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A PROSPECTIVE STUDY TO PREDICT GESTATIONAL DIABETES MELLITUS FROM FIRST TRIMESTER ANTHROPOMETRIC INDICES AND HOMEOSTASIS MODEL ASSESSMENT OF INSULIN RESISTANCE

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ABSTRACT **Background:** Gestational diabetes mellitus (GDM) is a pregnancy-specific condition associated with elevated blood sugar levels, posing significant risks to maternal and fetal health. The prevalence of GDM is increasing, particularly in India, necessitating effective screening and intervention strategies. **Objective:** This study aimed to identify predictive anthropometric and biochemical parameters for GDM in pregnant women during their first trimester. **Methods:** A prospective observational study was conducted at SMS Medical College, Jaipur, involving 144 pregnant women attending antenatal care. Participants were assessed based on inclusion and exclusion criteria, with detailed anthropometric measurements and fasting glucose and insulin levels collected. HOMA-IR was calculated to evaluate insulin resistance. An oral glucose tolerance test (OGTT) was performed between 24-28 weeks to diagnose GDM. **Results:** The majority of participants were aged 25-30 years, with a higher incidence of GDM in those with a family history of diabetes (75%, $p = 0.0001$). No GDM cases were observed in women with a BMI <18.5 kg/m², while higher BMI values correlated with GDM risk ($p = 0.11$). Significant findings included mean fasting glucose levels of 99.4 mg/dl in the GDM group versus 91.35 mg/dl in the non-GDM group ($p = 0.009$) and mean HOMA-IR values demonstrating higher risks of GDM with increasing levels ($p = 0.007$). Predictive capabilities were assessed, with HOMA-IR showing an AUC of 0.65, outperforming fasting glucose and insulin. **Conclusion:** Elevated first trimester hip circumference, fasting glucose, insulin, and HOMA-IR significantly increase the risk of developing GDM. Although BMI, hip circumference, and HOMA-IR can aid in predicting GDM, their overall predictive ability requires enhancement through larger studies focusing on first trimester biochemical markers to improve early detection and intervention strategies.

KEYWORDS : Gestational diabetes mellitus, insulin resistance, HOMA-IR, anthropometric measurements, fasting glucose, predictive markers.

INTRODUCTION

Gestational diabetes mellitus (GDM) is a unique medical condition that arises exclusively during pregnancy, characterized by elevated blood sugar levels that are first identified during gestation.[1] GDM is a common pregnancy complication, posing risks to maternal and fetal health, with a rising global prevalence, especially in regions like India. The escalating incidence of GDM in India has reached staggering proportions, with some areas reporting rates as high as 33.3%.[2] GDM is associated with an increased risk of perinatal complications and long-term health issues for both mothers and their children. Key risk factors include genetic predisposition, high pre-pregnancy BMI, excessive pregnancy weight gain, advanced maternal age, and a history of GDM. The pathogenesis of GDM centers on the interplay between insulin resistance and chronic inflammation.[3] These mechanisms highlight the need for comprehensive screening, early intervention, and targeted management to reduce its negative impact on maternal and fetal health.

The fetus's brief exposure to an abnormal metabolic environment in GDM can trigger epigenetic changes, affecting insulin function and increasing the risk of future metabolic disorders. Early prediction of GDM is crucial for enabling proactive interventions. Lifestyle modifications for high-risk women may help prevent GDM-related complications, protecting both maternal and fetal health.

Anthropometric parameters are reliable predictors of diabetes, with insulin resistance (IR) being central to GDM development. The HOMA-IR, using fasting glucose and insulin, effectively detects IR.

The Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) is a key tool for evaluating insulin resistance and is a strong predictor of health outcomes. Elevated HOMA-IR values are linked to increased risks of type 2 diabetes, hypertension, and cardiovascular events, underscoring its clinical utility as a prognostic indicator in metabolic and cardiovascular disorders.[4]

Early detection of glucose intolerance and GDM using maternal anthropometric indices and HOMA-IR in first trimester enables timely intervention and their follow up will reduce maternal and neonatal complications.

MATERIAL AND METHODS

This was a prospective observational study conducted at Department of Obstetrics and Gynaecology, SMS Medical College, Jaipur. A total of 144 women undergoing antenatal care on basis of inclusion and exclusion criteria were selected.

Inclusion Criteria

1. Pregnant women attending antenatal OPD between 6 -14 weeks of gestation and willing for follow up.
2. Women who are willing to give consent for the study.
3. Women who are not participating in any other study.

Exclusion Criteria

1. Age >40 years.
2. Multiple pregnancy.
3. Any acute or chronic disease, such as abnormal renal and liver function, heart disease, autoimmune disease, diabetes and hypertension.

Procedure

Women receiving antenatal care were selected based on specific inclusion and exclusion criteria, with informed consent obtained prior to the study and approval from the institute's review board and ethical committee. A detailed assessment included age, obstetric history (e.g., stillbirth, intrauterine death, macrosomic fetus), medical and surgical history, general examination, and obstetric examination. Routine investigations were conducted. In pregnant women at 6-14 weeks of gestation, anthropometric indices such as weight, height, waist circumference hip circumference was measured and BMI was determined. Blood samples were collected to measure fasting glucose and insulin levels, with HOMA-IR calculated using the formula: (Fasting glucose in mg/dl × Fasting insulin in uIU/ml) / 405. All participants were followed up between 24-28 weeks of pregnancy, during which an oral glucose tolerance test with 75 g of glucose was conducted, regardless of fasting status (DIPSI). GDM was diagnosed

if the blood glucose level was ≥140 mg/dl two hours after the test.

Statistical Analysis

Continuous variables were summarized as mean and were analyzed by using unpaired 't' test. Nominal/ categorical variables were summarized as proportions and were analyzed by using chi-square/ Fischer exact test. P-value <0.05 was taken as significant.

RESULTS AND OBSERVATIONS

In the present study, age distribution of study subjects shows majority (63.89%) of patients were in age group 25-30 years. We found that 61.11% cases from rural areas and 38.89% cases were from urban areas. There were 79.86% Hindu and 20.14% Muslim cases . The study participants were divided by occupation, with 77.78% cases being housewives and 22.22% cases being individuals who were working. The educational background of the study's participants showed that 66.67% cases were literate, while 33.33% cases were illiterate. The socio-economic status of participants indicated that 43.06% were from the lower socio-economic class, 18.06% from the lower middle class, 6.94% from the upper lower class, 11.81% from the upper middle class, and 20.14% from the upper class.

Table 1: GDM Development In Relation To 1st Trimester BMI

BMI (in kg/m2)	With GDM		Non GDM		Total
	No. of Patients	Percentage	No. of Patients	Percentage	
<18.5	0	0	4	100	4
18.5-22.9	5	8.77	52	91.23	57
23-24.9	11	32.35	23	67.65	34
≥25	14	28.57	35	71.43	49
Total	30	20.83	114	79.17	144
Mean±SD	26.18±3.76		24.94±3.78		
P-Value	0.11				

The table illustrates the relationship between GDM development and first-trimester BMI values. No subjects with a BMI <18.5 kg/m² developed GDM. Among those with a BMI of 18.5-22.9 kg/m², 8.77% developed GDM; in the 23-24.9 kg/m² group, 32.35% developed GDM; and among those with a BMI ≥25 kg/m², 28.57% developed GDM. Higher BMI values correlated with a greater likelihood of developing GDM, though the p-value of 0.11 indicates statistical insignificance. Hashemipour S et al reported a higher GDM incidence in participants with a BMI ≥25 kg/m² (19.5% vs. 11.9%; p=0.014). Sunanda Bharatnur et al found a greater mean BMI in the GDM group (32.79±1.47) compared to the non-GDM group (31.15±1.22), with a significant p-value of 0.00005.

Table 2: GDM Development In Relation To 1st Trimester Waist And Hip Circumference

Parameter	With GDM		Non GDM		Total		p-value
	Mean	SD	Mean	SD	Mean	SD	
Waist Circumference	77.36	14.9	74.55	9.15	75.13	10.61	0.19
Hip circumference	96.7	7.28	93.35	5.38	94.04	5.96	0.009

In our study, Waist circumference (WC) was higher in the GDM group, with a mean of 77.36 cm compared to 74.55 cm in the non-GDM group, though the p-value of 0.19 indicates statistical insignificance. Hip circumference was also greater in the GDM group, with a mean of 96.7 cm versus 93.35 cm in the non-GDM group, and the p-value of 0.009 indicates highly significant. Ebrahimi-Mameghani et al concluded that a WC >88 cm is a significant predictor of GDM (OR: 3.77). Han et al found that the risk of GDM increases with a WC >78.5 cm and that WC at 20–24 weeks of gestation, along with pre-pregnancy BMI and gestational BMI, can predict GDM occurrence.

Table 3: GDM Development In Relation To 1st Trimester HOMA-IR

HOMA-IR	With GDM		Non GDM		Total
	No. of Patients	Percentage	No. of Patients	Percentage	
<1	0	0	2	100	2
1-2.9	15	15.46	82	84.54	97
>2.9	15	33.33	30	66.67	45
Total	30	20.83	114	79.17	144
Mean±SD	3.32±1.59		2.60±1.20		
P-Value	0.007				

In the study, none of the subjects with HOMA-IR <1 developed gestational diabetes mellitus (GDM). Among those with HOMA-IR values of 1 to 2.9, 15.46% developed GDM, while 33.33% of those with HOMA-IR >2.9 did, indicating a higher risk associated with elevated HOMA-IR. The p-value was 0.007, signifying statistical significance. Hashemipour S et al reported median HOMA-IR values of 3.1 in GDM cases and 2.2 in non-GDM cases (p < 0.001), with GDM incidence of 8.2%, 13.5%, and 24.6% across the first, second, and third tertiles of HOMA-IR, respectively (p < 0.001).

In the present study patients with gestational diabetes mellitus (GDM) had a mean fasting glucose level of 99.4 mg/dl, significantly higher than the 91.35 mg/dl in the non-GDM group (p = 0.009). The mean fasting insulin level was also higher in the GDM group at 13.68 uIU/ml compared to 11.46 uIU/ml in the non-GDM group (p = 0.03). Mahjabeen S et al.12 reported that the GDM group exhibited significantly higher insulin resistance (GDM vs. NGT: 10.19 vs. 6.88 µIU/ml, p = 0.001). Martinez et al.13 found that women diagnosed with GDM at 24-28 weeks had elevated fasting glucose, fasting insulin, and HOMA levels at 14 weeks of pregnancy.

We found that the mean post-2-hour blood sugar level from the 75 g OGTT per DIPSI criteria was 169.9 mg/dl for gestational diabetes mellitus (GDM) patients and 100.22 mg/dl for non-GDM cases, with a statistically significant p-value of <0.0001. Anjalakshi et al reported 100% sensitivity and specificity for the 75 g DIPSI test in diagnosing GDM. Samar Rudra found a sensitivity of 71.4%, specificity of 95.4%, a positive predictive value of 73%, a negative predictive value of 97%, and a diagnostic accuracy of 93%. Tripathi et al reported sensitivity and specificity values of 74.1% and 96.9%, respectively, in a study of 936 pregnant women.

Table 4: ROC Curve for the Prediction of GDM Using BMI, Waist Circumference and Hip Circumference.

Parameter	Area	95 % confidence interval	Cut-off value	Sensitivity	Specificity
BMI	0.676	0.579-0.772	23.24	80	30
Waist Circumference	0.517	0.38-0.65	70.5	53.3	40
Hip Circumference	0.625	0.496-0.755	92.5	63.3	47

The study found that Body Mass Index (BMI) had an AUC of 0.676, with a 95% confidence interval of 0.579 to 0.772. The optimal cutoff value was 23.24 kg/m², yielding a sensitivity of 80% and specificity of 30%. Waist Circumference (WC) showed an AUC of 0.517, with a cutoff of 70.5 cm, sensitivity of 53.3%, and specificity of 40%. Hip Circumference (HC) had an AUC of 0.625, a cutoff of 92.5 cm, sensitivity of 63.3%, and specificity of 47%.

Thus, BMI and Hip Circumference are better predictors of GDM compared to Waist Circumference. Takmaz T et al. indicated that at 20-24 weeks, optimal WC cutoff was 100 cm (sensitivity: 84%, specificity: 70%), with prepregnancy BMI at 25 kg/m² (sensitivity: 81.8%, specificity: 76%) and gestational BMI at 28.3 kg/m² (sensitivity: 75%, specificity: 77.4%) showing significant predictive capacity for GDM.

Table 5: ROC Curve for the Prediction of GDM Using Glucose, Insulin and HOMA-IR.

Parameter	Area	95 % confidence intervel	Cut-off value	Sensitivity	Specificity
GLUCOSE	0.579	0.454-0.704	89.5	60	43
INSULIN	0.605	0.493-0.716	8.76	83.3	30
HOMA-IR	0.65	0.545-0.764	2.05	86.7	39

The first trimester glucose level had an AUC of 0.579, with a 95% confidence interval of 0.454 to 0.704. The cutoff value was 89.5 mg/dl, resulting in a sensitivity of 60% and specificity of 43%. For insulin, the AUC was 0.605 (95% CI: 0.493 to 0.716), with a cutoff of 8.76 uIU/ml, sensitivity of 83.3%, and specificity of 30%. HOMA-IR demonstrated a better predictive capacity, with an AUC of 0.65 (95% CI: 0.545 to 0.764), a cutoff of 2.05, sensitivity of 86.7%, and specificity of 39%.

Thus, HOMA-IR is a superior predictor of GDM compared to fasting glucose and insulin. Naama Schwartz found that 1- and 2-hour post-100 g glucose load and mean daily glucose were significantly associated with GDM, with AUCs of 59% (95% CI: 53%-64%), 58% (95% CI: 52%-63%), and 57% (95% CI: 51%-63%), respectively.

Bitó T et al. reported that insulin determination at fasting and 120 minutes had sensitivities of 69.2% and 92.3%, and specificities of

96.4% and 85.7%, respectively, for predicting GDM between gestation weeks 24-28. Increased serum insulin levels at both time points before gestation week 16 were strong predictive factors for GDM. Hashemipour S et al found HOMA-IR to be a moderate predictor of GDM development, with AUC values of 0.638 (p = 0.005) and 0.622 (p = 0.008). The optimal HOMA-IR cut-offs were 2.06 (sensitivity 67.5%, specificity 61.1%) for normal BMI and 3.13 (sensitivity 64.6%, specificity 61.8%) for overweight/obese BMI.

CONCLUSION

From our study we conclude that pregnant women with higher first trimester hip circumference, fasting glucose, insulin and HOMA-IR have a significantly increased risk of developing gestational diabetes mellitus and thus can be used to stratify a high risk group. Body Mass Index, Hip circumference and HOMA-IR can be used to predict gestational diabetes mellitus but they do not possess a significant predictive ability. Larger clinical trials and research focussing on first trimester biochemical markers could enhance prediction accuracy, thus preventing gestational diabetes mellitus and it's associated complications.

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