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Original Research Article

CORRELATION STUDY BETWEEN MATERNAL BODY MASS INDEX AND HBA1C LEVELS IN FIRST TRIMESTER OF PREGNANCY

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ABSTRACT

Background: Obesity is increasingly prevalent among women of reproductive age and is linked to adverse pregnancy outcomes such as gestational diabetes mellitus, hypertensive disorders, and fetal macrosomia. Early pregnancy body mass index (BMI) is considered an important predictor of metabolic risk, while glycated hemoglobin (HbA1c) provides an estimate of average glycemic levels over the preceding 2–3 months. Understanding the relationship between BMI and HbA1c in early pregnancy may assist in identifying women at risk of hyperglycemia and improving maternal–fetal outcomes. The aim is to evaluate the correlation between maternal BMI and HbA1c levels during the first trimester of pregnancy.
Materials and Methods: This observational cross-sectional study was conducted among pregnant women attending the antenatal clinic at Yenepoya Medical College Hospital, Deralakatte, Mangalore. A total of 162 eligible women aged 18–40 years with singleton pregnancies in their first trimester were recruited using consecutive sampling. Women with pre-existing diabetes, medical conditions or medications affecting glucose metabolism, and hemoglobinopathies were excluded. Data were collected using a structured form, including demographic and obstetric details. BMI was calculated from measured height and weight, and venous blood samples were obtained for HbA1c estimation. Descriptive statistics were used to summarize data, and correlation analysis was performed to assess the relationship between BMI and HbA1c, with significance set at $p < 0.05$.
Results: The study evaluated BMI and HbA1c levels in early pregnancy and analyzed their relationship. Preliminary findings indicated variation in HbA1c values across BMI categories. Comparison between the two groups using the Mann–Whitney U test demonstrated a statistically significant difference in HbA1c levels ($U = 506.00$, $p = 0.0001$). This finding suggests that obesity is significantly associated with higher HbA1c levels and poorer glycemic control.
Conclusion: This study explores the potential correlation between maternal BMI and HbA1c levels in early pregnancy. Identifying such a relationship may support early risk stratification for hyperglycemia in pregnancy and enhance preventive strategies aimed at improving maternal and neonatal health outcomes.
Keywords: BMI, HbA1c, first trimester, pregnancy, hyperglycemia, maternal health, correlation study.

INTRODUCTION

Pregnancy is a dynamic physiological state marked by profound metabolic and hormonal changes aimed at supporting fetal development and maternal adaptation. During this period, insulin sensitivity and glucose metabolism undergo substantial modifications, particularly as gestation progresses.

Maternal metabolic health during the first trimester is a critical factor that helps determine both maternal and fetal health outcomes, with early interventions being essential to mitigate risks (Catalano et al., 2017).[1] Early identification of women at risk of metabolic dysfunction can help in preventing adverse outcomes such as gestational diabetes mellitus (GDM), preeclampsia, and fetal overgrowth. Women who develop GDM may have impaired glucose homeostasis early in or prior to pregnancy, as shown by their elevated first trimester HbA1c. First trimester HbA1c may aid in early identification of at risk women (Hinkle et al., 2018).[2]

Maternal BMI is a widely accepted anthropometric measure reflecting nutritional and metabolic reserves. There was a synergistic effect on PTB (pre term birth) risk due to abnormal weight and glycemia in addition to a conventional main effect resulting from either of them. Achieving desirable weight and glucose control before conception should be advised (Xu Q et al., 2021).[3] HbA1c measured before advised routine screening period reflects early pathophysiological imbalances in beta-cell function and glucose disposal that are characteristic of GDM development and may be beneficial in early risk stratification (Bozkurt et al., 2020).[4]

Given the rising burden of maternal obesity and gestational diabetes, particularly in developing countries like India, it is important to explore the interrelationship between maternal BMI and HbA1c levels in early pregnancy. Early pregnancy HbA1c offers a simple screening test for gestational diabetes, allowing those at uppermost risk to receive early intervention and greatly decrease the need for OGTT (oral glucose tolerance test). This can also be carried out using point-of-care HbA1c in LMICs (low-income and middle-income countries) (Saravanan P et al. ,2024).[5] This study thus aims to examine the correlation between maternal BMI and HbA1c levels during the first trimester of pregnancy and to evaluate the clinical significance of this association in predicting adverse maternal and fetal outcomes.

The increasing prevalence of obesity among women of reproductive age is a major global public health concern. According to the World Health Organization (2022), In 2022, 43% of adults aged 18 years and over were overweight and 16% were living with obesity.[6] In India, data from the National Family Health Survey (NFHS-5) show that about one in four women of reproductive age is overweight or obese (ICMR, 2021).[7] Excess adiposity before or during early pregnancy alters maternal metabolism, increasing the risk of insulin resistance and glucose intolerance. Elevated BMI has been shown to increase circulating free fatty acids, promote inflammation, and impair insulin signaling, ultimately leading to hyperglycemia (Catalano et al., 2014).[1]

HbA1c, a biochemical marker formed by non-enzymatic glycation of hemoglobin, reflects the average blood glucose concentration over the previous 2–3 months. It has the advantage of being a non-fasting test, making it highly suitable for pregnant women. Although HbA1c levels tend to decrease slightly during pregnancy due to increased red cell turnover, higher values during the first trimester are predictive of later gestational dysglycemia and adverse pregnancy outcomes (Sweeting et al., 2017).[8] Studies have demonstrated that women with higher early-pregnancy HbA1c levels are more likely to develop GDM and to deliver large-for-gestational-age infants (Bozkurt et al., 2020).[4]

In resource-limited settings, where advanced screening methods such as oral glucose tolerance tests (OGTT) are often unavailable or costly, combining BMI and HbA1c assessments during the first antenatal visit can provide a practical alternative for identifying women at risk for gestational diabetes and related complications (Saravanan et al., 2024).[5]

REVIEW OF LITERATURE

Several studies have investigated the association between maternal BMI and HbA1c during early pregnancy, consistently demonstrating a positive correlation between the two.

(Wang X el al. 2023) found that Pre-pregnancy overweight/obesity and late-pregnancy high HbA1c increased the risk of other gestational metabolic diseases of women with GDM. Monitoring and controlling late-pregnancy HbA1c was effective in reducing metabolic diseases, particularly in those who were overweight/obese before conception.[9]

(Song X et al. 2022) findings shown that pre-pregnancy overweight/obesity raised the risks of macrosomia and LGA (large for gestational age) newborns independently and considerably mediated via GDM (gestational diabetes mellitus). Additional, concerns about GDM and fetal overgrowth should be intricated in weight-control interventions aiming overweight or obese women throughout the whole pregnancy.[10]

(Xu Q et al.,2021) conducted a population based cohort study and found that the associations of PTB (pre-term birth) with BMI varied with levels of FPG (fasting plasma glucose), and associations of PTB with FPG diverse with levels of BMI. There was a synergistic impact on PTB risk due to abnormal weight and glycemia besides a usual main effect derived from either of them. Achieving required weight and glucose control before conception should be advised.[3]

(Pan Y et al., 2016) studied that abnormal pre-pregnancy BMIs were associated with increased risks of adverse pregnancy outcomes.[11]

(Liu P et al., 2016) found that being overweight or obese was associated with a higher risk of still birth, large for gestational age, macrosomia, admission to the neonatal intensive care unit and LBW (low birth weight), while being underweight was associated with an increased risk of preterm birth, small for gestational age, and LBW. Women of childbearing age should maintain a normal body mass index before pregnancy.[12]

(Nisar et al., 2024) study concluded that maternal HbA1c level is an independent risk factor for predicting adverse pregnancy outcomes such as stillbirth, preterm birth, and LGA (large for gestational age) among women in South Asia and Sub-Saharan Africa.[13]

(Callaway et al., 2006) concluded that Rising BMI is linked with maternal and neonatal outcomes that may increase the costs of obstetric care. To assist in planning health service delivery BMI should be regularly recorded on perinatal data collection sheets.[14]

(Osmundson SS et al., 2016) studied that Early treatment for women with a first-trimester HbA1C of 5.7 to 6.4% did not significantly reduce the risk of GDM except in nonobese women.[15]

Overall, the literature supports a consistent positive correlation between maternal BMI and HbA1c during the first trimester of pregnancy. Both parameters independently predict metabolic dysfunction and adverse outcomes, but their combination enhances predictive accuracy. Monitoring these parameters early in pregnancy can enable timely lifestyle and therapeutic interventions to improve both maternal and neonatal outcomes, especially in low-resource environments where standard glucose testing may be limited.

MATERIALS AND METHODS

This cross-sectional observational study aimed to study the correlation between body mass index (BMI) and HbA1c in the first trimester of pregnancy. The study duration spanned 5 months, encompassing participant enrolment and data collection in the first trimester.

Inclusion criteria:

- Age between 18 and 40 years
- Pregnant women attending antenatal clinic in first trimester of pregnancy whose height & weight is measured and HbA1c values are available.
- Singleton pregnancy

Exclusion criteria:

- Women with known pre-existing diabetes mellitus (Type 1 or Type 2).
- Women with chronic medical conditions affecting glucose metabolism (e.g., thyroid disorders, Cushing's syndrome, polycystic ovary syndrome).
- Use of medications that influence glucose metabolism (e.g., corticosteroids, antipsychotics).
- Severe anemia or hemoglobinopathies affecting accuracy of HbA1c measurement (e.g., sickle cell disease, thalassemia).
- Women's condition unstable due to suspected ectopic pregnancy rupture, severe hyperemesis.

According to the Obstetrics and Gynaecology Department, YMCH protocol, during the first antenatal visit in the first trimester – age, height was measured using a stadiometer, and weight was measured using a standard weighing scale and documented in the file. HbA1c levels were tested using high-performance liquid chromatography (HPLC) in blood samples of all pregnant women in the first trimester during the booking visit as per departmental protocol. Pregnant women who visited the Obstetrics and Gynaecology OPD (out-patient department) for antenatal care in their first trimester and fulfilled the inclusion criteria were included in the study after obtaining informed consent. BMI was not documented in the patient file; hence, BMI was calculated by the principal investigator using height and weight documented in their outpatient file with the standard formula.

$$BMI = \frac{weight\,(kg)}{height^2\,(m^2)}$$

HbA1c levels obtained as per departmental protocol were noted by the principal investigator.

The participants in the study were categorised into two groups based on their Body Mass Index (BMI) to assess the relationship between BMI and relevant clinical parameters. Group 1 included 81 participants with a BMI ranging from 18.5–22.9, representing individuals with a normal BMI as per WHO classification for adult Asians. Group 2 included 81 participants with a BMI greater than 23, classifying them as overweight/obese according to WHO classification for adult Asians (WHO Expert Consultation).[16]

Enrolment continued until 81 participants were included in each group, allowing for a balanced comparative analysis. This stratification allowed for a comparative analysis across different BMI categories. Correlation between participants of various BMI categories and HbA1c levels were assessed.

RESULTS

Comparative analysis was performed to determine differences in mean HbA1c levels across BMI categories and to assess the correlation between maternal BMI and HbA1c levels.

Table 1: shows data of group 1 (Normal BMI) - BMI between 18.5-22.9

	Age (Mean + SD)	Height (Mean + SD)	weight (Mean + SD)	BMI (Mean + SD)	HbA1c (Mean + SD)
AVERAGE VALUE	27.79 + 5.40	154.76 + 6.55	50.18 + 5.35	20.90 + 1.23	5.0 + 0.84

In Group 1 (Normal BMI: 18.5–22.9 kg/m²), 81 participants with mean age 27.79 demonstrated anthropometric and glycemic parameters within normal physiological ranges. The mean height of the participants was 154.76 cm, with an average body weight of 50.18 kg, resulting in a mean BMI of 20.9

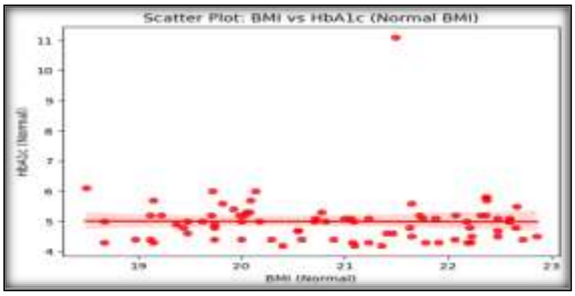
kg/m², which falls well within the defined normal BMI category. The mean HbA1c level was 5%, indicating normal long-term glycemic control and absence of dysglycemia in this group. Overall, these findings reflect a metabolically healthy population with normal body composition and optimal glycemic status.

Table 2: shows data of group 2 (Overweight/Obese BMI) - BMI >23

	Age (Mean + SD)	Height (Mean + SD)	weight (Mean + SD)	BMI (Mean + SD)	HbA1c (Mean + SD)
Average value	29.58 + 5.55	154.76 + 6.76	66.95 + 11.74	27.91 + 4.32	6.74 + 1.66

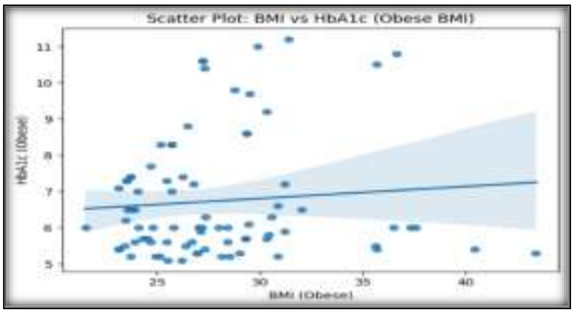
In Group 2 (Overweight/Obese; BMI >23 kg/m²), 81 participants with mean age 29.58 exhibited higher anthropometric measurements and impaired glycemic parameters compared to the normal BMI group. The mean height was 154.76 cm, while the average body weight was 66.95 kg, resulting in a mean BMI of 27.91 kg/m², confirming classification into the overweight/obese category. The mean HbA1c level was 6.74%, which is indicative of poor glycemic control and falls within the diabetic range. These findings suggest a clear association between increased body mass index and elevated HbA1c levels, reflecting a higher risk of metabolic dysfunction among overweight and obese individuals.

- Since variables are non-normal for correlation analysis, we use Spearman correlation coefficient formula and scatter diagram



Normal (Group 1) BMI Vs HbA1c
r = -0.047

The correlation coefficient between Normal (Group1) BMI Vs HbA1c was r = −0.047, indicating a very weak negative correlation. This suggests that there is almost no linear/monotonic relationship between BMI and HbA1c among individuals with normal BMI. In practical terms, changes in BMI within the normal range are not meaningfully associated with changes in HbA1c levels in this group.



Overweight/ Obese (group 2) - BMI Vs HbA1c
r = 0.060

The correlation coefficient between Overweight/Obese (group 2) - BMI Vs HbA1c was r = 0.060, indicating a very weak positive correlation. This suggests that there is no meaningful association between BMI and HbA1c levels among overweight/obese individuals.

Table 3: Comparison between HbA1c of Group 1 (Normal - BMI) and group 2 (Overweight/obese - BMI) was performed using the Mann–Whitney U test.

Variables	Median	IQR	U statistics	P value
Normal BMI (Group 1) HbA1c	5.0	0.7	506.00	0.0001
Overweight/obese BMI (Group 2) HbA1c	6.0	1.7		

The median HbA1c level in the normal group was 5.0 with an interquartile range (IQR) of 0.7, whereas the obese group showed a higher median HbA1c of 6.0 with a wider (IQR)of 1.7, indicating greater variability in glycemic levels among obese individuals. Comparison between the two groups using the Mann–Whitney U test demonstrated a statistically significant difference in HbA1c levels (U = 506.00, p = 0.0001). This finding suggests that obesity is significantly associated with higher HbA1c levels and poorer glycemic control.

DISCUSSION

The findings of the present study demonstrate a clear relationship between maternal body mass index and glycemic status during the first trimester of pregnancy. Women with a normal BMI exhibited optimal HbA1c levels, reflecting normal glucose metabolism and metabolic health in early gestation. In contrast, participants classified as overweight or obese showed significantly higher HbA1c levels, suggesting impaired glycemic control even in the first trimester.

These results indicate that increasing maternal BMI is associated with elevated HbA1c levels, highlighting excess body weight as an important risk factor for early dysglycemia in pregnancy. The presence of raised HbA1c in overweight and obese women during early gestation underscores the likelihood of pre-existing insulin resistance, which may predispose these women to gestational diabetes mellitus and adverse maternal–fetal outcomes later in pregnancy.

(Amylidi-Mohr S et al., 2023) study shows that Gestational diabetes mellitus was observed in 14.7% of women (115/785). Those who developed GDM had significantly higher first-trimester HbA1c and random plasma glucose levels and a higher body mass index, and were more likely to have a previous history of GDM or a first-degree family history of diabetes. A predictive model combining maternal characteristics with early pregnancy HbA1c and random plasma glucose showed good discriminatory ability for GDM (AUC 0.76; 95% CI: 0.70–0.81), indicating that these parameters can effectively identify women at increased risk of GDM in the first trimester.[17]

(Bozkurt L et al., 2020) study concluded that HbA1c assessed prior to the routine screening window may capture early abnormalities in β-cell function and glucose regulation that precede the onset of gestational diabetes, making it a valuable marker for early identification and risk stratification of women likely to develop GDM.[18]

(Nisar et al., 2024) study shows that Maternal HbA1c has been identified as an independent predictor of adverse pregnancy outcomes, including stillbirth, preterm delivery, and large-for-gestational-age infants among women in South Asia and Sub-Saharan Africa. Early screening and timely intervention in these populations may help reduce the risk of such complications.[13]

(Parsaei M et al., 2024) study findings demonstrated that, in addition to known risk factors, a prior history of preeclampsia and raised fasting blood glucose levels in early pregnancy independently predict the development of gestational diabetes mellitus. Early identification and close follow-up of women with these risk factors may enable timely diagnosis and intervention, thereby helping to reduce the overall burden of GDM.[19]

(Yang X et al., 2002) study shows that Women with impaired glucose tolerance during pregnancy showed a markedly higher risk of adverse outcomes, including premature rupture of membranes, preterm delivery, breech presentation, and delivery of high–birth-weight infants, even after adjustment for maternal age, pre-pregnancy BMI, hospital level, and other confounders. These findings indicate that impaired glucose tolerance in pregnancy is a significant predictor of unfavourable pregnancy outcomes.[20]

(Hughes RC et al., 2014) studied that HbA1c testing was easily implemented compared with the limited uptake of early oral glucose tolerance tests. An HbA1c level of ≥5.9% (≥41 mmol/mol) successfully identified women with diabetes and also detected a subgroup at markedly increased risk of adverse pregnancy outcomes.[21]

(Amylidi-Mohr S et al., 2025) study findings indicate that real-time continuous glucose monitoring (rtCGM) does not improve pregnancy outcomes in individuals with gestational diabetes. Nevertheless, participants showed a clear preference for rtCGM, suggesting its potential role in simplifying disease management. Future cost-effectiveness analyses are needed to determine the most resource-efficient monitoring strategy. To our knowledge, this is the first adequately powered randomized trial evaluating the impact of rtCGM on pregnancy outcomes.[22]

Overall, this study emphasizes the importance of early screening of glycemic status, particularly among women with higher BMI, and supports the need for preconception counselling, weight optimization, and early lifestyle interventions to improve maternal metabolic health and pregnancy outcomes.

Limitations of the Study: The cross-sectional design limits causal inference, and HbA1c measured at a single first-trimester, time point may not capture glycemic changes throughout pregnancy. Unmeasured factors such as diet, physical activity, and socioeconomic status, along with the single-center setting and limited sample size, may affect generalizability. Future large, multicenter longitudinal studies are needed to validate these findings and to examine the impact of early BMI–HbA1c interactions on gestational diabetes and maternal–fetal outcomes.

CONCLUSION

This study demonstrates a significant association between maternal body mass index and HbA1c levels during the first trimester of pregnancy. Women with higher BMI showed significantly elevated HbA1c levels compared with those of normal BMI, indicating poorer glycemic control in early gestation. The statistically significant difference observed using the Mann–Whitney U test underscores obesity as an important risk factor for early dysglycemia in pregnancy. These findings highlight the value of early assessment of BMI and HbA1c for identifying women at increased metabolic risk and support the need for early monitoring and preventive strategies to reduce the risk of gestational diabetes and related adverse pregnancy outcomes.

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