during the three trimesters of pregnancy, especially initial trimesters have significant effect on neonatal birth weight.In the first trimester, each kilogram of weight gain might result in 12.89 gm more neonatal birth weight for overweight women and 23.25 g less neonatal birth weight for underweight women, respectively, in comparison to normal weight women.This would further influence the weight gain effects inall three trimesters on neonatal birth weight (19). Henceforth, a pregnant woman needs to control the amount and the rate of weight gain as well as the pattern in which she gains weight gain during the three trimesters (19).

In the present study, BMI of pregnant women and birth weight of their neonates were positively correlated with each other. This indicates pregnant women with low BMI (underweight) have greater chances of giving birth to an underweight neonate and a pregnant woman with high BMI (overweight/obese) might give birth to an overweight (obese) neonate. These findings are in line with the study findings by Silva et al (15). Women with low pre-pregnancy BMI have higher and increased risks of adverse neonatal birth outcomes such as preterm birth and low birth weight (LBW) (20). Further, with a high BMI (obese) the frequency of macrosomia increases. An obese pregnant woman seems more likely to have a macrosomic neonate than a normal BMI (normal weight) woman (21).

A significantly positive correlation was noted between total GWG and birth weight of neonates for all education levels, socio-economic status except that of lower class, employment status, parity. This is in line with the study conducted by Chen et al (14).This suggests that socio-economic factors of mother have a great impact on the total GWG and birth weight of neonates. It is noted that women with less than a high school degreeand low income had higher odds of gaining inadequate GWG which is mostly due to a less understanding of the benefits of a healthy pregnancy diet andrestricted access to healthy food (22).

Therefore, itis important to limit weight gain in pregnancy to reduce the risk of complications during pregnancy and delivery and to avoid overweight and obesity later in life and the possible accompanying health related problems.

Our study has its own limitations. First, the sample size included only low-risk pregnant women. Second, maternal, and fetal outcomes of these associations under study were not explored. Third, management strategy for under and over GWG, and low and high pre-pregnancy BMIin relation to neonatal birth weight has not been explored. Future studies are recommended forthe above studied relationship of GWG and BMI with neonatal birth weight in high-risk pregnancies and to explore various management strategies for preventing the adverse effects.

CONCLUSION

With increasing pre-pregnancy BMI and GWG of mother, the chances of increase in neonatal birth weight also increases. Therefore, it is important to limit weight gain in pregnancy to reduce the risk of complications during pregnancy and delivery. Further, it is essential to explore the various adverse outcomes of these associations not only for the neonates but also for the mothers.

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TABLES

Table 1: Distribution of demographic and baseline variables

Variables	**(n=1031)** **f (%)**

Age groups (years)	
18-20	157 (15.23)
21-25	596 (57.81)
26-30	251(24.35)
>30	27 (2.62)
Religion	
Hindu	920 (89.23)
Muslim	68 (6.6)
Others	43 (4.17)
Education level	
<12 years in school	636 (61.69)
>12 years in school	395 (38.31)
Socioeconomic status (in class) [b]	
Lower class	12 (1.16)
Lower middle class	119 (11.54)
Middle class	283 (27.45)
Upper middle class	329 (31.91)
Upper class	288 (27.93)
Employment status	
Housewife	856 (83.03)
Working	175 (16.97)
Parity	
Nullipara	559 (54.22)
Non-Nullipara	472 (45.78)
BMI (Kg/m^2)	
<18.5	150 (14.55)
18.5-24.9	744 (72.16)
25-29.9	122 (11.83)
30 and above	15 (1.45)
Birth weight of neonate (in Kg)	
<2.5	158 (15.32)
2.5-2.99	425 (41.22)
3.0-3.49	346 (33.56)
3.5-3.99	96 (9.31)
4 and above	6 (0.58)
GWG according to NHM Recommendations	
Below Recommendation	196 (19.01)
Within Recommendation	732 (71)
Above Recommendation	103 (9.99)

GWG: Gestational weight gain; f: frequency; %: percentage; b: As per modified B.G. Prasad classification of socioeconomic status (Prasad, 1970); BMI: body mass index; Kg: kilogram; NHM: National health mission

Table 2: Association of birth weight of neonate with BMI of mother

BMI of mother (Kg/m^2)	**Birth weight of neonate (Kg) (n=1031)**					***P* value** [c]
	< 2.50 f (%)	**2.50-2.99 f (%)**	**3.00-3.49 f (%)**	**3.50- 3.99 f (%)**	**≥ 4 f (%)**	
< 18.5	73	42	31	4	0	< 0.001**
18.5- 24.9	80	354	288	22	0	

25.0- 29.9	5	28	25	63	1	
≥ 30	0	1	2	7	5	

BMI: Body mass index; C: Chi-square test of independence; f (%): frequency (percentage); *= highly significant

Table 3: Comparison of gestational weight gain (GWG) by pregnant women in 1st, 2nd and 3rd trimesters and total weight gain over BMI

GWG (Kg)	**BMI (Kg/m^2)**				***P* value ^{KW}**
	< 18.5 (Underweight)	**18.5 – 24.9 (Normal weight)**	**25.0 – 29.9 (Overweight)**	**≥ 30 (Obese)**	
	(Mean ± SD)	**(Mean ± SD)**	**(Mean ± SD)**	**(Mean ± SD)**	
1st Trimester	1.75 ± 0.59	1.6 ± 0.58	1.66 ± 0.65	1.8 ± 0.86	0.0453*
2nd Trimester	5.11 ± 0.79	5.33 ± 0.67	5.29 ± 0.83	4.93 ± 0.8	0.0049*
3rd Trimester	5.18 ± 0.67	5.28 ± 0.61	5.21 ±0.67	5.07 ± 0.8	0.2217
Total gestational weight gain	12.03 ± 1.39	12.21 ± 0.92	12.16 ± 1.49	11.8 ± 2.04	0.4916

GWG: Gestational weight gain; BMI: Body mass index; SD: Standard deviation; KW: Kruskal Wallis Test; Kg: Kilogram; *= significant

Table 4: Comparison of birth weight of neonates and weight gain by pregnant women during each trimester, total weight gain and weight gain according to NHM recommendations

GWG (in Kg)	**Birth weight of neonate (Kg) (Mean ± SD)**	***P* value^{KW*}**
1st trimester		
1	2.89 ± 0.42	0.0179*
2	2.96 ± 0.41	
3	3.01 ± 0.45	
4	3.77	
2nd trimester		
3	2.51 ± 0.4	< 0.001**
4	2.69 ± 0.46	
5	2.91 ± 0.41	
6	3.03 ± 0.38	
7	3.28 ± 0.59	
3rd trimester		
3	2.52 ± 0.21	< 0.001**
4	2.69 ± 0.47	
5	2.92 ± 0.42	
6	3.02 ± 0.39	
7	3.06 ± 0.47	
Total weight gain		
8	2.31 ± 0.21	< 0.001**

9	2.57 ± 0.45	
10	2.59 ± 0.5	
11	2.65 ± 0.42	
12	2.97 ± 0.38	
13	3.01 ± 0.35	
14	3.19 ± 0.43	
15	3.2 ± 0.43	
16	3.87 ± 0.13	
17	2.83 ± 0.7	
GWG according to NHM recommendations		
Below recommendations	2.49 ± 0.34	< 0.001**
Within recommendations	2.96 ± 0.3	
Above recommendations	3.56 ± 0.37	

GWG: Gestational weight gain; NHM: National health mission; SD: Standard deviation; KW: Kruskal Wallis Test; Kg: Kilogram; *: significant; **: highly significant

Table 5: Correlation of BMI with birth weight of neonates, weight gain at each trimester and total weight gain

Correlation	**rho-value**	***P* value** [s]
BMI and GWG in 1st trimester	-0.0358	0.2507
BMI and GWG in 2nd trimester	0.0546	0.7994
BMI and GWG 3rd trimester	0.0502	0.1073
BMI and total GWG	0.0372	0.2323
BMI and birth weight of neonate	0.3540	< 0.001**

BMI: Body mass index; GWG: Gestational weight gain; Kg: Kilogram S: Spearman's rank correlation; **: highly significant

Table 6: Correlation of total GWG by pregnant women and birth weight of their neonates over different variables

Variable	**Mean ± SD**		**rho-value**	***P* value** [s]
	Total GWG (Kg)	**Birth weight of neonate (Kg)**		
Education level				
<12 years in school	12.06 ± 1.09	2.89 ± 0.4	0.3567	< 0.001**
>12 years in school	12.36 ± 1.1	3 ± 0.44	0.2487	< 0.001**
Socio-economic status				
Lower class	10.92 ± 1.38	2.62 ± 0.46	0.3148	0.319
Lower-middle class	11.8 ± 1.16	2.75 ± 0.41	0.5256	< 0.001**

Middle class	12.1 ± 1.08	2.89 ± 0.4	0.3878	< 0.001**
Upper middle class	12.28 ± 1.08	2.9 ± 0.39	0.2716	< 0.001**
Upper class	12.34 ± 1.04	3.1 ± 0.42	0.1569	0.0076*
Employment status				
Housewife	12.19 ± 1.1	2.96 ± 0.42	0.3054	< 0.001**
Working	12.12 ± 1.09	2.8 ± 0.37	0.4324	< 0.001**
Parity				
Nullipara	12.16 ± 1.04	2.92 ± 0.43	0.3233	< 0.001**
Non-nullipara	12.2 ± 1.18	2.95 ± 0.41	0.3230	< 0.001**
BMI (Kg/m^2)				
<18.5	12.03 ± 1.39	2.61 ± 0.44	0.6799	< 0.001**
18.5-24.9	12.21 ± 0.92	2.91 ± 0.33	0.2669	< 0.001**
25-29.9	12.16 ± 1.49	3.35 ± 0.44	0.3897	< 0.001**
30 and above	11.8 ± 2.04	3.76 ± 0.41	0.2485	0.3719
GWG according to NHM recommendations				
Below recommendations	10.86 ± 0.82	2.49 ± 0.34	0.0862	0.2296
Within recommendations	12.43 ± 0.84	2.96 ± 0.3	0.0376	0.3102
Above recommendations	12.83 ± 1.32	3.56 ± 0.37	-0.2025	0.0423*

BMI: Body mass index; GWG: Gestational weight gain; Kg: Kilogram; NHM: National health mission; SD: Standard deviation; S: Spearman's rank correlation; *: significant; **: highly significant0000000000000000000000000000000000000000000000000000000000000000000000000000