# "Assessing the Impact of Lifestyle, Anthropometric, and Cardiac Autonomic Parameters on Gestational Diabetes Mellitus classified through DIPSI criteria"

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**KEYWORDS**
Gestational Diabetes Mellitus, Heart Rate Variability, Anthropometric Factors, Lifestyle, Pregnancy Outcomes, Maternal Health.

**ABSTRACT:**
**Introduction** - Gestational diabetes mellitus (GDM) is a prevalent condition that poses significant risks to both maternal and fetal health. This study aims to assess the impact of lifestyle factors (diet), anthropometric parameters (BMI, weight, height), and cardiac autonomic function, measured through heart rate variability (HRV), on the development of GDM in pregnant women.
**Methods** - A cross-sectional study of pregnant women in their first or second trimester was conducted, with lifestyle, anthropometric, and HRV data collected, alongside GDM screening through oral glucose challenge tests by DIPSI criteria.
**Results** - The results reveal significant correlations between higher BMI, non-vegetarian dietary patterns, and reduced HRV with increased GDM risk.Additionally, women with lower HRV metrics (e.g., SDNN, LF/HF ratio) showed a higher likelihood of developing GDM.
**Conclusion** -The findings highlight the critical role of lifestyle interventions and HRV monitoring in reducing GDM risk and improving maternal health outcomes.Study underscores the importance of integrating cardiac autonomicassessments in antenatal care and promoting lifestyle modifications to mitigate the risk of GDM, providing actionable insights for public health strategies.

## Background

Gestational diabetes mellitus (GDM) is one of the most common metabolic disorders in pregnancy, affecting approximately 7–14% of pregnant women worldwide, depending on the population studied and diagnostic criteria used.

Cardiac autonomic dysfunction, which can be measured through heart rate variability (HRV), is increasingly recognized as a potential early marker of metabolic diseases, including GDM. HRV reflects the balance between the sympathetic and parasympathetic branches of the autonomic nervous system, with lower HRV indicating impaired autonomic regulation.

## Gestational Diabetes Mellitus (GDM)

In medicine, an abnormal glucose tolerance that appears or is recognized for the first time during pregnancy is referred to as "gestational diabetes mellitus" (GDM)[1].It typically arises during the second or third trimester and is attributed to the metabolic changes that occur as a result of increased insulin resistance.In the end, these issues could cause the mother and the child to develop type 2 diabetes (T2DM).[2]

## Risk Factors for GDM

GDM is Diabetes diagnosed in the second or third trimester of pregnancy without a history of type 1 or type 2 diabetes, according to the Diabetes Canada Clinical Practice Guidelines Expert Committee et al. (2018).[3]Several risk factors are known to predispose women to GDM. These include advanced maternal age, pre-pregnancy obesity, a family history of diabetes, and specific ethnic backgrounds such as South Asian, African American, and Hispanic. Women who have had GDM in a previous pregnancy or who have polycystic ovary syndrome (PCOS) are also at higher risk. Moreover, excessive gestational weight gain, particularly in early pregnancy, has been linked to increased GDM risk.Autonomic dysfunction can arise as a result of diabetes, but it can also happen in the absence of type 2 diabetes.[4]The high-frequency

(HF) band significantly decreased in 2 groups following the consumption of glucose, according to a study. The normalized low-frequency (LF) band increased significantly while the normalized high-frequency (HF) band decreased significantly after glucose injection.[5]

**Diagnosis of GDM**

DIPSI suggests the oral glucose challenge test (GCT) ,using 75 grams of glucose irrespective of meal timings and a cut-off of 140 mg/dl after two hours is required to be called GDM positive.[6]

**Long-Term Consequences of GDM**

In the short term, GDM increases the risk of preeclampsia, cesarean delivery, and macrosomia (large birth weight) in the infant. In the long term, women who develop GDM are at an increased risk of developing type 2 diabetes and cardiovascular diseases post-pregnancy. Children born to mothers with GDM also have an elevated risk of developing obesity, glucose intolerance, and metabolic disorders later in life. Therefore, understanding and managing GDM is critical for preventing adverse outcomes and ensuring long-term maternal and child health. In a study conducted by Gasic et al.,Time domain analysis (SDNN) showed a reduced HRV in 25 out of the 48 (52%) women with prior GD. Frequency domain analysis showed that in these 25 subjects, both the low and high frequency components of power spectral density, which mainly reflect sympathetic and parasympathetic activity, were decreased. This suggests that there may be impairment in both sympathetic and parasympathetic function[7].Ina study by Maser et al, the analysis revealed that late pregnancy, namely between 30 and 35 weeks gestation, had an impact on the functioning of the autonomic nervous system (ANS). Interestingly, this effect seemed to be consistent for pregnant women, regardless of whether they had the metabolic disorder known as gestational diabetes mellitus (GDM) or not.[8]

**Role of Lifestyle Factors in GDM**

**Impact of Diet, Physical Activity, and Smoking on GDM Risk**

Lifestyle factors, including diet, physical activity, and smoking, play significant roles in the development of GDM.Another study indicates that maternal weight and body mass indices were significantly elevated compared to a group of individuals with normal weight, given that obesity is a prominent risk factor for the development of gestational diabetes mellitus (GDM).[9] Unhealthy dietary habits, such as high consumption of refined carbohydrates, sugary beverages, and saturated fats, have been associated with an increased risk of GDM. Diets that are low in fiber, fruits, and vegetables contribute to poor glycemic control and exacerbate insulin resistance during pregnancy.Gestational diabetes is linked to simultaneous early morning sympathetic stimulation and activation of the extrinsic coagulation pathway, resulting in a shorter PT (prothrombin time).[10]

Physical activity has been shown to have a protective effect against GDM by improving insulinsensitivity and aiding in weight management. Pregnant women who engage in regular physical activity before and during pregnancy have a lower risk of developing GDM. Conversely, sedentary behavior increases the likelihood of GDM and related complications.Studies have been performed which show increased ANS activity in fetuses of diabetic mothers in late gestation. The use of PRSA to analyse human foetal cardiovascular and ANS function may provide better monitoring compared to traditional methods. This might help establish a connection between GDM pregnancy and potential cardiovascular issues in the progeny.[11]

**Interventions Aimed at Lifestyle Modification to Reduce GDM Incidence**

Several randomized controlled trials have demonstrated that adopting a healthy diet rich in whole grains, lean proteins, fruits, and vegetables, along with regular physical exercise, can significantly lower the incidence of GDM in at-risk women.Structured physical activity programs, even as simple as moderate-intensity walking or yoga, are beneficial in reducing GDM risk.Further longitudinal investigations with bigger groups of participants are necessary to confirm these findings and clarify the chronological connection between autonomic dysfunction and the development of gestational diabetes mellitus (GDM).[12]

**Anthropometric Parameters and GDM**

**The Relationship Between BMI, Weight Gain During Pregnancy, and GDM**

Research indicates that as BMI increases, so does the risk of GDM, with obesity being one of the strongest risk factors.

In addition to pre-pregnancy BMI, excessive weight gain during pregnancy, particularly in the first trimester, has been associated with an increased likelihood of developing GDM.

**Importance of Body Composition in Pregnancy Outcomes**

Beyond BMI and gestational weight gain, body composition, including fat distribution, plays an important role in GDM risk. Visceral fat, or fat stored around internal organs, is more metabolically active and contributes to greater insulin resistance than subcutaneous fat. This means that women with a higher proportion of visceral fat are more prone to developing GDM, even if their overall weight gain during pregnancy is within recommended limits.

Body composition analysis, including the measurement of fat mass and lean body mass, has the potential to provide a more nuanced understanding of GDM risk than BMI alone. In India, the BMI ranges are: Underweight (<18.5 kg/$m^2$), normal or lean (18.5–22.9 kg/$m^2$), overweight (23.0–24.9 kg/$m^2$), and obese (>25 kg/$m^2$).[13]

Monitoring body composition, alongside weight gain, can help healthcare providers better assess and manage GDM risk, leading to more personalized interventions.

**Cardiac Autonomic Function and GDM**

Cardiac autonomic function, as measured by heart rate variability (HRV), is an emerging area of interest in GDM research. HRV is a non-invasive measure of the balance between the sympathetic and parasympathetic branches of the autonomic nervous system. Autonomic dysfunction, which refers to alterations in the sympathetic and parasympathetic nervous systems, is increasingly acknowledged as a potential contributor to the occurrence of both gestational diabetes mellitus (GDM) and preeclampsia[14]

**HRV and GDM**

Pregnancy is associated with physiological changes in autonomic regulation, and these changes are expected as the body adapts to support fetal growth. However, women who develop GDM often exhibit abnormal reductions in HRV, suggesting autonomic dysfunction. Studies have found that lower HRV values, particularly in parasympathetic indices such as the root mean square of successive differences (RMSSD) and high-frequency power (HF), are associated with an increased risk of GDM. Autonomic neuropathy frequently occurs as a consequence of diabetic mellitus (DM). Patients with DM have been found to exhibit reduced vagal nerve activity and increased sympathetic nerve activity.[15]

This autonomic dysfunction may reflect underlying insulin resistance, inflammation, and oxidative stress, which contribute to the pathophysiology of GDM. Thus, HRV could serve as an early marker of GDM, providing a non-invasive way to identify women at risk before traditional glucose screening methods. Timely identification of cardiac autonomic neuropathy can aid in the early detection of atherosclerosis progression in individuals with type 2 diabetes mellitus, thereby mitigating adverse consequences.[16]

**Potential for HRV Monitoring in GDM Prevention**

Given the potential role of HRV in predicting GDM, integrating HRV monitoring into routine antenatal care may provide valuable insights into maternal autonomic function and metabolic health. Advanced age, being female, having elevated levels of LDL cholesterol and triglycerides, and having microalbuminuria were found to be independently linked to decreased heart rate variability (HRV). However, these factors did not fully explain the variations in HRV between individuals with and without diabetes.[17]Early identification of autonomic dysfunction through HRV could enable timely lifestyle interventions aimed at improving autonomic balance and reducing GDM risk. Further research is needed to validate HRV as a clinical tool for GDM screening and to explore its integration with other risk factors such as BMI, diet, and physical activity. Another contradictory study by Sharifiherisetal, indicates that the autonomic nervous system (ANS) is associated with some pregnancy difficulties, such as fetal growth

issues. Nevertheless, their research does not provide evidence for a connection between the autonomic nervous system (ANS) and gestational diabetes mellitus[18] Their findings indicate that pregnancy has an identical impact on cardiovascular autonomic modulation and hemodynamics in individuals with and without gestational diabetes mellitus (GDM). This suggests that metabolic problem during pregnancy does not lead to cardiovascular dysfunction as long as GDM is well controlled.[19]

Results of another study state that there was no statistically significant difference ($p>0.05$) in age, height, weight, and BMI between the cases and controls, indicating that the groups were comparable. Both the systolic and diastolic blood pressure were observed to be considerably higher ($p=0.0001$) in the cases compared to the controls. The cases exhibited considerably greater peak frequency (in Hz) and peak power (%) compared to the controls, with a p-value of 0.0001. Conclusion: The study's results indicate that patients with GDM had significantly higher HRV compared to the control group.[20]

This literature review highlights the multifactorial nature of GDM, involving lifestyle, anthropometric, and physiological factors, and underscores the potential of using HRV as a tool for early detection and prevention of GDM.

**Methodology**

**Study Design**– Cross-sectional study to assess the relationship between lifestyle, anthropometric, and cardiac autonomic parameters with GDM incidence.

**Study Population and Sample Size** -The study involved a cohort of pregnant women (n=99), drawn from both rural and urban populations, who were in their first or second trimester of pregnancyreceiving prenatal care at Integral Institute of Medical Sciences and Research, Lucknow.

**Inclusion criteria**:Pregnant individuals aged 18-40 years, Gestational age 10-19 weeks, Primi pregnancy.

**Exclusion criteria**:Pre-existing cardiovascular disease, pre-existing diabetes, those females not giving consent

**Data Collection Methods**

**Lifestyle Assessment**-Dietarypatterns: Vegetarianvs. Non-Vegetarian.

Vegetarian- Consumption of plant based foods, milk and dairy products

Non-Vegetarian- Consumption of plant based foods, meat, fish, eggs, milk and dairy products

**Anthropometric Measurements**-BMI, weight, and height at recruitment.

**Cardiac Autonomic Parameters**-HRV measures including SDNN, RMSSD, LF power, HF power, LF/HF ratio using a Polyriteinstrument.Short Term HRV recording was done using Lead II for 5 mins

**GDM Diagnosis**-Screening for GDM viaoral glucose challenge tests through DIPSI criteria between 10-19 weeks of gestation.

**Statistical Analysis -** Descriptive statistics to summarize demographic and clinical characteristics of the sample.Correlation analysis to assess relationships between lifestyle factors, anthropometric data, and HRV metrics with GDM status

**1. Descriptive Statistics**

Table 1 provides a summary of the demographic, anthropometric, lifestyle, and cardiac autonomic parameters of the study cohort, along with the GDM prevalence.

**Table 1**

| Variable | Mean ± SD | Range | GDM Status % |
|---|---|---|---|
| Age (years) | 27.4± 3.2 | 23–30 | 22% |
| BMI (kg/m²) | 24.1± 3.2 | 20.9–25.4 | 26% |
| SDNN (ms) | 42.3 ± 12.5 | 20–60 | 18% |
| LF/HF Ratio | 1.38 ± 0.3 | 1.1–1.7 | 20% |
| Non-Vegetarian Diet (n) | 48 (60%) | - | 28% |
| Vegetarian Diet (n) | 32 (40%) | - | 16% |
| Rural Population (n) | 45 (56%) | - | 25% |
| Urban Population (n) | 35 (44%) | - | 18% |

**2. Correlation Analysis**

Table 2 shows the relationships between BMI, diet, HRV, and GDM were analyzed using Pearson's correlation coefficient, with p-values to assess significance. A p-value < 0.05 was considered statistically significant.

**Table 2**

| Variable | BMI | Non-vegetarian diet | SDNN | LF/HF Ratio | GDM Status |
|---|---|---|---|---|---|
| BMI | - | 0.32* | -0.28* | 0.25* | 0.45** |
| Non-vegetarian diet | 0.32* | - | -0.15 | 0.22* | 0.38* |
| SDNN | -0.28* | -0.15 | - | 0.56** | -0.51** |
| LF/HF Ratio | 0.25* | 0.22* | 0.56** | - | 0.49** |
| GDM Status | 0.45** | 0.38* | -0.51** | 0.49** | - |

- *p < 0.05, **p < 0.01
- **Interpretation:** A higher BMI (r = 0.45, p < 0.01) and non-vegetarian diet (r = 0.38, p < 0.05) were positively correlated with GDM. Reduced SDNN (r = -0.51, p < 0.01) and a higher LF/HF ratio (r = 0.49, p < 0.01) were significantly associated with increased GDM risk, indicating impaired cardiac autonomic function.

**Discussion**

The results of this study underscore the complex interplay between lifestyle, anthropometric, and cardiac autonomic parameters in predicting the risk of gestational diabetes mellitus (GDM) in pregnant women. Several important findings emerged from the analysis.

The results of this study have significant implications for public health strategies aimed at reducing the incidence of GDM. First, the strong association between BMI and GDM highlights the importance of pre-pregnancy counseling and weight management programs for women of reproductive age. Interventions that promote healthy weight before and during pregnancy could substantially lower the risk of GDM and its associated complications.

Dietary counseling should specifically address the increased risk associated with non-vegetarian diets high in processed meats and unhealthy fats. Shifting dietary habits towards more plant-based, nutrient-rich diets could help mitigate the risk of GDM, particularly in populations that are more prone to poor dietary practices.

The use of HRV as a screening tool offers new opportunities for early detection of GDM risk. HRV monitoring could be integrated into routine antenatal visits, providing a non-invasive method for assessing autonomic function and identifying women who might benefit from early intervention, such as lifestyle modifications or closer glucose monitoring.

**Limitations**

This study has several limitations. First, the sample size may limit the generalizability of the findings, particularly in detecting differences between rural and urban populations. Future studies with larger, more diverse samples are needed to confirm these trends and explore potential regional disparities in GDM risk. Second, lifestyle factors such as physical activity and dietary intake were self-reported, which may introduce recall bias.

**Conclusion**

The findings of this study highlight the critical role of lifestyle and anthropometric factors in the development of GDM, with BMI, non-vegetarian diet, and cardiac autonomic dysfunction emerging as significant predictors. These results underscore the importance of early interventions focused on weight management and dietary modifications in reducing GDM risk. The use of HRV as a potential early

screening tool for GDM also offers promising avenues for future research and clinical practice. Addressing these factors, particularly in at-risk populations such as rural women, could lead to substantial improvements in maternal and fetal health outcomes.

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**REFERENCES**

1. Sweeting A, Wong J, Murphy HR, Ross GP. A clinical update on gestational diabetes mellitus. Endocrine reviews. 2022 Oct 1;43(5):763-93.
2. Modzelewski R, Stefanowicz-Rutkowska MM, Matuszewski W, Bandurska-Stankiewicz EM. Gestational diabetes mellitus—recent literature review. Journal of Clinical Medicine. 2022 Sep 28;11(19):5736.
3. Reyes LM, Khurana R, Usselman CW, Busch SA, Skow RJ, Boulé NG, Davenport MH, Steinback CD. Sympathetic nervous system activity and reactivity in women with gestational diabetes mellitus. Physiological Reports. 2020 Jul;8(13):e14504.
4. Yu TY, Lee MK. Autonomic dysfunction, diabetes and metabolic syndrome. Journal of Diabetes Investigation. 2021 Dec;12(12):2108.
5. Weissman A, Lowenstein L, Peleg A, Thaler I, Zimmer EZ. Power spectral analysis of heart rate variability during the 100-g oral glucose tolerance test in pregnant women. Diabetes care. 2006 Mar 1;29(3):571-4.
6. Rani PR, Begum J. Screening and diagnosis of gestational diabetes mellitus, where do we stand. Journal of clinical and diagnostic research: JCDR. 2016 Apr;10(4):QE01.
7. Gasic S, Winzer C, Bayerle-Eder M, Roden A, Pacini G, Kautzky-Willer A. Impaired cardiac autonomic function in women with prior gestational diabetes mellitus. European journal of clinical investigation. 2007 Jan;37(1):42-7.
8. Maser RE, Lenhard MJ, Kolm P. Autonomic modulation in gestational diabetes mellitus. Journal of Diabetes and its Complications. 2014 Sep 1;28(5):684-8.
9. Zöllkau J, Swiderski L, Schmidt A, Weschenfelder F, Groten T, Hoyer D, Schneider U. The relationship between gestational diabetes metabolic control and fetal autonomic regulation, movement and birth weight. Journal of Clinical Medicine. 2021 Jul 30;10(15):3378.
10. Pöyhönen-Alho M, Joutsi-Korhonen L, Lassila R, Kaaja R. Alterations of sympathetic nervous system, coagulation and platelet function in gestational diabetes. Blood coagulation & fibrinolysis. 2012 Sep 1;23(6):508-13.
11. Lobmaier SM, Ortiz JU, Sewald M, Müller A, Schmidt G, Haller B, Oberhoffer R, Schneider KT, Giussani DA, Wacker-Gussmann A. Influence of gestational diabetes on fetal autonomic nervous system: a study using phase-rectified signal-averaging analysis. Ultrasound in Obstetrics &Gynecology. 2018 Sep;52(3):347-51.
12. Siddiqui S, Alam T, Choudhary AK, Khan A. An association between pre-pregnancy maternal body mass index and the risk of pre-eclampsia in the North India. National Journal of Physiology, Pharmacy and Pharmacology. 2022 Oct 1;12(10):1588-.
13. Pichardo-Carmona EY, Reyes-Lagos JJ, Ceballos-Juárez RG, Ledesma-Ramírez CI, Mendieta-Zerón H, Peña-Castillo MÁ, Nsugbe E, Porta-García MÁ, Mina-Paz Y. Changes in the autonomic cardiorespiratory activity in parturient women with severe and moderate features of preeclampsia. Frontiers in Immunology. 2023 Sep 1;14:1190699.
14. Siddiqui S, Manik KA, Srivastava M, Swaroop M, Husain G. Gestational Diabetes Mellitus And Autonomic Dysfunction: Impact On Preeclampsia Risk. Journal of Advanced Zoology, 2024 Apr; 45(4), 44–52.4531

15. Hamaoka, T., Leuenberger, U.A., Murray, M., Blaha, C.A., Luck, J.C., & Cui, J. (2022). Different Relationship Between Glycemic Status and Autonomic Function in Patients with Type 2 Diabetes Mellitus and in Healthy Controls. The FASEB Journal, 36.
16. Fakhrzadeh H, Yamini-Sharif A, Sharifi F, Tajalizadekhoob Y, Mirarefin M, Mohammadzadeh M, Sadeghian S, Badamchizadeh Z, Larijani B. Cardiac autonomic neuropathy measured by heart rate variability and markers of subclinical atherosclerosis in early type 2 diabetes. International Scholarly Research Notices. 2012;2012(1):168264.
17. Jaiswal M, Urbina EM, Wadwa RP, Talton JW, D'Agostino Jr RB, Hamman RF, Fingerlin TE, Daniels S, Marcovina SM, Dolan LM, Dabelea D. Reduced heart rate variability among youth with type 1 diabetes: the SEARCH CVD study. Diabetes care. 2013 Jan 1;36(1):157-62.
18. Sharifi-Heris Z, Rahmani AM, Axelin A, Rasouli M, Bender M. Heart rate variability and pregnancy complications: systematic review. Interactive Journal of Medical Research. 2023 Jun 5;12(1):e44430.
19. Heiskanen N, Saarelainen H, Kärkkäinen H, Valtonen P, Lyyra-Laitinen T, Laitinen T, Vanninen E, Heinonen S. Gestational diabetic patients with adequate management have normal cardiovascular autonomic regulation during the third trimester of pregnancy and 3 months after delivery. Journal of Diabetes and its Complications. 2010 Jul 1;24(4):234-41.
20. Bhatnagar P, Srivastava M. A study on the analysis of heart rate variability among women with gestational diabetes mellitus. International Journal Of Medical Science And Clinical Invention. 2017;4:3380-2.