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Serum Vitamin D Status and Glycemic Profile in Women with Gestational Diabetes Mellitus

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Abstract

Background: *The incidence of gestational diabetes mellitus (GDM) is increasing worldwide. Various studies have linked vitamin D deficiency to abnormal glucose metabolism. This study aimed to determine the association between serum vitamin D levels in pregnant women and GDM.*

Methods: *This Case-control study was conducted at the Department of the Gynaecology & Obstetrics, Rangpur Medical College and Hospital, Rangpur, from July 2022 to 2023. A total of 50 pregnant women with GDM were included as cases and another 50 pregnant women without GDM were included as controls after obtaining informed written consent. Socio-demographic characteristics, obstetric history and laboratory profiles were reported. Data were analyzed using SPSS-26.*

Results: *The mean age of the total population was 26.69±4.44 years and the cases were significantly older than the controls (28.14±3.37 vs. 25.24±4.91 years, p=0.001). Besides, cases had significantly higher BMI than controls (22.25±1.51 vs 21.45±1.99 Kg/m2, p=0.027). The mean serum vitamin D level was significantly lower in the cases than in the controls (24.06±8.67 vs. 28.09±8.30 ng/mL, p=0.019). Among the cases, 44% had vitamin D insufficiency and 30% had vitamin D deficiency, while among the controls, 38% had vitamin D insufficiency and 14% had vitamin D deficiency. Vit-D deficiency was found to be a significant risk factor for GDM after adjusting for other confounders (AOR=7.44, CI=1.79-30.96, p=0.006). Serum vitamin-D level had a significant negative linear association with BMI (r=-0.746, p<0.001) and fasting blood glucose (r=-0.210, p=0.036).*

Conclusion: *The mean serum vitamin D level was lower in pregnant women with GDM than in non-GDM pregnant women. However, further multicenter studies are required.*

Keywords: *GDM, Serum Vitamin-D, glycemic profile.*

1. Introduction

Gestational diabetes mellitus (GDM) is one of the most common metabolic complications of pregnancy and poses a substantial challenge for obstetric care due to its short- and long-term consequences for both mother and offspring. Globally, the prevalence of GDM has risen markedly over the past two decades, paralleling the increasing burden of type 2 diabetes mellitus (T2DM), sedentary lifestyles and the obesity epidemic [1]. Recent estimates suggest that GDM affects approximately 5–25% of pregnancies worldwide, with more than a 30% increase reported in both developed and developing countries, highlighting its emergence as a significant public health concern [2].

The American Diabetes Association defines GDM as glucose intolerance of variable severity with onset or first recognition during pregnancy [3]. Pregnancy itself represents a diabetogenic state characterized by progressive insulin resistance induced by placental hormones, including human placental lactogen, estrogen, progesterone and cortisol. In healthy pregnancies, pancreatic β-cells adapt through increased insulin secretion to maintain euglycaemia. However, in women who develop GDM, this compensatory β-cell response is inadequate, leading to hyperglycaemia and metabolic dysregulation resembling the pathophysiology of T2DM [4].

GDM is associated with a wide spectrum of adverse maternal and neonatal outcomes. Maternal complications include pre-eclampsia, preterm labor, increased rates of primary caesarean section, postpartum wound infections and a substantially elevated lifetime risk of developing T2DM [5]. Fetal and neonatal complications include macrosomia, birth trauma, respiratory distress syndrome, neonatal hypoglycaemia, hyperbilirubinaemia and metabolic disturbances such as hypocalcaemia. Moreover, offspring of mothers with GDM are at increased risk of obesity, insulin resistance and diabetes later in life, supporting the concept of fetal programming of adult disease [6].

Pregnancy is also a period of heightened nutritional vulnerability due to increased maternal and fetal metabolic demands. Among micronutrients, vitamin D has gained considerable attention for its potential role beyond skeletal health. Vitamin D is synthesized in the skin upon ultraviolet exposure and undergoes sequential hydroxylation in the liver and kidneys to form 25-hydroxyvitamin D [25(OH)D] and the biologically active 1,25-dihydroxyvitamin D [$1,25(OH)_2D$] [7]. Although $1,25(OH)_2D$ is the active form, serum 25(OH)D concentration is considered the most reliable marker of vitamin D status due to its longer half-life [8].

Vitamin D receptors are widely distributed in multiple tissues, including pancreatic β-cells, placenta and uterine decidua, suggesting a broader physiological role in glucose metabolism, immune modulation, implantation, placental angiogenesis and fetal development [9]. During pregnancy, adequate vitamin D is essential to meet increased calcium demands, particularly in the third trimester, supporting maternal bone health and fetal skeletal growth [10].

Vitamin D deficiency is highly prevalent worldwide, with disproportionately higher rates reported in Middle Eastern and South Asian populations due to limited sun exposure, cultural clothing practices, air pollution, darker skin pigmentation, obesity and socioeconomic factors [11,12]. Accumulating evidence indicates that hypovitaminosis D is associated with insulin resistance, impaired β-cell function and altered glucose homeostasis in both diabetic and non-diabetic populations [13]. Experimental and observational studies suggest that vitamin D may influence insulin secretion through regulation of intracellular calcium flux in β-cells and enhance insulin sensitivity by upregulating insulin receptor expression in peripheral tissues [14].

Traditional risk factors for GDM include advanced maternal age, obesity, family history of T2DM, prior GDM, previous macrosomic infant and certain ethnic backgrounds. However, recent studies have proposed vitamin D deficiency as a potentially modifiable risk factor for GDM, given its biological plausibility and amenability to supplementation [15]. Several observational studies have reported lower circulating 25(OH)D levels in women with GDM compared with normoglycaemic pregnant women, although findings remain inconsistent across populations [16].

Given the high prevalence of both GDM and vitamin D deficiency, particularly in resource-limited settings, identifying modifiable nutritional risk factors is crucial for primary prevention strategies. Improving maternal vitamin D status may offer a simple, low-cost intervention to reduce the risk of GDM and its associated adverse outcomes. Therefore, this study aims to investigate the association between maternal serum vitamin D levels and gestational diabetes mellitus, contributing evidence toward preventive and risk-stratification strategies in obstetric care.

2. Materials & Methods

This hospital-based case–control study was conducted in the Outpatient Department and Inpatient Department of Gynaecology and Obstetrics at Rangpur Medical College Hospital, Rangpur, Bangladesh. The study was carried out over a period of one year following approval from the Institutional Review Board (July 2022 to June 2023). The study population comprised pregnant women at more than 22 weeks of gestation attending the study site during the study period.

A total of 100 participants were enrolled and divided into two groups: 50 pregnant women diagnosed with gestational diabetes mellitus (cases) and 50 pregnant women without gestational diabetes mellitus (controls). Diagnosis of GDM was based on standard clinical and biochemical criteria as practiced at the study center.

2.1. Sample Selection

Inclusion Criteria

- Pregnant women with gestational age >22 weeks
- Primigravida or second gravida
- For cases: diagnosed with gestational diabetes mellitus
- For controls: normoglycaemic pregnant women without GDM

Exclusion criteria

- Multiple pregnancy
- Obesity
- Previous history of gestational diabetes mellitus
- History of unexplained stillbirth
- Strong family history of diabetes mellitus
- Presence of chronic medical illnesses
- Known liver disease
- Refusal or inability to provide informed consent

2.2. Data Collection Procedure

After obtaining ethical approval, eligible pregnant women attending the outpatient or inpatient services were approached consecutively. The purpose, procedure and potential implications of the study were explained in detail and written informed consent was obtained before enrollment. Data were collected by the principal investigator using a predesigned, semi-structured case record form. Information on socio-demographic characteristics, obstetric history and clinical parameters was obtained through direct interview and review of medical records. Clinical examination and anthropometric measurements were performed following standard procedures. Fasting blood samples were collected in the morning under aseptic conditions for estimation of fasting blood sugar, two-hour postprandial blood glucose and serum vitamin D levels. Serum vitamin D concentration was measured in the biochemistry laboratory of the study center using standardized laboratory methods. All measurements and data recording were performed uniformly to ensure accuracy, reliability and consistency across both study groups.

2.3. Ethical Considerations

Ethical approval for the study was obtained from the Ethical Review Committee and Research Review Committee of Rangpur Medical College Hospital before initiation of the study. Participation was entirely voluntary and written informed consent was obtained from each participant after providing clear information regarding the study objectives, procedures, benefits and potential risks in the local language. Confidentiality of participant information was strictly maintained by anonymizing data and restricting access to research records. Participants were informed of their right to refuse participation or withdraw from the study at any stage without any effect on their standard medical care. The study did not involve any invasive procedures beyond routine blood sampling and no financial incentives were provided.

2.4. Statistical Analysis

Data were checked for completeness and consistency before analysis. Statistical analysis was performed using SPSS version 26.0. Descriptive statistics were used to summarize socio-demographic, clinical and laboratory variables; categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation. The unpaired Student's t-test was applied to compare normally distributed continuous variables between cases and controls and the chi-square test was used for comparison of categorical variables. Pearson's correlation coefficient was employed to assess the relationship between serum vitamin D levels and selected continuous variables. Multivariate logistic regression analysis was performed to estimate odds ratios and identify independent predictors of gestational diabetes mellitus. A p-value of less than 0.05 was considered statistically significant.

3. Results

Table 1. *Distribution of the study subjects by age (n = 100)*

Age group (years)	Case (n=50)		Control (n=50)		Total (n=100)		p-value
	No.	%	No.	%	No	%	
<20	0	0	7	14	7	7	0.022
20-29	36	72	32	64	68	68	
≥30	14	28	11	22	25	25	
Mean±SD (years)	28.14±3.37		25.24±4.91		26.69±4.44		0.001

In this table-1 showed that the mean age of the total population was 26.69±4.44 years, wherein maximum patients were between 20–29 years (56.7%). Pregnant women with GDM were significantly older than non-GDM pregnant women (28.14±3.37 vs 25.24±4.91 years, p=0.001).

Table 2. *Distribution of the study subjects by socio-demographic characteristics (n = 100)*

Variables		Case (n=50)		Control (n=50)		Total (n=100)		p-value
		No.	%	No.	%	No	%	
Residence	Urban	17	34	17	34	34	34	1
	Rural	33	66	33	66	66	66	
Education	Illiterate	6	12	4	8	10	10	0.596
	Up to primary	11	22	13	26	24	24	
	Below SSC	23	46	27	54	50	50	
	SSC and above	10	20	6	12	16	16	
Occupation	Housewife	40	80	42	84	82	82	0.603
	Service holder	10	20	8	16	18	18	
Monthly family income (BDT)	<10000	11	22	14	28	25	25	0.467
	10000-20000	25	50	27	54	52	52	
	20001-40000	14	28	9	18	23	23	

Table-2 showed that the maximum number of study women were hailed from rural residence (66%), having education level below SSC (50%), were housewife (82%) and had a monthly family income of 10000-20000 Taka (52%). Socio-demographic characteristics in both groups were similarly distributed (p>0.05).

Table 3. *Distribution of the study subjects by anthropometric measurements (n = 100)*

Variables	Case (n=50)	Control (n=50)	Total (n=100)	p-value
Height (cm)	156.44±2.94	156.54±3.48	156.49±3.21	0.877
Weight (Kg)	54.57±4.37	52.67±5.26	53.62±4.90	0.052
BMI (Kg/m^2)	22.25±1.51	21.45±1.99	21.85±1.81	0.027

Table-3 showed that the Pregnant women with GDM had significantly higher BMI than non-GDM pregnant women (22.25±1.51 vs 21.45±1.99 Kg/m2, p=0.027).

Table 4. *Distribution of the study subjects by obstetric characteristics (n = 100)*

Characteristics		Case (n=50)		Control (n=50)		Total (n=100)		p-value
		No.	%	No.	%	No	%	
Gestational age (weeks)	23-28	13	26	13	26	26	26	0.888
	29-36	25	50	23	46	48	48	
	37-39	12	24	14	28	26	26	
	Mean±SD	32.40±4.62		32.64±4.72		32.52±4.65		0.798
Gravida	1st	19	38	24	48	43	43	0.313
	2nd	31	62	26	52	57	57	
Para	0	25	50	28	56	53	53	0.548
	1	25	50	22	44	47	47	

Table-4 showed that the maximum number of study women were nulliparous (53%) and had 2nd gravida (57%). The mean gestational age was 32.52±4.65 weeks. Obstetric characteristics in both groups were similarly distributed ($p>0.05$).

Table 5. *Distribution of the study subjects by blood sugar level (n = 100)*

Variables	Case (n=50)	Control (n=50)	p-value
Fasting blood sugar (mmol/L)	6.03±0.37	4.59±0.27	<0.001
2-hours after breakfast blood sugar (mmol/L)	8.66±1.77	7.05±1.56	<0.001

Table-5 showed the mean blood sugar level before and 2 hours after. The mean of both fasting and 2 hours after breakfast blood sugar was significantly higher in GDM mothers than in non-GDM individuals ($p<0.05$).

Table 6. *Distribution of the study subjects by serum vitamin D level (n = 100)*

Serum 25-dihydroxyvitamin D 25(OH)$_2$	Case (n=50)		Control (n=50)		Total (n=100)		p-value
	No.	%	No.	%	No	%	
≥30 ng/mL	13	26	24	48	37	37	0.023
<30 ng/mL	37	74	26	52	63	63	
Mean±SD ((ng/mL))	24.06±8.67		28.09±8.30		26.07±8.69		0.019

Table-6 showed that the mean serum vitamin-D level was significantly lower in GDM mothers than in non-GDM pregnant women (24.06±8.67 vs 28.09±8.30 ng/mL, $p=0.019$). Besides, pregnant women with GDM had a significantly higher proportion of having serum vitamin-D <30 ng/mL (74% vs 52% in non-GDM women, $p=0.023$).

Table 7. *Distribution of the study subjects by serum vitamin D reference category (n=100)*

Serum 25-dihydroxyvitamin D 25(OH)2	Case (n=50)		Control (n=50)		Total (n=100)		p-value
	No.	%	No.	%	No	%	
Sufficient (≥30 ng/mL)	13	26	24	48	37	37	0.041
Insufficient (20-29.9 ng/mL)	22	44	19	38	41	41	
Deficient (<20 ng/mL)	15	30	7	14	22	22	

Among pregnant women with GDM, 44% had vitamin-D insufficiency and 30% had vitamin-D deficiency, while among non-GDM women, 38% had vitamin-D insufficiency and 14% had vitamin-D deficiency ($p<0.05$).

Table 8. *Linear association of variables with serum vitamin-D level in study patients (n=100).*

Variables	Correlation co-efficient (r)	Significance
Age	-0.139	0.169
BMI	-0.746	<0.001
Gestational age	0.015	0.885
Fasting blood glucose	-0.21	0.036
2HABF	-0.126	0.211

Serum vitamin-D level had a significant negative linear association with BMI ($r=-0.746$, $p<0.001$) and fasting blood glucose ($r=-0.210$, $p=0.036$).

Table 9. *Risk factor analysis by multivariate logistic regression for GDM (n=100)*

Variables of interest	Adjusted OR	95% CI	p-value
Age ≥30	1.351	0.52-3.53	0.539
BMI ≥23	0.358	0.10-1.28	0.115
Gestational age ≥29	0.912	0.35-2.36	0.849
Vit-D sufficiency (≥30 ng/mL)	1.00 (Reference)		
Vit-D insufficiency (20-29.9 ng/mL)	2.337	0.92-5.94	0.074
Vit-D deficiency (<20 ng/mL)	7.436	1.79-30.96	0.006

A multivariate logistic regression model was constructed with age ≥30, BMI ≥23, gestational age ≥29 and vitamin-D level as independent variables and GDM as the dependent variable.

Vit-D deficiency was found to be a significant risk factor for GDM after adjusting for other confounders (AOR=7.44, CI=1.79-30.96, p=0.006).

4. Discussion

This case–control study was conducted to evaluate the association between maternal serum vitamin D levels and gestational diabetes mellitus (GDM) among pregnant women attending a tertiary care hospital. A total of 100 pregnant women were enrolled, comprising 50 women diagnosed with GDM and 50 normoglycaemic pregnant women, selected after matching predefined inclusion and exclusion criteria. The findings of the present study suggest that vitamin D deficiency is significantly associated with GDM and may contribute to altered glucose metabolism during pregnancy [5].

The mean age of the overall study population was 26.69 ± 4.44 years, with more than half of the participants belonging to the 20–29-year age group. This age distribution reflects the typical reproductive age range in Bangladesh and is comparable to findings reported by Mahmood et al., who observed that most pregnant women with GDM were between 20 and 30 years of age in a similar population [17]. Notably, women with GDM in the present study were significantly older than non-GDM pregnant women, indicating that advancing maternal age may play an important role in the development of GDM. Findings from Dwarkanath et al., Cabrera et al., similarly demonstrate that increasing maternal age is a consistent and independent risk factor for GDM across different populations [5,18]. Furthermore, Li et al., in a large systematic review and meta-analysis involving over 120 million participants, demonstrated a linear increase in GDM risk with advancing maternal age, supporting the biological plausibility of age-related insulin resistance and declining β-cell function during pregnancy [19].

In addition to age, body mass index (BMI) was found to be significantly higher among pregnant women with GDM compared with non-GDM controls in the present study. This observation is consistent with extensive literature indicating that increased BMI is a major risk factor for gestational diabetes mellitus. Dwarkanath et al. and Pleskačová et al. reported similar associations between higher BMI and increased GDM risk [5,20]. A recent meta-analysis by Rahnemaei et al. further confirmed that women with higher BMI during early pregnancy are at significantly increased risk of developing GDM, emphasizing the role of adiposity-related insulin resistance in the pathogenesis of the disease [21].

The present study also demonstrated a strong inverse relationship between serum vitamin D levels and BMI. Findings from Pleskačová et al. and Cheng et al. similarly reported that higher BMI is associated with lower circulating vitamin D concentrations during pregnancy [20,22]. Vranić et al. proposed volumetric dilution as a plausible mechanism underlying this relationship, suggesting that vitamin D is distributed into a larger adipose tissue mass in individuals with higher BMI, resulting in lower serum concentrations despite similar total body vitamin D stores [23].

A key finding of this study is that mean serum vitamin D levels were significantly lower in women with GDM compared with non-GDM pregnant women. Additionally, the prevalence of both vitamin D insufficiency and deficiency was markedly higher among GDM cases. After adjustment for potential confounders, vitamin D deficiency emerged as a significant independent risk factor for GDM. Similar findings were reported by Mahmood et al. in a Bangladeshi population, where women with GDM had significantly lower mean serum vitamin D levels compared with controls [17]. Consistent results have been documented internationally, with Cabrera et al. and Pleskačová et al. reporting significantly reduced vitamin D concentrations among women with GDM across diverse ethnic and geographic settings [18,20]. Furthermore, meta-analyses conducted by Aghajafari et al. and Wei et al. demonstrated that low maternal vitamin D status during pregnancy is associated with an increased risk of GDM, reinforcing the robustness of this association [2425].

However, not all studies have reported a significant association between vitamin D deficiency and GDM. Dwarkanath et al. found no statistically significant relationship between maternal vitamin D levels and GDM [5]. These discrepancies may be explained by variations in study design, diagnostic criteria for GDM, vitamin D deficiency cut-off values, sample size, seasonal timing of blood sampling, ethnic diversity and environmental factors such as sunlight exposure.

The present study further observed a significant negative correlation between serum vitamin D levels and fasting blood glucose concentrations. This finding aligns with the results of Pleskačová et al., who reported that lower vitamin D levels are associated with poorer glycaemic control during pregnancy [20]. The biological mechanisms underlying this association may involve vitamin D–mediated regulation of insulin secretion, modulation of intracellular calcium flux in pancreatic β-cells, enhancement of insulin sensitivity in peripheral tissues and attenuation of inflammatory pathways implicated in insulin resistance.

Overall, the findings of this study suggest that hypovitaminosis D may play a contributory role in the development of gestational diabetes mellitus. Given the high prevalence of vitamin D deficiency among pregnant women and the relative safety, affordability and accessibility of vitamin D supplementation, improving maternal vitamin D status may represent a feasible and effective strategy for reducing the burden of GDM and its associated maternal and neonatal complications. Further large-scale prospective studies and randomized controlled trials are required to establish causality and to define optimal screening and supplementation protocols during pregnancy.

5. Limitations of the Study

This study is limited by its single center design, small purposive sample, lack of medication effect tracking and absence of detailed dietary data, which may affect generalizability and introduce unmeasured confounding.

6. Conclusion

This study observed that the mean serum vitamin D level was significantly lower in GDM mothers than in non-GDM pregnant women. Overall, pregnant women with GDM had a significantly higher prevalence of low vitamin D levels than non-GDM women. Vit-D deficiency was found to be a significant risk factor for GDM after adjusting for other confounders. These results correspond with those of previous studies, with slight variations. However, further multicenter studies with larger sample sizes are recommended to provide more information about the role of vitamin D supplementation in mothers with GDM, thus helping clinicians to better manage these patients.

Conflicts of Interest

There are no conflicts of interest.

Ethical Approval

This study approved by the institutional ethical review committee.

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