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The amplifying effect of maternal obesity on perinatal outcomes in gestational diabetes mellitus

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ABSTRACT

Aims: This study aimed to evaluate the impact of maternal body-mass index (BMI) in the first trimester on perinatal outcomes in pregnant women diagnosed with gestational diabetes mellitus (GDM).

Methods: This retrospective cohort study included 210 women with GDM, categorized into three groups based on first-trimester BMI: normal weight (BMI<25.0 kg/m²), overweight (BMI 25.0–29.9 kg/m²), and obese (BMI≥30.0 kg/m²). Perinatal outcomes such as preterm birth, low birth weight, macrosomia, NICU admission, and Apgar scores were compared across groups. Multivariate logistic regression analyses were conducted to evaluate the independent association between obesity and adverse perinatal outcomes.

Results: The rates of preterm birth <37 weeks (35.7%, p<0.001) and <34 weeks (11.4%, p=0.016) were significantly higher in the obese group. Although low birth weight (<2500 g) was observed in 10.0% of obese women, this difference was not statistically significant (p=0.211). Macrosomia (≥4000 g) was more frequent in the obese group (11.4%) but did not reach statistical significance (p=0.261). NICU admission rates were higher in obese women (22.9%, p=0.089). In adjusted analyses, obesity was independently associated with increased odds of preterm birth <34 weeks (adjusted OR: 6.01, p=0.012) and low birth weight (adjusted OR: 4.68, p=0.026). Additionally, Spearman correlation analysis revealed a weak, non-significant positive correlation between gestational weight gain and gestational age at birth (r=0.122, p=0.077).

Conclusion: In pregnant women with GDM, first-trimester maternal obesity is associated with an increased risk of early preterm birth and low birth weight. These findings underscore the importance of assessing and managing maternal BMI early in pregnancy to improve perinatal outcomes.

Keywords: Gestational diabetes mellitus, maternal obesity, perinatal outcomes, preterm birth

INTRODUCTION

Variable levels of hyperglycemia that are initially identified during gestation are the hallmark of gestational diabetes mellitus (GDM), a common metabolic disease of pregnancy.[1] Between 13.97% and 14.8% of people worldwide have GDM, and its incidence is rising in tandem with rising obesity rates.[2,3]

One of the most important risk factors for the development of GDM is obesity, which is defined as having a pre-pregnancy body-mass index (BMI) of ≥30 kg/m². Compared to women of normal weight, those who are obese have a three to nine times higher risk of developing GDM.[4] The primary causes of this association include insulin resistance and persistent low-grade inflammation seen in obese people.[5,6]

Adverse prenatal outcomes, such as preterm birth, hypertensive problems, cesarean sections, and neonatal issues including low birth weight or macrosomia, are caused by both GDM and obesity on their own.[7-11] Furthermore, these risks may be increased if maternal obesity and GDM coexist.[12]

Although the synergistic consequences of obesity and GDM are becoming more well acknowledged, there are contradictions in the literature about which condition is more responsible for particular negative outcomes. These differences could be due to the confounding effect of excessive gestational weight gain (GWG), the timing of BMI assessment (first vs. second trimester), and differences in GDM screening techniques (universal vs. risk-based).[13-15]

The purpose of this study was to assess the relationship between pre-pregnancy BMI and unfavorable perinatal outcomes in women with GDM. We aimed to evaluate the independent impact of maternal obesity on obstetric and neonatal problems by utilizing first-trimester BMI data and controlling for GWG in multivariate models.

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METHODS

This study has been approved by the Scientific Researches Ethics Committee of Bursa City Hospital (Date: 14.05.2025, Decision No: 2025/10-12). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

This retrospective cohort study was conducted at a tertiary care center between January 2022 and December 2024. Medical records of 1.128 pregnant women who delivered at our institution and had recorded BMI values between the 8th and 12th weeks of gestation were screened. After applying exclusion criteria (pre-gestational diabetes, chronic hypertension, multifetal gestation, and missing data), 345 patients with GDM diagnosed according to the International Association of Diabetes and Pregnancy Study Groups (IADPSG) criteria were identified. To obtain equal group sizes for comparison, 210 patients were selected and categorized into three groups of 70 each.

GDM diagnosis was made if at least one of the following thresholds was met during a 75-g oral glucose tolerance test (OGTT): fasting plasma glucose ≥92 mg/dl, 1-hour ≥180 mg/dl, or 2-hour ≥153 mg/dl. Based on their first trimester BMI, participants were categorized into three groups: normal weight (BMI<25.0 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2), and obese (BMI≥30.0 kg/m^2).

Maternal BMI was calculated using anthropometric data recorded during the first antenatal visit between the 8th and 12th weeks of gestation. Maternal demographic and clinical characteristics including maternal age, gravidity, parity, smoking status, in vitro fertilization (IVF) history, and treatment modality (diet or insulin) were obtained from the hospital's electronic medical record system.

All patients received individualized dietary counseling from a certified dietitian according to national gestational diabetes guidelines. Insulin therapy was initiated in cases where glycemic targets were not achieved within two weeks of diet modification. Dose titration was tailored according to fasting and postprandial blood glucose levels.

Laboratory and clinical parameters recorded in the third trimester or at delivery were collected. These included GWG, fasting glucose level, HbA1c, total cholesterol, triglycerides, white blood cell count (WBC), hemoglobin (Hb), and platelet count.

Perinatal outcomes were extracted from delivery and neonatal records and included gestational age at delivery, birth weight, macrosomia (≥4000 g), preterm birth (<37 and <34 weeks), 1- and 5-minute Apgar scores, neonatal intensive care unit (NICU) admission, and mode of delivery (vaginal vs cesarean section).

Statistical Analysis

All data analyses were performed using IBM SPSS Statistics version 26.0. Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. Continuous variables were tested for normality using the Shapiro-Wilk test. Normally distributed variables were expressed as mean±standard deviation and compared using one-way ANOVA; non-normally distributed variables were expressed as median (minimum–maximum) and compared using the Kruskal-Wallis test. Categorical variables were expressed as numbers and percentages, and compared using the Chi-square or Fisher's exact test as appropriate.

Multivariate logistic regression models were constructed to assess the association between BMI categories and adverse perinatal outcomes, including preterm birth (<37 weeks and <34 weeks), low birth weight (<2500 g), macrosomia (≥4000 g), and NICU admission. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Two models were used: model 1 was unadjusted; model 2 was adjusted for maternal age, smoking status, fasting glucose, HbA1c, treatment modality, and GWG. A p-value of <0.05 was considered statistically significant.

RESULTS

This study included a total of 210 pregnant women diagnosed with GDM between 2022 and 2024. All cases had complete data for GWG and perinatal outcomes. Patients were stratified into three groups based on their BMI measured at the first prenatal visit (8–12 gestational weeks):

- Normal weight: BMI 18.5–24.9 kg/m^2 (n=70)
- Overweight: BMI 25.0–29.9 kg/m^2 (n=70)
- Obese: BMI ≥30.0 kg/m^2 (n=70)

Maternal and Laboratory Characteristics

As shown in **Table 1**, although maternal age was higher in the obese group, the difference was not statistically significant (p=0.109). GWG was significantly lower in the obese group compared to the other two groups (p<0.001). Laboratory parameters including HbA1c, fasting glucose, WBC, and triglyceride levels were significantly elevated in the obese group (all p<0.001). Total cholesterol was also significantly higher in the obese group compared to the normal weight group, but not compared to the overweight group. Insulin therapy was more frequently required in obese (68.6%) and overweight (50.0%) women compared to normal weight (28.6%) women (p<0.001); however, the difference between obese and overweight groups was not statistically significant. Smoking status (p=0.402) and IVF-conceived pregnancy rates (p=0.218) did not differ significantly among the groups.

Perinatal Outcomes

As presented in **Table 2**, the rate of preterm delivery before 37 weeks was significantly higher in the obese group (35.7%) than in overweight (14.3%) and normal weight (11.4%) groups (p<0.001). Similarly, <34-week deliveries were more common in the obese group (11.4%, p=0.016). The median gestational age was significantly lower in the obese group (37.0 weeks, p<0.001). Birth weight did not differ significantly between groups (p=0.061), and the rate of low birth weight (<2500 g) was also not statistically significant (10.0% in obese group, p=0.211). The prevalence of macrosomia (birthweight ≥4000 g) was higher in the obese group (17.1%) than in overweight (10.0%) and normal weight (7.1%) groups, but the difference

Table 1. Demographic, clinical, and laboratory parameters by BMI group

Variable	BMI normal (n=70)	BMI overweight (n=70)	BMI obese (n=70)	p-value
Age (years)	29.00 (19.00–41.00)	30.00 (20.00–41.00)	31.00 (20.00–49.00)	0.109[1]
Gravida	2.00 (1.00–5.00)	2.00 (1.00–7.00)	2.00 (1.00–7.00)	0.180[1]
Abortus	0.00 (0.00–2.00)	0.00 (0.00–3.00)	0.00 (0.00–3.00)	0.445[1]
Smokers (%)	11 (15.7%)	10 (14.3%)	12 (17.1%)	0.898[2]
IVF-conceived pregnancies (%)	4 (5.7%)	3 (4.3%)	2 (2.9%)	0.706[2]
Treatment modality, n (%)				**<0.001[2]**
Diet	50 (71.4%)[a]	35 (50.0%)	22 (31.4%)[b]	
Insulin	20 (28.6%)[b]	35 (50.0%)	48 (68.6%)[a]	
GWG (kg)	13.0 (7–17)[a]	12.4 (7–16)[a]	9.4 (6–16)[b]	<0.001[1]
HbA1c (%)	5.04 (4.00–6.10)[c]	5.23 (4.69–6.50)[b]	5.65 (4.99–6.90)[a]	<0.001[1]
Fasting glucose (mg/dl)	92.50 (85.00–118.00)[c]	95.00 (83.00–119.00)[b]	98.00 (83.00–295.00)[a]	<0.001[1]
Hemoglobin (g/dl)	11.60 (8.30–14.00)	11.20 (7.60–14.00)	11.90 (8.60–13.80)	0.374[1]
White blood cell ($\times10^3/\mu L$)	7.80 (5.50–16.50)[b]	8.46 (4.17–22.70)[b]	10.20 (5.50–23.00)[a]	<0.001[1]
Platelet ($\times10^3/\mu L$)	197.50 (85.00–303.00)[b]	200.00 (118.00–408.00)	214.00 (126.00–500.00)[a]	0.022[1]
Triglyceride (mg/dl)	176.50 (57.00–285.00)[c]	200.00 (58.00–347.00)[b]	233.00 (117.00–384.00)[a]	<0.001[1]
Total cholesterol (mg/dl)	179.50 (148.00–305.00)[b]	210.00 (123.00–360.00)[a]	207.00 (120.00–474.00)[a]	<0.001[1]

Data are presented as median (min–max) for continuous variables and as percentages (%) for categorical variables. BMI: Body-mass index, GWG: Gestational weight gain, 1 Kruskal–Wallis test, 2 Chi-square test p<0.05 was considered statistically significant. Superscripts a>b>c indicate significance in post-hoc Dunnett's T3 test

Table 2. Comparison of perinatal outcomes by BMI groups

Variable	BMI normal (n=70)	BMI overweight (n=70)	BMI obese (n=70)	p-value
<37 weeks delivery, n (%)	8 (11.4%)[b]	10 (14.3%)[b]	25 (35.7%)[a]	<0.001[2]
<34 weeks delivery, n (%)	2 (2.9%)	1 (1.4%)	8 (11.4%)	0.016[2]
Gestational age (weeks)	38.0 (32.0-41.0)[b]	38.0 (33.0-41.0)[b]	37.0 (32.0-42.0)[a]	<0.001[1]
Birth weight (g)	3242.5 (1910.0-4200.0)	3365.0 (1745.0-4590.0)	3262.5 (1430.0-4320.0)	0.061[1]
Low birth weight (<2500 g)	4 (5.7%)	2 (2.9%)	7 (10.0%)	0.211[2]
Macrosomia (≥4000 gr)	5 (7.1%)	7 (10.0%)	12 (17.1%)	0.160[2]
NICU admission, n (%)	8 (11.4%)	4 (5.7%)	10 (14.3%)	0.241[2]
RDS	1 (1.4%)	1 (1.4%)	2 (2.9%)	
TTN	4 (5.7%)	2 (2.9%)	2 (2.9%)	
Hypoglycemia	1 (1.4%)	1 (1.4%)	2 (2.9%)	
Hyperbilirubinemia	2 (2.9%)	0 (0%)	3 (4.3%)	
Sepsis	0 (0%)	0 (0%)	1 (1.4%)	
Delivery type, n (%)				
Vaginal	47 (67.1%)[a]	40 (57.1%)	23 (32.9%)[b]	<0.001[2]
Cesarean	23 (32.9%)[b]	30 (42.9%)	47 (67.1%)[a]	<0.001[2]
Other obstetric complications, n (%)	5 (%7.1)	2 (2.9%)	8 (%11.9)	0.144[2]
PPROM	3 (2.9%)	1 (1.4%)	1 (1.4%)	
Preeclampsia	0 (0%)	0 (0%)	4 (5.7%)	
IUGR	0 (0%)	0 (0%)	2 (2.9%)	
Placenta previa	2 (2.9%)	0 (0%)	0 (0%)	
Placental abruption	0 (0%)	1 (1.4%)	0 (0%)	
IUFD	0 (0%)	0 (0%)	1 (1.4%)	
APGAR score at 1st minute	9.0 (7.0-9.0)	9.0 (7.0-9.0)	9.0 (0.0-9.0)	0.117[1]
APGAR score at 5th minute	10.0 (8.0-10.0)[b]	10.0 (8.0-10.0)[b]	10.0 (0.0-10.0)[a]	0.007[1]

Data are presented as median (min–max) for continuous variables and as percentages (%) for categorical variables. 1 Kruskal–Wallis test, 2 Chi-square test p<0.05 was considered statistically significant. Superscripts a>b indicate significance in post-hoc Dunnett's T3 test. Pairwise comparisons of significantly different categorical variables were performed using Bonferroni-adjusted Chi-square or Fisher's exact test as appropriate. Abbreviations: BMI: Body-mass index, NICU: Neonatal intensive care unit, RDS: Respiratory distress syndrome, TTN: Transient tachypnea of the newborn, PPROM: Preterm premature rupture of membranes, IUGR: Intrauterine growth restriction, IUFD: Intrauterine fetal demise, APGAR: Appearance, pulse, grimace, activity, respiration

was not statistically significant (p=0.160). NICU admission rates were higher in the obese group (14.3%) but did not reach statistical significance (p=0.241). The 1-minute Apgar score did not differ among the groups (p=0.117), while the 5-minute Apgar score was significantly lower in the obese group (p=0.007). Obstetric complications such as preeclampsia (5.7%), IUGR (2.9%), and IUFD (1.4%) were observed only in the obese group. Cesarean delivery was significantly more frequent in the obese group (p<0.001).

Additionally, Spearman correlation analysis was performed to assess the relationship between GWG and key perinatal outcomes. As shown in **Supplementary Table 1**, a weak positive correlation was observed between GWG and gestational age at birth (r=0.122, p=0.077), although it did not reach statistical significance. No significant correlations were found between GWG and birth weight, NICU admission, or Apgar scores at 1 and 5 minutes.

Univariable Regression Analysis (Model 1)

In univariable regression (**Table 3**), obesity was significantly associated with an increased risk of <37-week delivery (OR: 4.31, 95% CI: 1.78–10.42, p=0.001) and lower 5-minute Apgar score (β=-0.3, 95% CI: -0.6 to -0.0, p=0.025). Although not statistically significant, obesity was associated with higher odds of macrosomia (OR: 2.69, 95% CI: 0.89–8.09, p=0.078). No statistically significant associations were observed for <34-week delivery, low birth weight, NICU admission, or 1-minute Apgar score.

Multivariable Regression Analysis (Model 2)

After adjusting for maternal age, fasting glucose, smoking, treatment modality, and GWG (**Table 4**), the following results were obtained:

- The association between obesity and <37-week delivery remained significant, and the adjusted odds ratio further increased (OR:6.62, 95% CI:2.11–20.74, p=0.001).

- <34-week delivery and low birth weight (<2500 g), which were not significant in model 1, became statistically significant in model 2 (p=0.012 and p=0.026, respectively).

- The association between obesity and macrosomia was not significant after adjustment (aOR:1.12, 95% CI: 0.27–4.62, p=0.880).

- Associations with NICU admission, 1-minute, and 5-minute Apgar scores were not significant in the adjusted model.

Additionally, Spearman correlation analysis was performed to assess the relationship between GWG and key perinatal outcomes. As shown in **Supplementary Table 1**, a weak positive correlation was observed between GWG and gestational age at birth (r=0.122, p=0.077), although it did not reach statistical significance. No significant correlations were found between GWG and birth weight, NICU admission, or Apgar scores at 1 and 5 minutes.

Visual Summary

The forest plots presented in **Figure 1** compare the univariable (model 1) and multivariable (model 2) regression results for the

Supplementary Table 1. Correlation between gestational weight gain (GWG) and perinatal outcomes

Variable	Gestational age at birth (weeks) r (p)	Birth weight (g) r (p)	NICU admission r (p)	Apgar score (1 min) r (p)	Apgar score (5 min) r (p)
GWG	0.122 (0.0772)	-0.061 (0.3773)	0.025 (0.719)	0.012 (0.8611)	0.012 (0.8611)

Statistical test: Spearman correlation analysis. r, Spearman correlation coefficient; p, p-value. Abbreviations: GWG: Gestational weight gain, NICU: Neonatal intensive care unit, Apgar: Appearance, pulse, grimace, activity, and respiration

Table 3. Model 1–univariable logistic and linear regression results

Outcome	Comparison group	OR or beta	95% confidence interval	p-value
Preterm <37 wks	Overweight	1.29	0.48–3.49	0.614
Preterm <37 wks	Obese	4.31	1.78-10.42	0.001
Preterm <34 wks	Overweight	0.49	0.04 – 5.56	0.567
Preterm <34 wks	Obese	4.39	0.90-21.45	0.068
Birth weight <2500g	Overweight	0.49	0.09-2.74	0.413
Birth weight <2500g	Obese	1.83	0.51-6.57	0.352
Macrosomia (>4000 g)	Overweight	1.44	0.44-4.79	0.55
Macrosomia (>4000 g)	Obese	2.69	0.89-8.09	0.078
NICU admission	Overweight	0.47	0.13-1.64	0.236
NICU admission	Obese	1.29	0.48-3.49	0.614
Apgar 1 min	Overweight	0.0	-0.2-0.3	0.747
Apgar 1 min	Obese	-0.2	-0.5-0.0	0.086
Apgar 5 min	Overweight	0.0	-0.2-0.3	0.915
Apgar 5 min	Obese	-0.3	-0.6--0.0	0.025

Reference group: Normal weight, GDM; Model 1: OR values are derived from univariable logistic regression models. Apgar scores are continuous variables and were analyzed using linear regression. Reported values for Apgar scores represent β (beta) coefficients (mean difference). Abbreviations: NICU: Neonatal intensive care unit, APGAR: Appearance, pulse, grimace, activity, respiration

Table 4. Model 2–multivariable logistic and linear regression results

Outcome	Comparison group	OR or beta	95% confidence interval	p-value
Preterm <37 wks	Overweight	1.45	0.52-4.07	0.482
Preterm <37 wks	Obese	6.62	2.11-20.74	0.001
Preterm <34 wks	Overweight	0.66	0.06-7.75	0.741
Preterm <34 wks	Obese	12.00	1.74-82.63	0.012
Birth weight <2500g	Overweight	0.76	0.13-4.51	0.759
Birth weight <2500g	Obese	6.66	1.25-35.34	0.026
Macrosomia (>4000 g)	Overweight	1.10	0.32-3.83	0.880
Macrosomia (>4000 g)	Obese	1.12	0.27-4.62	0.880
NICU admission	Overweight	0.52	0.14-1.9	0.324
NICU admission	Obese	1.93	0.52-7.11	0.322
Apgar 1 min	Overweight	0.08	-0.13-0.28	0.446
Apgar 1 min	Obese	-0.04	-0.29-0.21	0.744
Apgar 5 min	Overweight	0.09	-0.1-0.28	0.362
Apgar 5 min	Obese	0.0	-0.23-0.24	0.975

Reference group: Normal weight GDM; Model 2: OR values are derived from multivariable logistic regression models adjusted for age, fasting glucose, smoking, treatment type, GWG. Apgar scores are continuous variables and were analyzed using linear regression. Reported values for Apgar scores represent β (beta) coefficients (mean difference). Abbreviations: NICU: Neonatal intensive care unit, APGAR: Appearance, pulse, grimace, activity, respiration

obese group. In the logistic regression panel (A), the adjusted odds ratios (aORs) for <37-week and <34-week deliveries, as well as low birth weight (<2500 g), were higher in model 2. Among these, <34-week delivery and low birth weight reached statistical significance only after adjustment. Regarding macrosomia, although a positive association was observed in model 1 (OR:2.69), it did not reach statistical significance and the association was further attenuated in model 2 (aOR:1.12). In the linear regression panel (B), the association between obesity and the 5-minute Apgar score observed in model 1 disappeared after adjustment for covariates.

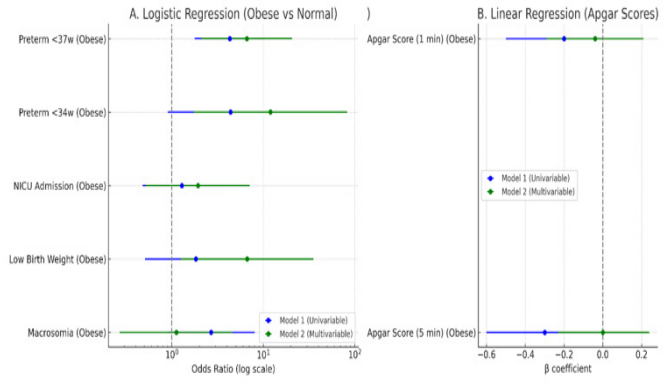

Figure 1. Forest plot showing the association between obesity and adverse perinatal outcomes in GDM patients
Forest plots illustrating the association between maternal obesity and adverse perinatal outcomes in pregnancies complicated by gestational diabetes mellitus (GDM). Panel A presents odds ratios (log scale) for obesity (vs. normal BMI) in relation to preterm birth (<37 and <34 weeks), NICU admission, low birth weight, and macrosomia, using both univariable (Model 1, blue) and multivariable (model 2, green) logistic regression analyses. Panel B shows β coefficients for 1-minute and 5-minute Apgar scores using linear regression, again comparing model 1 and model 2. Confidence intervals are displayed for all estimates.

To provide a visual summary of distribution patterns, a heatmap was created to display the frequency of selected perinatal outcomes across BMI categories (**Figure 2**). The highest rates of preterm delivery (<37 and <34 weeks), macrosomia (≥4000 g), NICU admission, and cesarean section were observed in the obese group. In contrast, the normal weight group showed the highest rates of vaginal delivery. This figure highlights the overall increase in adverse outcomes with increasing BMI.

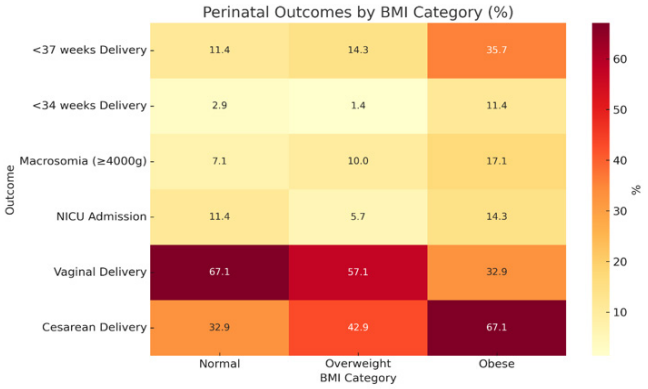

Figure 2. Heatmap visualization of selected perinatal outcomes across BMI categories
Heatmap visualization of selected perinatal outcomes across different BMI categories in women with gestational diabetes mellitus (GDM). The chart illustrates the percentage distribution of outcomes including <37 weeks and <34 weeks deliveries, macrosomia (≥4000g), NICU admission, vaginal delivery, and cesarean delivery across normal, overweight, and obese BMI groups. Darker shades represent higher percentages. Notably, the obese group demonstrated the highest rates of preterm delivery, macrosomia, NICU admission, and cesarean section.

DISCUSSION

Our study demonstrated that preterm birth rates before both 37 and 34 weeks of gestation were significantly higher among obese pregnant women with GDM. This finding suggests that maternal obesity may increase the risk of early delivery in pregnancies complicated by GDM. Increased systemic inflammation, insulin resistance, and endothelial dysfunction associated with obesity may trigger the preterm birth process by impairing uteroplacental perfusion and promoting early placental aging. As consistently noted in the literature, both early and late pregnancy complications are more frequently observed in obese pregnant women, and preterm birth stands out as one of the most significant outcomes.[16,17] This is in line with our findings. A recent large-scale prospective cohort study provided strong support for this association by showing that maternal obesity in combination with GDM significantly

increased the risk of both spontaneous (OR 1.98; 95% CI: 1.13–3.47) and medically indicated (OR 2.05; 95% CI: 1.25–3.37) preterm births.[18] These findings support the idea that the coexistence of obesity and GDM may act through multiple biological pathways, including inflammation, vascular dysfunction, and placental aging, to increase preterm birth risk. Conversely, one study reported that obesity was not significantly associated with spontaneous preterm birth in women with GDM but was linked only to indicated preterm birth.[19] Such discrepancy may be attributed to differences in sample characteristics, study design, and definitions of preterm birth. Nevertheless, it is widely recognized that the metabolic disturbances caused by obesity, particularly in the presence of GDM, may amplify inflammatory mechanisms and increase the likelihood of preterm delivery.

In our study, the rate of low birth weight (<2500 g) was significantly higher among obese women with GDM, while macrosomia (birthweight ≥4000 g) was more frequent in this group, albeit not reaching statistical significance. These findings suggest that maternal obesity may exert dual and heterogeneous effects on fetal growth. On the one hand, obesity-related metabolic dysfunctions may impair uteroplacental blood flow and nutrient transfer, restricting fetal growth. On the other hand, heightened insulin resistance and increased transplacental glucose transfer may predispose to excessive fetal growth. Several studies have reported that obese women had an increased risk of both intrauterine growth restriction (IUGR) and macrosomia.[20,21] These findings highlight the non-uniform nature of obesity's effects on fetal development and underscore the importance of considering individual metabolic profiles and placental function when interpreting fetal growth outcomes.

Our findings also revealed a significantly higher cesarean delivery rate among obese women with GDM compared to those with normal BMI. This result aligns with previous research indicating that maternal obesity is a strong independent risk factor for cesarean section.[22,23] Several mechanisms may contribute to this relationship, including increased incidence of labor dystocia, macrosomia, and a higher prevalence of pregnancy complications requiring surgical delivery. Furthermore, altered myometrial contractility and increased soft tissue impedance in obese women may reduce the likelihood of successful vaginal delivery. These factors collectively support the need for individualized intrapartum management strategies in obese pregnant women, particularly those with GDM.

In our study, NICU admission rates were numerically higher in the obese group compared to the normal BMI group, although this difference did not reach statistical significance. However, previous studies have demonstrated a clear association between maternal obesity and increased NICU admission risk.[24,25] For instance, a large retrospective analysis in Belgium showed that maternal obesity was independently associated with a 38% higher adjusted odds of NICU admission in neonates born to obese mothers.[24] Similarly, in the DEPOSIT cohort study, Ray et al.[25] reported that maternal obesity conferred a significantly higher risk of NICU admission, particularly in pregnancies complicated by diabetes. These findings underscore the need for diligent neonatal monitoring and preparedness in managing obese pregnancies complicated by GDM.

Additionally, we performed a Spearman correlation analysis to explore the association between GWG and key perinatal outcomes. The analysis revealed a weak positive correlation between GWG and gestational age at birth, which did not reach statistical significance ($r=0.122$, $p = 0.077$). However, no significant correlation was observed between GWG and birth weight, NICU admission, or Apgar scores. These results suggest that while GWG may have a modest influence on pregnancy duration, its impact on neonatal outcomes may be limited in this cohort. In contrast, Ke et al.[26] reported that excessive GWG was significantly associated with increased risks of macrosomia, LGA, and overall pregnancy complications among women with GDM, particularly when combined with obesity. Further studies with larger sample sizes are warranted to clarify the potential role of GWG in determining perinatal outcomes in pregnancies complicated by GDM.

In addition to medical interventions, lifestyle modifications play a crucial role in the management of maternal obesity, especially in pregnancies complicated by GDM. Evidence from a recent meta-analysis including over 40.000 pregnant women indicates that combined diet and physical activity interventions can reduce the incidence of GDM by approximately 18% compared with standard care (RR 0.82; 95% CI 0.74–0.94).[27] Preconception counseling, individualized dietary plans, and regular physical activity have also been shown to limit excessive GWG and reduce the risk of adverse perinatal outcomes. Therefore, integrating structured lifestyle interventions early in pregnancy may improve maternal-fetal outcomes and reduce the healthcare burden associated with obesity-related complications.

In recent years, novel non-invasive ultrasonographic techniques, such as fetal breathing movement (FBM) analysis and nasal flow Doppler, have been increasingly investigated for their potential to predict adverse perinatal outcomes, including preterm birth. A prospective multicenter cohort study demonstrated that combining the absence or irregularity of FBM with a nasal Doppler inspiration/expiration (I/E) ratio of <1.25 predicted preterm birth within 24 hours with 94.6% sensitivity.[28] These methods may provide additional insight into fetal well-being, particularly in high-risk pregnancies complicated by maternal obesity or GDM. Additionally, maternal nutritional quality assessed by validated scoring systems such as the healthy eating index (HEI) has also been linked to both fetal growth patterns and gestational age at delivery. For example, in a prospective multi-ethnic cohort study, lower HEI-2010 scores during pregnancy were associated with a 1.76-fold increased risk of delivering a large-for-gestational-age (LGA) infant. This finding highlights the role of maternal diet quality in modulating both fetal development and the timing of birth.

One of the strengths of our study is the use of first-trimester BMI measurements, which are less influenced by gestational weight changes and thus offer a more accurate assessment of pre-pregnancy obesity. Additionally, the study controlled

for important confounding variables such as maternal age, fasting glucose levels, HbA1c, smoking status, GWG, and treatment modality, which enhances the robustness of the results. Another strength is the homogeneous selection of patients with GDM according to IADPSG criteria and the stratified analysis of perinatal outcomes.

Limitations

However, our study has some limitations. First, its retrospective and single-center design may limit generalizability and introduce information bias. Second, we lacked detailed data on fetal well-being assessments such as biophysical profiles or fetal Doppler findings, which could have enriched the interpretation of neonatal outcomes. Third, although nutritional status likely plays a role in fetal development, we were unable to incorporate standardized dietary assessment tools such as the HEI due to data unavailability. Lastly, while our sample size was adequate for primary outcomes, it may not have been powered to detect subtle differences in some secondary outcomes like NICU admission or macrosomia.

CONCLUSION

This study highlights the significant impact of maternal obesity—defined by first-trimester BMI—on adverse perinatal outcomes in pregnancies complicated by GDM. Our findings indicate that obese women with GDM are at higher risk for preterm birth, low birth weight, and cesarean delivery. Although NICU admission and macrosomia rates were numerically higher in this group, these differences did not reach statistical significance. By using first-trimester BMI values, our study underscores the importance of early pregnancy weight assessment, and indirectly, the potential benefit of optimizing maternal weight even before conception. These results suggest that both preconceptional and early antenatal weight management strategies may help improve perinatal outcomes in women with GDM. Future prospective studies with larger cohorts are needed to validate these findings and guide clinical recommendations.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study has been approved by the Scientific Researches Ethics Committee of Bursa City Hospital (Date: 14.05.2025, Decision No: 2025/10-12).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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