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Original Research Article

Association between gestational weight gain and pregnancy outcomes in women with diabetes

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ABSTRACT

Background: Hyperglycemia is a common complication of pregnancy, and the prevalence of both pregestational and gestational diabetes has increased substantially over the past decade. Hyperglycemia in pregnancy is associated with adverse maternal and neonatal outcomes. Pre-pregnancy weight and gestational weight gain (GWG) are important determinants of maternal and fetal health. To investigate the association between GWG and adverse maternal and neonatal outcomes in women with diabetes.
Methods: A retrospective study included 1,600 singleton pregnant women with diabetes who delivered at Rajavithi Hospital between January 2016 and December 2023. GWG was classified according to Institute of Medicine (IOM) recommendations based on pre-pregnancy body mass index (BMI).
Results: Among the 1,600 pregnancies, 4.81% were underweight, 44.69% normal weight, 30.94% overweight, and 19.56% obese. Excessive GWG was associated with increased risks of gestational hypertension (adjusted odds ratio (aOR) 5.70, 95% confidence interval (CI) 1.73-18.80), large-for-gestational-age (LGA) (aOR 2.22, 95% CI 1.63-3.01), macrosomia (aOR 1.97, 95% CI 1.05-3.70), and postpartum hemorrhage (aOR 2.58, 95% CI 1.24-5.40), while reducing the risk of small-for-gestational-age [SGA] (aOR 0.45, 95% CI 0.21-0.95). Insufficient GWG was associated with lower risks of preeclampsia (aOR 0.43, 95% CI 0.20-0.93) and LGA (aOR 0.64, 95% CI 0.42-0.96), but with a higher risk of preterm birth (aOR 1.87, 95% CI 1.11-3.15).
Conclusions: In women with diabetes, excessive GWG is associated with adverse maternal and neonatal outcomes. Insufficient GWG is associated with reduced risks of various adverse outcomes.

Keywords: Gestational weight gain, Pre-pregnancy body mass index, Diabetes mellitus in pregnancy, Adverse pregnancy outcomes

INTRODUCTION

Hyperglycemia is one of the most common complications in pregnancy. There are two main types of diabetes in pregnancy: pre-gestational diabetes and gestational diabetes. The prevalence of both pregestational and gestational diabetes has increased dramatically in the past decade across all ethnic groups. A recent study in Northern Thailand found that from 2003 to 2022, pre-gestational and gestational diabetes continuously increased from 0.3% to 1.5% and 3.4% to 22%.[1] All forms of hyperglycemia in pregnancy are associated with worse perinatal outcomes (e.g., preeclampsia, preterm birth, fetal macrosomia).[2] Pre-pregnancy weight and weight gain during pregnancy are important factors influencing maternal and fetal health. The Institute of Medicine (IOM; Washington, DC, USA) revised the guidelines for weight gain during pregnancy. Total weight gain for women with a pre-pregnancy BMI below 18.5 is 12.5-18 kg throughout pregnancy. For women with a pre-pregnancy BMI of 18.5-24.9, weight gain should be 11.5-16.0 kg throughout pregnancy. Women with a pre-pregnancy BMI of 25.0-29.9 should

have 7-11.5 kg weight gain throughout pregnancy. Women with grade I obesity (BMI of 30.0-34.9) should gain 4.5-11.0 kg with grade II obesity (BMI of 35.0-39.9) 0-4 kg, and with grade III obesity (BMI over 40.0) up to 0-4 kg throughout pregnancy.[3] Diabetes mellitus in pregnancy and excessive or insufficient weight gain during pregnancy are also serious medical problems.[4] Previous studies have found that excessive total weight gain in women with GDM was linked to increased adverse pregnancy outcomes and neonatal morbidity.[5,6] However, the effects of gestational weight gain (GWG) on maternal and neonatal outcomes in diabetic pregnancies remain controversial. Therefore, the aim of this study was to evaluate the GWG with pre-pregnancy BMI and pregnancy outcomes among pregnant women with diabetes mellitus.

METHODS

A retrospective cohort study included data from 1,600 singleton pregnant women with diabetes who delivered at Rajavithi Hospital between January 2016 and December 2023. The study was approved by the ethics committee of Rajavithi Hospital (No. 67153). The flow diagram of participant selection is demonstrated in Figure 1. The inclusion criteria were women diagnosed with diabetes, including gestational diabetes mellitus (GDM) and pre-GDM (PDM), who were aged 18 years or older and delivered at a gestational age of 25 weeks or more. The exclusion criteria included unavailable information on pre-pregnancy weight, height, or BMI (n=508); multifetal gestation (n=66); maternal chronic hypertension (CHT) (n=265); and other maternal comorbidities (e.g. heart disease, renal disease) (n=25). A total of 3,924 women with diabetes were initially identified. After applying the exclusion criteria, 864 individuals were excluded, resulting in 3,060 eligible participants. Computer-generated simple random sampling was then conducted, yielding a final analytic sample of 1,600 patients.

Data collection

Data were retrieved from medical records. Maternal characteristics and clinical variables included maternal age; gravida; parity; gestational age; pre-pregnancy body weight, height, and BMI; body weight at labor; total gestational weight gain; mode of delivery; type of diabetes mellitus; estimated blood loss; obstetric complications; fetal birth status; birth weight; Apgar scores at 1, 5, and 10 minutes; NICU admission; and neonatal respiratory distress.

Diagnosis of PDM and GDM

PDM was diagnosed according to ADA criteria before pregnancy (FPG ≥7.0 mmol/l, HbA1c ≥6.5%, or RPG ≥11.1 mmol/l with confirmation).[7] GDM was diagnosed during pregnancy using the two-step approach with a 100-g oral glucose tolerance test (OGTT) based on Carpenter-Coustan thresholds. GDM was confirmed when at least two values met or exceeded the diagnostic criteria: fasting ≥5.3 mmol/l (95 mg/dl), 1-hour ≥10.0 mmol/l (180 mg/dl), 2-hour ≥8.6 mmol/l (155 mg/dl), or 3-hour ≥7.8 mmol/l (140 mg/dl).[8]

Classification group based on pre-pregnancy BMI and GWG

Participants were categorized into GWG groups based on pre-pregnancy BMI according to IOM guidelines. BMI categories were 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). For each BMI category, GWG was classified as insufficient, sufficient, or excessive using the following cutoffs: <12.70/11.34/6.80/5 kg; 12.70-18.14/11.34-15.87/6.80-11.34/5-9.07 kg; and >18.14/15.87/11.34/9.07 kg for underweight, normal-weight, overweight, and obese women, respectively.[9]

Pregnancy outcomes

Pregnancy outcomes included maternal outcomes such as gestational hypertension, preeclampsia, postpartum hemorrhage, placenta accreta spectrum, placental abruption, placenta previa, intraamniotic infection, prolonged premature rupture of membranes, fetal non-reassuring status, fetal malpresentation, preterm and postterm birth. Neonatal outcomes included live birth or stillbirth, birth-weight categories (AGA, SGA and LGA), fetal macrosomia, low Apgar scores, NICU admission, and neonatal respiratory distress.

Statistical analyses

The sample size was calculated using the difference in macrosomia rates between excessive GWG and non-excessive GWG groups reported by Gou et al (18.6% vs. 13.2%).[6] With α=0.05 and 80% power, the minimum required sample was 718 participants per group. After adding 10% to account for missing data, the final target sample size was 800 per group, yielding planned allocations of 400 insufficient GWG, 400 sufficient GWG, and 800 excessive GWG participants.

Data analysis was performed using SPSS version 26. Categorical variables were summarized as frequencies and percentages, and continuous variables as mean±SD. Group comparisons were conducted using the Chi-square test for categorical data and one-way ANOVA or the Kruskal-Wallis test for continuous data. Associations between GWG and maternal or neonatal outcomes were examined using univariable and multivariable logistic regression, reported as odds ratios (ORs) with 95% CIs. Statistical significance was set at $p<0.05$.

RESULTS

Table 1 shows that a total of 1,600 women were included in the analysis, consisting of 400 (25.0%) in the insufficient GWG group, 400 (25.0%) in the sufficient

GWG group, and 800 (50.0%) in the excessive GWG group. The distribution of pre-pregnancy BMI categories was as follows: 80 women (5.0%) were underweighted, 694 (43.4%) were normal weight, 506 (31.6%) were overweight, and 320 (20.0%) were obese. Baseline characteristics differed significantly across GWG groups. Women in the excessive GWG group were younger and had a higher pre-pregnancy BMI compared with those in the sufficient and insufficient groups (p<0.001). The distribution of diabetes type also varied significantly, with the sufficient GWG group showing the highest proportion of GDM and the lowest proportion of PDM (p=0.002). Mean gestational age at delivery was slightly higher in the sufficient and excessive groups than in the insufficient group (p=0.002). Mode of delivery demonstrated significant variation, with the excessive GWG group having the highest rate of cesarean section (60.5%) compared with the other groups (p<0.001).

Table 2 summarizes maternal and neonatal outcomes across GWG groups. Gestational hypertension and preeclampsia occurred more frequently in the excessive GWG group, with significant differences among groups (p=0.001 and p=0.002). Other maternal complications did not differ significantly. Mean birth weight and birth-weight categories differed markedly across groups (p<0.001), with the excessive GWG group showing the highest mean birth weight, the greatest proportion of LGA infants, and the highest rate of macrosomia. In contrast, SGA was more frequent in the insufficient GWG group.

Table 3 shows the associations between gestational weight gain categories and maternal and neonatal outcomes using univariable and multivariable logistic regression analyses. After adjusting for maternal age, pre-pregnancy BMI, diabetes status, and gestational age, the analysis showed that excessive GWG was significantly associated with higher odds of several adverse maternal and neonatal outcomes. Women with excessive GWG had increased risks of gestational hypertension (aOR 5.70, 95% CI 1.73-18.80), postpartum hemorrhage (aOR 2.58, 95% CI 1.24-5.40), LGA (aOR 2.22, 95% CI 1.63-3.01), and macrosomia (aOR 1.97, 95% CI 1.05-3.70). Insufficient GWG was associated with a reduced likelihood of LGA (aOR 0.64, 95% CI 0.42-0.96) and an increased risk of SGA (aOR 2.01, 95% CI 0.21-0.95). Insufficient GWG was associated with lower risk of preeclampsia (aOR 0.43, 95% CI 0.20-0.93) and associated with an increased risk of preterm birth (aOR 1.87, 95% CI 1.11-3.15).

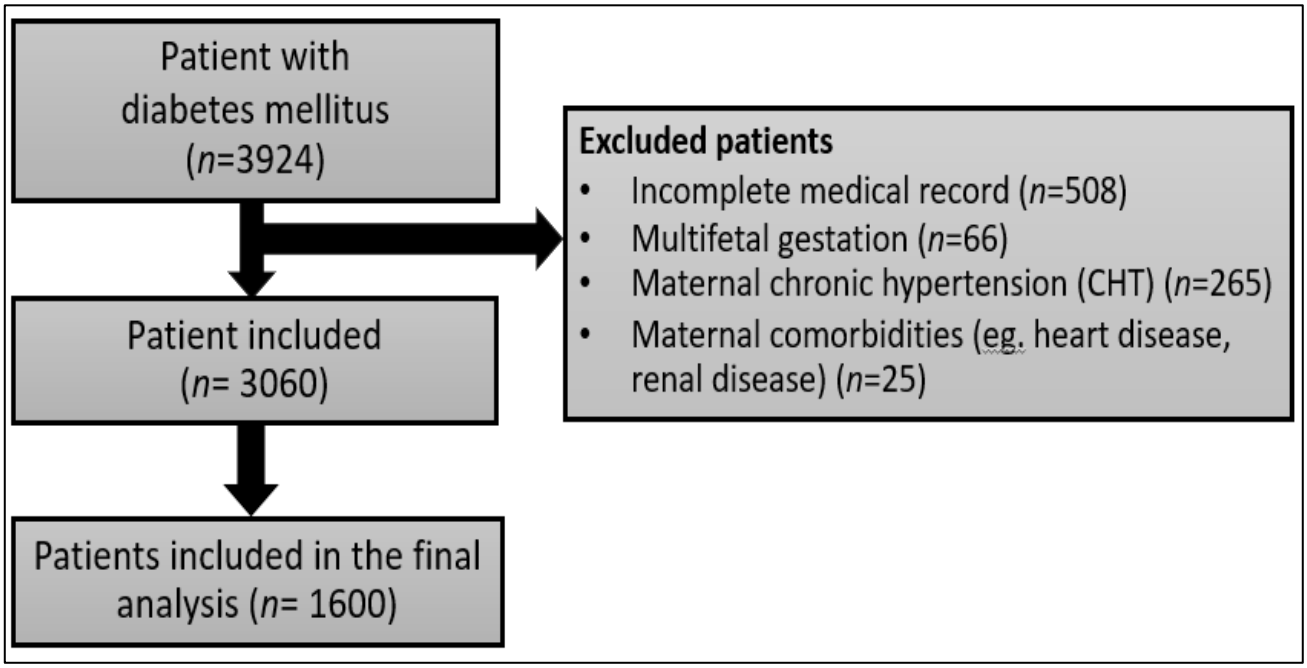

Figure 1: Flow diagram.

Table 1: Characteristics of women with diabetes relative to institute of medicine (IOM).

Characteristics	Insufficient, (n=400)	Sufficient, (n=400)	Excessive, (n=800)	P value
Age (in years)	34.0±5.2 (5.2)	32.9±5.1 (5.1)	31.6±5.5 (5.6)	<0.001
Pre-pregnancy BMI (kg/m^2)	24.7±4.8 (4.9)	25.4±5.1 (5.2)	26.4±5.3 (5.3)	<0.001
Underweight	35 (8.7%)	19 (4.6%)	26 (3.2%)	
Normal	217 (54.3%)	185 (46.3%)	292 (36.5%)	
Overweight	89 (22.3%)	130 (32.6%)	287 (35.9%)	
Obese	59 (14.7%)	66 (16.5%)	195 (24.4%)	

Continued.

Characteristics	Insufficient, (n=400)	Sufficient, (n=400)	Excessive, (n=800)	P value
Type of diabetes				
GDM	373 (93.2%)	391 (97.7%)	746 (93.3%)	0.002
PDM	27 (6.8%)	9 (2.3%)	54 (6.7%)	
Gestational age	37.8±2.1 (2.2)	38.2±1.7 (1.8)	38.2±1.5 (1.6)	0.002
Parity				
Nulliparity	140 (35%)	128 (32%)	301 (37.6%)	0.153
Multiparity	260 (65%)	272 (68%)	499 (62.4%)	
Mode of delivery				
Normal delivery	208 (52%)	181 (45.2%)	306 (38.2%)	<0.001
Operative vaginal delivery	5 (1.3%)	8 (2%)	10 (1.3%)	
Cesarean section	187 (46.8%)	211 (52.8%)	484 (60.5%)	

*Data are shown as mean±SD for continuous variables and n (%) for categorical variables. BMI: Body mass index; GDM: gestational diabetes; PDM: pregestational diabetes, p<0.05 was considered statistically significant.

Table 2: Maternal and neonatal outcomes.

Outcomes	Insufficient, (n=400)	Sufficient, (n=400)	Excessive, (n=800)	P value
GHT	8 (2%)	3 (0.8%)	35 (4.4%)	0.001
Preeclampsia	12 (3%)	27 (5.3%)	64 (8%)	0.002
PPH	17 (4.3%)	9 (2.3%)	47 (5.9%)	0.064
PAS	3 (0.8%)	0	3 (0.4%)	0.222
Placenta previa	10 (2.5%)	4 (1.0%)	9 (1.1%)	0.118
Abruptio placenta	0 (0%)	1 (0.3%)	0 (0%)	0.223
Fetal non reassuring status	31 (7.8%)	28 (7%)	59 (7.4%)	0.921
Intraamniotic infection	2 (0.5%)	1 (0.3%)	3 (0.4%)	0.846
Prolong PROM	12 (3%)	8 (2%)	23 (2.9%)	0.613
Malpresentation	20 (5%)	9 (2.3%)	30 (3.8%)	0.118
CPD	23 (5.8%)	29 (7.2%)	61 (7.6%)	0.483
Preterm birth	43 (10.8%)	24 (6.0%)	55 (6.9%)	0.042
Mean birth weight	2,906.6±540.4	3,084.7±500.1	3,261.0±520.8	<0.001
AGA	325 (80%)	316 (79%)	533 (66%)	----
SGA	27 (6.8%)	15 (3.8%)	14 (1.8%)	<0.001
LGA	48 (12.2%)	69 (17.2%)	253 (32.2%)	<0.001
Macrosomia	4 (1.0%)	13 (3.3%)	52 (6.5%)	<0.001
Normal Apgar score	392.8 (98%)	396 (99%)	794 (99.3%)	----
Low apgar score	8 (2%)	4 (1%)	6 (0.8%)	0.148
Stillbirth	5 (1.3%)	0 (0%)	0 (0%)	0.001
NICU admission	12 (3%)	9 (2.3%)	17 (2.1%)	0.632
Acute respiratory distress	37 (9.3%)	42 (10.5%)	75 (9.4%)	0.784

*Data shown as mean±SD for continuous variables and n (%) for categorical variables. GHT: gestational hypertension; PPH: Postpartum hemorrhage; PAS: placenta accreta spectrum; PROM: premature rupture of membrane; CPD: cephalopelvic disproportion; Appropriate for gestational age; NICU admission: neonatal intensive care unit admission. p<0.05 was considered statistically significant.

Table 3: Uni and multivariate logistic regression for maternal and neonatal outcomes.

Outcomes	N	cOR	95% CI	P value	aOR	95% CI	P value
GHT							
Sufficient	0.8%						
Insufficient	2.0%	2.70	0.71-10.26	0.14	2.92	0.76-11.22	0.12
Excessive	4.4%	6.05	1.85-19.81	0.003	5.70	1.73-18.80	0.004
Preeclampsia							
Sufficient	5.3%						
Insufficient	3.0%	0.56	0.27-1.15	0.11	0.43	0.20-0.93	0.03
Excessive	8.0%	1.57	0.94-2.61	0.08	1.61	0.95-2.74	0.78
PPH							
Sufficient	2.3%						
Insufficient	4.3%	1.93	0.85-4.38	0.11	1.78	0.78-4.06	0.17
Excessive	5.1%	2.35	1.13-4.89	0.02	2.58	1.24-5.40	0.02

Continued.

Outcomes	N	cOR	95% CI	P value	aOR	95% CI	P value
LGA							
Sufficient	17.3%						
Insufficient	12.5%	0.69	0.46-1.02	0.06	0.64	0.42-0.96	0.03
Excessive	31.0%	2.22	1.65-2.99	<0.001	2.22	1.63-3.01	<0.001
Macrosomia							
Sufficient	3.3%						
Insufficient	1.0%	0.30	0.10-0.93	0.04	0.34	0.17-1.04	0.06
Excessive	6.5%	2.07	1.11-3.85	0.02	1.97	1.05-3.70	0.03
SGA							
Sufficient	3.8%						
Insufficient	6.8%	1.86	0.97-3.55	0.06	1.78	0.92-3.46	0.088
Excessive	3.5%	0.46	0.22-0.96	0.04	0.45	0.21-0.95	0.04
Fetal non reassuring							
Sufficient	7.0 %						
Insufficient	7.8%	1.12	0.66-1.69	0.69	1.17	0.68-2.00	0.57
Excessive	7.4%	1.06	0.66-1.90	0.81	0.98	061-1.57	0.92
Low apgar score							
Sufficient	1%						
Insufficient	2%	2.02	0.60-6.76	0.25	1.94	0.56-6.74	0.30
Excessive	0.8%	0.75	0.21-2.67	0.65	0.78	0.21-2.89	0.72
Placenta previa							
Sufficient	1%						
Insufficient	2.5%	2.29	1.03-5.09	0.04	1.55	0.46-5.22	0.48
Excessive	1.1%	1.69	0.80-3.60	0.17	1.42	0.43-4.71	0.57
Malpresentation							
Sufficient	2.3%						
Insufficient	5%	2.29	1.03-5.09	0.04	2.05	0.92-4.60	0.80
Excessive	3.8%	1.69	0.80-3.60	0.17	1.84	0.86-3.94	0.11
Preterm birth							
Sufficient	6%						
Insufficient	10.8%	1.89	1.12-3.17	0.020	1.87	1.11-3.15	0.020
Excessive	6.9%	1.157	0.71-1.90	0.570	1.17	0.71-1.93	0.530

*aOR adjusted for age, pre-pregnancy BMI, type of diabetes, gestational age. GHT: gestational hypertension; PPH: postpartum hemorrhage; LGA: large for gestational age; SGA: small for gestational age.

DISCUSSION

In this retrospective cohort study, gestational weight gain showed significant associations with several maternal and neonatal outcomes among women with diabetes. Insufficient GWG was linked to lower risks of preeclampsia and fetal LGA, consistent with previous studies by Ferreira et al and Shi et al.[10,11] These findings suggest that lower weight gain may reduce fetal overgrowth and hypertensive disorders in diabetic pregnancies. However, insufficient GWG was also associated with an increased risk of preterm birth, aligning with earlier reports by Gou et al and Shi et al.[6,11] Conversely, excessive GWG was significantly associated with higher risks of fetal LGA, macrosomia, and gestational hypertension. These results are in agreement with previous studies by Guo et al, Xie et al and prior literature which demonstrates that excessive maternal weight gain exacerbates fetal overgrowth and hypertensive complications.[6,10,12,13] The association with PPH observed in our study may be explained by uterine over-distension and impaired contractility, mechanisms previously described in obstetric studies.[14,15] Excessive GWG was also associated with a lower risk of fetal SGA, a finding consistent with earlier research.[6]

Together, these findings show that GWG has important and varied effects on pregnancy outcomes in women with diabetes. Although the IOM guidelines offer general recommendations, our results suggest that the most appropriate GWG range for women with diabetes may not be the same as for the overall obstetric population. This highlights the importance of providing individualized weight-gain advice and closer clinical monitoring, especially for women who gain more weight than recommended.

The findings from this study indicate that excessive gestational weight gain in women with diabetes is associated with higher risks of maternal and neonatal complications, whereas insufficient weight gain may be linked to lower rates of several adverse outcomes. These results suggest that the optimal gestational weight-gain range for women with diabetes may differ from the current IOM recommendations.

Strengths of this study include its large sample size: 1,600 women with diabetes, encompassing both GDM and PDM, which provided sufficient statistical power to detect clinically meaningful differences across gestational weight gain categories.

This study has several limitations. First, its retrospective design restricts causal inference and may be affected by missing or incomplete clinical data. Second, because the study was conducted at a single center, the findings may not be fully generalizable to broader populations. Although major confounders were adjusted for, residual confounding from unmeasured factors-such as dietary habits, physical activity, and glycemic control during pregnancy-may still be present. Additionally, pre-pregnancy weight was obtained from medical records and may not accurately reflect weight at conception, potentially introducing measurement bias.

CONCLUSION

In conclusion, in pregnant women with diabetes, excessive gestational weight gain is associated with increased risks of adverse maternal and neonatal outcomes. When inappropriate GWG is identified, timely monitoring and early intervention are essential to help reduce complications. In contrast, insufficient GWG was associated with lower risks of several adverse outcomes.

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