

Gestational Diabetes Mellitus as an Independent Predictor of Postpartum Cardiovascular Risk: A 2-Year Prospective Cohort Study

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Abstract

Background: Gestational diabetes mellitus (GDM) is increasingly recognized as a predictor of long-term cardiovascular risk.

Objective: To evaluate the impact of GDM on cardiovascular risk markers over a two-year postpartum period in a prospective cohort.

Methodology: A prospective cohort study was conducted from January 2022 to December 2023. A total of 208 women between the ages of 18 and 45 who gave birth at the study center were included in the research. Pre-existing diabetes, hypertension, cardiovascular illness, renal problems, autoimmune conditions, multiple pregnancies, and insufficient follow-up were among the exclusion criteria. At six, twelve, and twenty-four months after giving birth, the participants were monitored. Blood pressure, fasting glucose, lipid profiles, anthropometric measures, and the prevalence of metabolic diseases were all noted.

SPSS 26.0 was used to analyze the data, and independent t-tests, chi-square tests, and multivariate regression were used to evaluate independent relationships.

Results: Of the 208 women completing follow-up, 104 had prior GDM. GDM women had persistently higher BMI (29.12 ± 3.80 vs. 26.95 ± 3.35 kg/m², $p < 0.01$), systolic (128.55 ± 11.05 vs. 121.12 ± 10.88 mmHg, $p < 0.01$) and diastolic blood pressure (82.35 ± 7.88 vs. 76.88 ± 7.45 mmHg, $p < 0.01$), fasting glucose (110.22 ± 14.12 vs. 95.88 ± 12.12 mg/dL, $p < 0.01$), total cholesterol (215.35 ± 32.12 vs. 198.55 ± 27.88 mg/dL, $p < 0.01$), LDL (138.22 ± 24.35 vs. 123.12 ± 22.55 mg/dL, $p < 0.01$), triglycerides (165.35 ± 32.88 vs. 138.55 ± 30.12 mg/dL, $p < 0.01$), and lower HDL (45.12 ± 8.55 vs. 51.12 ± 8.35 mg/dL, $p < 0.01$) compared to controls at 24 months. Incidence of type 2 diabetes,

hypertension, dyslipidemia, and metabolic syndrome was 28 (26.92%), 22 (21.15%), 35 (33.65%), and 18 (17.31%) in GDM women versus 4 (3.85%), 8 (7.69%), 12 (11.54%), and 3 (2.88%) in controls (all $p < 0.01$).

Conclusion: GDM independently predicts sustained postpartum cardiovascular risk, highlighting the need for early monitoring and preventive strategies.

Introduction

One of the most prevalent metabolic issues of pregnancy is gestational diabetes mellitus (GDM), which is characterized by glucose intolerance that initially appears or is identified during pregnancy [1]. It is becoming more common worldwide in tandem with increased rates of obesity, sedentary lifestyles, and older mothers [2]. Growing research indicates that the effects of GDM go much beyond pregnancy, especially for maternal cardiovascular health, despite the well-established short-term obstetric and neonatal consequences of GDM, such as macrosomia, preeclampsia, and surgical delivery [3].

The metabolic and circulatory systems are put through a physiological stress test during pregnancy [4,5]. Underlying insulin resistance, endothelial dysfunction, dyslipidemia, and low-grade inflammation are common in women with GDM, and several of these conditions have been linked to cardiovascular disease (CVD) [6]. These metabolic anomalies may continue or re-emerge after delivery, even if glucose tolerance may return to normal. This puts the afflicted women at risk for type 2 diabetes mellitus, hypertension, and atherosclerotic cardiovascular disease in the future [7]. As a result, GDM is becoming more widely acknowledged as an early indicator of future cardiometabolic risk rather than only a temporary pregnancy-related condition [8].

A history of GDM has been linked in a number of epidemiological studies to a higher frequency of cardiovascular risk factors, such as metabolic syndrome, subclinical vascular alterations, and impaired glucose control [9]. With little prospective follow-up in the early postpartum years, the majority of the research now in publication, however, is based on retrospective designs or long-term registry data [10]. Additionally, there is still a dearth of data from low- and middle-income nations, where the prevalence of both GDM and cardiovascular disease is rising quickly [11]. Adverse cardiovascular trajectories may start to appear in the early postpartum years, providing a window of opportunity for prompt risk assessment and preventative measures [12].

Well-designed prospective studies that assess cardiovascular and metabolic markers across time are necessary to comprehend the temporal link between GDM and eventual cardiovascular risk. For women with a history of GDM, a targeted follow-up in the first few years after delivery may provide important insights into early risk patterns, development, and possible predictors of cardiovascular morbidity.

Research Objective

To evaluate the impact of GDM on long-term cardiovascular risk over a two-year postpartum period using a prospective cohort design.

Methodology

Study Design and Setting

This study was designed as a prospective cohort study and was conducted at the Department of Gynecology and Obstetrics, Liaquat Memorial Hospital Kohat and MTI DI Khan Hospital, over a period of two years, from January 2022 to December 2023.

Inclusion and Exclusion Criteria

Women who gave birth between the ages of 18 and 45 were eligible to be included in the research. Women who were diagnosed with GDM during pregnancy using standard oral glucose tolerance test (OGTT) criteria made up the exposed group. Women who

were matched for parity and age and had normal glucose tolerance throughout pregnancy made up the comparison group. A history of type 1 or type 2 diabetes mellitus, chronic hypertension, established cardiovascular disease, renal illness, autoimmune diseases, or use of drugs known to alter glucose or lipid metabolism prior to pregnancy were among the exclusion criteria. Additionally, women with pre-existing metabolic problems, numerous pregnancies, or insufficient follow-up data were not included.

Sample Size

The study started with 224 individuals, including women with a history of GDM and normoglycemic controls. 16 individuals were lost to follow-up throughout the two-year follow-up period, leaving 208 participants in the final analyzed sample. In order to account for anticipated attrition and provide sufficient statistical power to identify clinically significant variations in cardiovascular risk indicators between the two groups, the sample size was determined.

Data Collection

Baseline demographic, obstetric, and clinical data were recorded at the time of delivery. Participants were prospectively monitored six, twelve, and twenty-four months after giving birth. Anthropometric assessments, blood pressure readings, fasting blood glucose, lipid profiles, and other pertinent biochemical markers of cardiovascular risk were among the data gathered. To guarantee uniformity, all measurements were conducted using standardized procedures. Laboratory tests were carried out at the hospital's accredited diagnostic facilities, and follow-up evaluations were carried out via outpatient clinic appointments.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) version 26.0 was used to input and analyze the data. Categorical data were shown as frequencies and percentages, whilst continuous variables were given as mean $\pm$ standard deviation or median (interquartile range). The independent t-test for continuous variables and the chi-square test for categorical variables were used to compare groups. To find independent relationships between GDM and cardiovascular risk factors, multivariate regression analysis was used. Statistical significance was defined as a p-value of less than 0.05.

Ethical Approval

Ethical approval for the study was obtained from the Institutional Review Board of the Department of Gynecology and Obstetrics, Liaquat Memorial Hospital, Kohat, and the study was conducted in collaboration with MTI DI Khan Hospital. Written informed consent was obtained from all participants prior to enrollment. Participant confidentiality was maintained throughout the study, and all procedures were conducted in accordance with the principles of the Declaration of Helsinki.

Results

Women with GDM (n=104) had a higher mean age (30.45 ± 4.12 years) and BMI (28.35 ± 3.65 vs. 26.12 ± 3.22 kg/m², $p < 0.01$) at baseline compared to non-GDM women (29.87 ± 4.05 years, $p = 0.32$), shown in table 1. Group nulliparity was similar (43.27% vs. 47.12%, $p = 0.53$). Family history of diabetes was more common in GDM (36.54% vs. 19.23%, $p = 0.01$). The GDM group had higher rates of cesarean births (50% vs. 34.62%, $p = 0.03$), gestational hypertension (13.46% vs. 4.81%, $p = 0.02$), and macrosomia (>4 kg) (17.31% vs. 5.77%, $p = 0.01$).

Table 1. Baseline Demographic, Obstetric, and Clinical Characteristics (n=208)

Variable	GDM (n=104)	Non-GDM (n=104)	p-value
Age (years, mean $\pm$ SD)	30.45 $\pm$ 4.12	29.87 $\pm$ 4.05	0.32
BMI (kg/m ² , mean $\pm$ SD)	28.35 $\pm$ 3.65	26.12 $\pm$ 3.22	<0.01
Nulliparity, n (%)	45 (43.27)	49 (47.12)	0.53
Family history of diabetes, n (%)	38 (36.54)	20 (19.23)	0.01
Cesarean delivery, n (%)	52 (50.00)	36 (34.62)	0.03
Gestational hypertension, n (%)	14 (13.46)	5 (4.81)	0.02
Macrosomia (>4kg), n (%)	18 (17.31)	6 (5.77)	0.01

Over the 2-year follow-up, GDM women consistently had higher weight and BMI at 6 months (70.45 $\pm$ 8.12 kg; 28.55 $\pm$ 3.68 kg/m²), 12 months (71.12 $\pm$ 8.35 kg; 28.88 $\pm$ 3.72 kg/m²), and 24 months (72.35 $\pm$ 8.55 kg; 29.12 $\pm$ 3.80 kg/m²) compared to non-GDM women (66.32–67.12 kg; 26.42–26.95 kg/m², all p <0.01), indicating sustained post-pregnancy weight and BMI elevation in the GDM group (table 2).

Table 2. Anthropometric Measurements During Follow-Up (6, 12, 24 Months)

Timepoint	Variable	GDM (Mean $\pm$ SD)	Non-GDM (Mean $\pm$ SD)	p-value
6 months	Weight (kg)	70.45 $\pm$ 8.12	66.32 $\pm$ 7.88	<0.01
	BMI (kg/m ²)	28.55 $\pm$ 3.68	26.42 $\pm$ 3.25	<0.01
12 months	Weight (kg)	71.12 $\pm$ 8.35	66.85 $\pm$ 7.92	<0.01
	BMI (kg/m ²)	28.88 $\pm$ 3.72	26.72 $\pm$ 3.28	<0.01
24 months	Weight (kg)	72.35 $\pm$ 8.55	67.12 $\pm$ 8.05	<0.01
	BMI (kg/m ²)	29.12 $\pm$ 3.80	26.95 $\pm$ 3.35	<0.01

Systolic and diastolic blood pressures, as well as fasting glucose, were significantly higher in GDM women at all follow-up points (table 3). At 6 months, systolic BP was 124.35 $\pm$ 11.22 mmHg versus 118.47 $\pm$ 10.55 mmHg (p <0.01), diastolic BP 79.12 $\pm$ 7.88 vs. 74.65 $\pm$ 7.10 mmHg (p <0.01), and fasting glucose 105.55 $\pm$ 12.12 vs. 92.35 $\pm$ 10.88 mg/dL (p <0.01). These differences persisted at 12 and 24 months, demonstrating early and sustained elevation of cardiovascular risk markers in the GDM cohort.

Table 3. Blood Pressure and Fasting Glucose During Follow-Up

Timepoint	Variable	GDM (Mean $\pm$ SD)	Non-GDM (Mean $\pm$ SD)	p-value
6 months	Systolic BP (mmHg)	124.35 $\pm$ 11.22	118.47 $\pm$ 10.55	<0.01
	Diastolic BP (mmHg)	79.12 $\pm$ 7.88	74.65 $\pm$ 7.10	<0.01
	Fasting Glucose (mg/dL)	105.55 $\pm$ 12.12	92.35 $\pm$ 10.88	<0.01
12 months	Systolic BP (mmHg)	126.22 $\pm$ 10.88	119.87 $\pm$ 10.22	<0.01
	Diastolic BP (mmHg)	80.35 $\pm$ 7.45	75.12 $\pm$ 7.05	<0.01
	Fasting Glucose (mg/dL)	108.47 $\pm$ 13.22	94.35 $\pm$ 11.55	<0.01
24 months	Systolic BP	128.55 $\pm$ 11.05	121.12 $\pm$ 10.88	<0.01

	(mmHg)			
	Diastolic BP (mmHg)	82.35 ± 7.88	76.88 ± 7.45	<0.01
	Fasting Glucose (mg/dL)	110.22 ± 14.12	95.88 ± 12.12	<0.01

GDM women exhibited a more atherogenic lipid profile compared to non-GDM women at 6, 12, and 24 months (table 4). At 24 months, total cholesterol was 215.35 ± 32.12 mg/dL versus 198.55 ± 27.88 mg/dL ($p<0.01$), LDL 138.22 ± 24.35 vs. 123.12 ± 22.55 mg/dL ($p<0.01$), HDL 45.12 ± 8.55 vs. 51.12 ± 8.35 mg/dL ($p<0.01$), and triglycerides 165.35 ± 32.88 vs. 138.55 ± 30.12 mg/dL ($p<0.01$), reflecting persistent dyslipidemia in the GDM group.

Table 4. Lipid Profile During Follow-Up

Timepoint	Variable	GDM (Mean ± SD)	Non-GDM (Mean ± SD)	p-value
6 months	Total Cholesterol (mg/dL)	208.25 ± 28.45	192.55 ± 25.34	<0.01
	LDL (mg/dL)	132.12 ± 22.35	118.45 ± 21.22	<0.01
	HDL (mg/dL)	46.22 ± 8.12	52.35 ± 7.88	<0.01
	Triglycerides (mg/dL)	158.55 ± 30.45	132.88 ± 28.12	<0.01
12 months	Total Cholesterol (mg/dL)	212.88 ± 30.12	196.22 ± 26.45	<0.01
	LDL (mg/dL)	135.55 ± 23.12	120.88 ± 21.88	<0.01
	HDL (mg/dL)	45.88 ± 8.35	51.55 ± 8.12	<0.01
	Triglycerides (mg/dL)	162.22 ± 31.12	135.88 ± 29.12	<0.01
24 months	Total Cholesterol (mg/dL)	215.35 ± 32.12	198.55 ± 27.88	<0.01
	LDL (mg/dL)	138.22 ± 24.35	123.12 ± 22.55	<0.01
	HDL (mg/dL)	45.12 ± 8.55	51.12 ± 8.35	<0.01
	Triglycerides (mg/dL)	165.35 ± 32.88	138.55 ± 30.12	<0.01

Over 2 years, women with GDM had higher incidence of type 2 diabetes (26.92% vs. 3.85%, $p<0.001$), hypertension (21.15% vs. 7.69%, $p=0.01$), dyslipidemia (33.65% vs. 11.54%, $p<0.001$), and metabolic syndrome (17.31% vs. 2.88%, $p<0.001$) compared to non-GDM women, indicating substantially increased cardiometabolic risk in the postpartum period (table 5).

Table 5. Incidence of New Metabolic Disorders (2-Year Follow-Up)

Outcome	GDM (n=104)	Non-GDM (n=104)	p-value
Type 2 Diabetes, n (%)	28 (26.92)	4 (3.85)	<0.001
Hypertension, n (%)	22 (21.15)	8 (7.69)	0.01
Dyslipidemia, n (%)	35 (33.65)	12 (11.54)	<0.001
Metabolic Syndrome, n (%)	18 (17.31)	3 (2.88)	<0.001

Adjusted for age, BMI, parity, and family history of diabetes, GDM remained independently associated with higher cardiovascular risk markers at 24 months (table 6). Significant positive associations were observed for systolic BP ($\beta=6.85$, 95% CI 4.12–9.58, $p<0.001$), diastolic BP ($\beta=5.22$, 2.88–7.55, $p<0.001$), fasting glucose

($\beta=12.35$, 8.88–15.82, $p<0.001$), total cholesterol ($\beta=16.88$, 10.55–23.22, $p<0.001$), LDL ($\beta=15.35$, 9.88–20.82, $p<0.001$), triglycerides ($\beta=24.12$, 16.88–31.35, $p<0.001$), and composite CV risk score ($\beta=2.18$, 1.55–2.81, $p<0.001$), while HDL was negatively associated ($\beta=-5.22$, -7.12– -3.32, $p<0.001$), confirming that GDM independently predicts worse long-term cardiovascular risk.

Table 6. Multivariate Regression Analysis: Independent Associations Between GDM and Cardiovascular Risk Markers at 24 Months (n=208)

Outcome Variable	β (Unstandardized)	95% CI	p-value
Systolic BP (mmHg)	6.85	4.12 – 9.58	<0.001
Diastolic BP (mmHg)	5.22	2.88 – 7.55	<0.001
Fasting Glucose (mg/dL)	12.35	8.88 – 15.82	<0.001
Total Cholesterol (mg/dL)	16.88	10.55 – 23.22	<0.001
LDL (mg/dL)	15.35	9.88 – 20.82	<0.001
HDL (mg/dL)	-5.22	-7.12 – -3.32	<0.001
Triglycerides (mg/dL)	24.12	16.88 – 31.35	<0.001
Composite CV Risk Score	2.18	1.55 – 2.81	<0.001
Note: β = regression coefficient; CI = confidence interval; positive β indicates higher values in GDM group, negative β indicates lower values (e.g., HDL).			

Discussion

The baseline characteristics of our prospective cohort revealed that, in comparison to controls, women with GDM had a significantly higher BMI (28.35 ± 3.65 vs. 26.12 ± 3.22 kg/m², $p<0.01$), a higher prevalence of family history of diabetes (36.54% vs. 19.23%, $p=0.01$), gestational hypertension (13.46% vs. 4.81%, $p=0.02$), and macrosomia (17.31% vs. 5.77%, $p=0.01$). Given that increased pre-pregnancy BMI and gestational hypertension are recognized risk factors for future cardiometabolic risk in GDM patients, these baseline metabolic differences mirror established risk patterns [8]. Through common pathways of insulin resistance and endothelial dysfunction, women with GDM often exhibit underlying metabolic stresses that predispose them to cardiovascular disease (CVD) [13].

Women in the GDM group maintained greater weight and BMI at 6, 12, and 24 months postpartum, according to longitudinal anthropometric follow-up (e.g., 72.35 ± 8.55 vs. 67.12 ± 8.05 kg, $p<0.01$ at 24 months). Given that previous meta-analyses have shown that post-GDM women had considerably higher BMIs than those without GDM, with standardized mean differences constant across broad populations, these persistent increases in weight and adiposity are alarming [14]. Our cohort's continued high levels of adiposity after giving birth is consistent with more general data showing that GDM is a predictor of long-term cardiometabolic risk beyond the index pregnancy [15]. At 24 months, GDM women had higher systolic (128.55 ± 11.05 vs. 121.12 ± 10.88 mmHg) and diastolic (82.35 ± 7.88 vs. 76.88 ± 7.45 mmHg) blood pressure and fasting glucose levels (110.22 ± 14.12 vs. 95.88 ± 12.12 mg/dL, all $p<0.01$). These increases are in line with other studies that found postpartum blood pressure and glycemic measurements, which are components of metabolic syndrome, are greater in women with a history of GDM than in controls [16].

Our lipid profile data likewise showed negative trends among GDM women throughout the course of follow-up, with lower HDL and higher LDL and total cholesterol at 24 months (total cholesterol 215.35 ± 32.12 vs. 198.55 ± 27.88 mg/dL; HDL 45.12 ± 8.55 vs. 51.12 ± 8.35 mg/dL, $p<0.01$). This is consistent with population-based data suggesting women with a history of GDM had a higher lifetime risk of dyslipidemia, with adjusted risks of around 1.45 times for LDL-defined dyslipidemia and 1.8 times for triglycerides when compared to their non-GDM counterparts [16, 17].

At two years, the GDM group had a significantly higher incidence of new cardio-metabolic diseases, including type 2 diabetes (26.92% vs. 3.85%), hypertension (21.15% vs. 7.69%), dyslipidemia (33.65% vs. 11.54%), and metabolic syndrome (17.31% vs. 2.88%, all $p < 0.01$). Longitudinal studies have demonstrated that women with a history of GDM are several times more likely to develop type 2 diabetes and other metabolic disorders after giving birth. Some of these studies have found that the risk of developing diabetes is up to seven times higher than that of controls, and the risk of hypertension is significantly higher [18].

Lastly, our multivariate model revealed clear correlations between GDM and negative cardiovascular risk indicators at 24 months (e.g., composite CV risk score $\beta = 2.18$, LDL $\beta = 15.35$, and total cholesterol $\beta = 16.88$, all $p < 0.001$). These adjusted associations confirm that GDM itself predicts an increase in cardiometabolic burden even after adjusting for age, BMI, parity, and family history. This pattern is consistent with earlier research that found women with prior GDM had a nearly twofold increased risk of cardiovascular events compared to those without, independent of intervening diabetes onset [19].

Study Strengths and Limitations

The primary advantage of this research is its prospective cohort design, which made it possible to systematically monitor women with and without GDM for two years after giving birth. This allowed for the early detection of cardiovascular risk indicators in a low- and middle-income nation where such data are scarce. The results' internal validity and robustness were improved by standardized assessments of anthropometry, blood pressure, fasting glucose, and lipid profiles as well as multivariate regression analysis that controlled for confounders such as age, BMI, parity, and family history. Furthermore, the trustworthiness of comparisons is strengthened by the presence of a matched control group and comparatively low attrition (7.1%). Limitations include the relatively short two-year follow-up period, which captures early but not long-term cardiovascular events, and the single-center design, which may restrict generalizability to larger groups. The lack of a thorough evaluation of postpartum therapies, dietary practices, and lifestyle variables may have affected the results. Future research with multi-center recruitment, longer follow-up, and thorough behavioral evaluations would provide a more thorough understanding of the trajectory of cardiometabolic risk after GDM.

Conclusion

This prospective two-year cohort research shows that compared to their normoglycemic peers, women with a history of GDM had a markedly increased postpartum cardiovascular risk. Throughout the follow-up period, there were noticeably higher rates of type 2 diabetes, hypertension, dyslipidemia, and metabolic syndrome, as well as persistent increases in weight, BMI, blood pressure, fasting glucose, and an atherogenic lipid profile. Even after controlling for age, BMI, parity, and family history of diabetes, multivariate analysis verified that GDM independently predicts unfavorable cardiovascular risk indicators. These results highlight the need for focused postpartum monitoring and preventive interventions to reduce future cardiovascular morbidity in this high-risk population, as GDM is not just a temporary pregnancy complication but a potent early indicator of long-term cardiometabolic risk.

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