ORIGINAL ARTICLE

ASSESSING GESTATIONAL DIABETES RISK: THE ASSOCIATION OF ABDOMINAL SUBCUTANEOUS FAT THICKNESS IN FIRST TRIMESTER AND GLUCOSE CHALLENGE TEST AT 24-28 WEEKS

Adila Anwar[1], Amina Akbar[2], Sadaf Afroze[1], Shakra Tabasam[3], Shahnaz Sheeba[2], Ghana Shahid[2]✉

[1]PAC Hospital Kamra-Pakistan, [2]Fazaia Medical College, Islamabad-Pakistan
[3]PAF Hospital, Islamabad-Pakistan

Background: Gestational diabetes mellitus (GDM) is a prevalent complication during pregnancy, impacting around 3–4% of expectant mothers. This condition heightens the risk of developing postpartum diabetes in mothers and obesity in their children. Additionally, GDM is associated with an increased incidence of infections, pre-eclampsia, eclampsia, and large-for-gestational-age infants, all contributing to perinatal morbidity. The purpose of this study was to investigate the association between GDM and abdominal subcutaneous fat thickness (ASFT), with the specific aim of identifying a predictive ASFT cut-off value for GDM. **Methods:** This cross-sectional analytical study was conducted at the Obstetrics and Gynaecology Departments of Pakistan Air Force Hospital, Kamra and Pakistan Air Force Hospital, Islamabad from December 2023 till May 2024. The study cohort comprised 288 pregnant women, aged between 21 and 35 years, who did not have diabetes, a history of smoking, high blood pressure, or metabolic syndrome. Pre-pregnancy body mass index (BMI) and weight gain were documented, and ASFT was measured using ultrasound. Between 24 and 28 weeks of gestation, participants underwent a 75 g oral glucose tolerance test (OGTT). Statistical analysis was conducted using ROC curve analysis and logistic regression with IBM SPSS version 23.0. **Results:** Among the 288 participants, 52 (18.05%) were diagnosed with GDM. The mean maternal ASFT was 2.2±0.4 cm, and there were significant differences between the GDM and non-GDM groups (p<0.05). An ASFT threshold of 2.1 cm demonstrated 76.25% sensitivity and 92.57% specificity for predicting GDM. **Conclusion:** Maternal ASFT measured by ultrasound in the first trimester can effectively predict the risk of GDM in the second trimester. This parameter may serve as an additional diagnostic tool for early GDM risk assessment.

Keywords: Gestational Diabetes Mellitus; Abdominal Subcutaneous Fat Thickness (ASFT); Ultrasound; First Trimester; Predictive Factor; OGTT; Diabetes Mellitus

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INTRODUCTION

Gestational diabetes mellitus (GDM) is a glucose metabolism disorder that emerges during pregnancy, representing a prevalent medical concern during this period.[1] Gestational diabetes mellitus impacts approximately 2% to 38% of pregnancies.[2] Women who experience GDM face an elevated risk of developing diabetes mellitus later in life, and their offspring are more likely to develop obesity.[1,3] GDM has been associated with a higher incidence of complications such as infections, shoulder dystocia, hypertensive disorders of pregnancy, and large for gestational age fetus among others.[4–7] GDM raises the risk of perinatal morbidity, including metabolic disorders, infant respiratory distress syndrome, and hyperbilirubinemia.[8–11]

To screen for gestational diabetes mellitus (GDM), the patients are given a 75-gram glucose load orally. This procedure is part of an oral glucose tolerance test (OGTT) conducted between the 24th and 28th weeks of pregnancy. This test has been adapted by ADA since 2003 and is also part of NICE guidelines recommendations for diagnosis of gestational diabetes mellitus. Since 2003, the ADA has also endorsed the one-step 75-gram, 2-hour OGTT for diagnosing GDM. This method is based on the modified Carpenter and Coustan glucose thresholds for fasting, 1-hour, and 2-hour measurements from the 100-gram, 3-hour OGTT, particularly for high-risk women.[12,13] Although this approach is considered more cost-effective, it is less validated compared to the 100-gram, 3-hour OGTT. The adoption of the modified Carpenter and Coustan thresholds has led to an almost 50% increase in the prevalence of GDM.[14,15] If blood glucose levels are at least 140 mg/dL or higher two hours after glucose ingestion, the test is considered

positive.[16] Once GDM is confirmed, treatment may include diet and exercise or insulin therapy, depending on fasting and 2-hour post-prandial blood glucose levels. Timely interventions such as these can decrease the maternal and neonatal complications associated with GDM.[11]

Various factors contribute to the risk of gestational diabetes mellitus (GDM), including Previous gestational diabetes[17], Previous macrosomic baby weighing 4.5 kg or more, Ethnicity with a high prevalence of diabetes[18], maternal age[19], body mass Index (BMI) before pregnancy (particularly BMI above 30 kg/m²), history of diabetes mellitus in the family, obesity, and gain in body weight during a pregnancy.[13] Among these, obesity is the most critical factor in increasing GDM risk.[11,20]

Early pregnancy body mass index (BMI) is commonly used to assess maternal obesity.[21] However, BMI does not account for the degree of abdominal obesity, which is linked to metabolic risk in non-pregnant individuals.[21–23] Abdominal subcutaneous fat thickness (ASFT) shows a significant link to obesity. Researchers have consistently found that individuals with higher ASFT measurements tend to exhibit greater levels of obesity. Various studies confirm this relationship, highlighting ASFT as a reliable indicator of obesity.[2,24,25] Computed tomography (CT) accurately measures ASFT, but its high cost and X-ray exposure make it unsuitable for pregnant women. Alternatively, ultrasonography (US) is a safer, cost-effective option that aligns well with CT measurements and eliminates X-ray exposure.[11] In pregnant women, greater maternal abdominal subcutaneous fat thickness has been associated with higher serum levels of haemoglobin A1C and C-reactive protein.[21,26] Recently, researchers have investigated the usefulness of maternal abdominal subcutaneous fat thickness (SCFT) for measuring abdominal obesity during pregnancy and predicting pregnancy outcomes.[27,28] Suresh *et al*. conducted a retrospective study of 1200 nulliparous women, revealing that ultrasound measurement of abdominal SCFT was a better predictor of gestational diabetes, caesarean delivery, and large-for-gestational-age neonates than BMI.[28]

This research investigates the association between maternal abdominal subcutaneous fat thickness (ASFT) measured by ultrasound in the first trimester and the subsequent development of gestational diabetes mellitus (GDM) later in pregnancy. Furthermore, the study seeks to establish a threshold value for ASFT that can effectively predict the risk of GDM.

MATERIAL AND METHODS

This cross-sectional analytical study was conducted at the Obstetrics and Gynaecology Departments of PAF Hospital Islamabad and PAF Hospital Kamra.288 pregnant women aged 21 to 35 who attended antenatal clinics and fulfilled the study criteria at these two centres were recruited for the study. The study took place from December 1, 2023 to May 31, 2024, focusing on women in their first trimester (9^{+6} to 12^{+6} weeks). We excluded women already diagnosed with any type of diabetes mellitus, high blood pressure (>140mmHg / 90mmHg), a history of active or past tobacco smoking, or metabolic syndrome.

We assessed the maternal abdominal subcutaneous fat thickness using an ultrasound scan during first trimester (9^{+6} to 12^{+6} weeks). The scan was conducted 1 cm above the umbilicus with a high-resolution convex array probe while patients lay in the supine position. We performed a longitudinal scan and measured the thickness of the subcutaneous fat at that point down to the rectus abdominis muscle at the end of expiration. The thickness of the anterior suprapatellar fat pad was measured as the distance between the anterior surface of the femur and the posterior border of the quadriceps tendon. All measurements were taken by a trained radiologist to ensure consistency and accuracy.

During their antennal follow-up visits, we asked these women to undergo a hexokinase glucose test during the second trimester of the pregnancy (24^{th}-28^{th} wk.). The patients were given a 75-gram glucose load orally and blood samples were taken from the study participants two hours after ingestion of glucose load. Gestational diabetes mellitus (GDM) was diagnosed based on blood plasma glucose measurement results more than 140.4 mg/dl or 7.8 mmol/l two hours after ingestion of the 75 g glucose load. We divided the patients into two groups for statistical analysis: those with a negative 75 g OGTT were placed in the control group, and those with a positive 75 g OGTT result were placed in the high-risk GDM group.

Our study calculated pre-pregnancy BMI for all participants. We determined pregnancy weight gain by determining the difference in weight measured at 24^{th}-28^{th}-week of gestation and weight last known weight measured before pregnancy. No study participant reported menstrual irregularities. We presented data as mean±standard deviation to ensure clarity. To compare baseline characteristics between groups, we employed independent sample t-tests. This approach allowed us to analyze both continuous and discrete variables effectively.

For GDM prediction, we conducted an analysis of the receiver operating characteristic (ROC)

curve for the independent variables. This method enabled us to calculate the sensitivity, specificity and area under the curve (AUC) for these variables. These metrics provided valuable insights into the predictive power of our variables. We further employed logistic regression analysis to determine the odds ratio for GDM risk. This analysis focused specifically on the influence of abdominal subcutaneous fat thickness. Our statistical approach aimed to uncover significant relationships between variables.

We utilized IBM SPSS version 23.0 for all statistical analyses. To ensure statistical significance, we set the threshold *p*-value at less than 0.05. Our methodology combined various statistical techniques to provide a comprehensive analysis of GDM risk factors. By employing these methods, we aimed to contribute valuable insights to the field of gestational diabetes research.

RESULTS

The study involved 288 participants in a gestational diabetes mellitus (GDM) screening. 81.95% (n=236) tested negative, while 18.05% (n=52) tested positive in the 75-gram OGTT. The participants were aged between 21 and 35 years, with an average age of 24 years and a standard deviation of 2.8 years. There was no statistically significant (p>0.05) age differences among the two groups. The average BMI before pregnancy was 23.0 kg/m² with a standard deviation of 2.6 kg/m² (table-1).

Based on Asian standards, 14.24% (n=41) of the participants were underweight, 47.92% (n=138) had normal weight, and 37.85% (n=109) were overweight. Among those diagnosed with GDM, a significantly higher proportion was overweight, with 26.92% (n=14) of participants falling into this category (p<0.05). The average gain in weight of study participants during pregnancy was 5.2±1.8 kg, which was statistically insignificant (p >0.05). The average ASFT measurement was 2.2±0.4 cm (p<0.001).

We conducted an ROC analysis to identify the most effective threshold values for predicting gestational diabetes mellitus (GDM). Pre-pregnancy BMI showed 83.28% sensitivity and 58.32% specificity at 22.3 kg/m² (AUC=0.69). Maternal ASFT demonstrated 76.25% sensitivity and 92.57% specificity at 2.1 cm (AUC=0.88).

The study found a significant link between elevated ASFT and occurrence of GDM. When applying ASFT threshold value of 2.1 cm, we found that the odds ratio for GDM was 14.13 [95% CI, 7.02 to 28.47; p=0.0001]. After accounting for the pre-pregnancy BMI of study participants, we found a slight reduction in the odds ratio, which was 13.78 [95% CI, 13.78 to 26.96; p=0.004].

ASFT=Abdominal Subcutaneous Fat Thickness, GDM=Gestational Diabetes Mellitus, CI=Confidence Interval

We found no significant link between increasing maternal age and GDM (p=.35). However, increased pre-pregnancy BMI correlated with higher GDM incidence, especially in obese women (p < .00001). Our findings showed no significant relationship between weight gain during pregnancy and occurrence of GDM (p= 0.67). There was a statistically significant association between history of previous gestational diabetes mellitus, family history of gestational diabetes and GDM in current pregnancy (p<0.05). No statistically significant association was observed between birth of a macrosomic baby in previous pregnancy and occurrence of GDM (p >0.05).

Table-1: Demographic features of study participants (n = 288)

	Normal Glucose Tolerance (n =236)	GDM (n=52)	t	*p*-value
Age (yrs.)	25.2±2.1	24.3±2.5	1.26	0.2
BMI before pregnancy (kg/m^2)	22.2±3.8	24.1±2.1	6.01	< 0.001
< 18.5 (n=41)	16.4±0.3	17.8±0.3	0.82	0.4
18.5-24.9 (n=138)	22.1±2.1	24.7±0.6	2.9	0.008
> 25 (n=109)	26.1±3.1	27.2±2.6	2.71	0.004
ASFT (cm)	1.6±0.4	2.8±0.4	10.01	<0.001
Weight gain (kg)	4.6±2.2	4.9±1.8	0.55	0.51

Table-2: Analysis of variables by a receiver operating characteristic curve (ROC)

	Area Under Curve	Sensitivity	Specificity	Youden index	*p* value
Age (yrs.)	0.51	89.14%	25.26%	0.15	0.3
Weight gain (kg)	0.62	52.77%	61.34%	0.16	0.9
Maternal ASFT (cm)	0.88	77.25%	92.57%	0.67	< 0.001
BMI Before Pregnancy (kg/m^2)	0.69	83.28%	58.32%	0.38	<0.001

Table-3: Risk of an abnormal OGTT after 100-g glucose dose with increased ASFT

	Controls (n=236)	GDM (n = 52)	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Maternal ASFT upto 2.1cm	212	20	1.0 (reference)	1.0 (reference)

Maternal ASFT 2.1 cm or more	24	32	14.13 (7.02-28.47)	13.78 (6.88-26.96)

Table-4 Association of different risk factors with occurrence of GDM

Risk factors	**GDM Diagnosed**	**No GDM Diagnosed**	**Row Totals**	***p* value**
BMI more than or equal to 30	30	28	58	<.00001
BMI less than 30	22	208	230	
Column Totals	52	236	288	
	GDM Diagnosed	No GDM Diagnosed	Row Totals	p value
age > 35 (yrs.)	21	112	133	0.35
age < 35 (yrs.)	31	124	155	
Column Totals	52	236	288	
	GDM Diagnosed	No GDM Diagnosed	Row Totals	p value
age > 35	23	112	135	0.67
age < 35	29	124	153	
Column Totals	52	236	288	
	GDM Diagnosed	No GDM Diagnosed	Row Totals	p value
Family History of GDM	32	38	70	<.00001
No family History of GDM	20	198	218	
	GDM Diagnosed	No GDM Diagnosed	Row Totals	p value
History of Previous GDM	35	52	87	<.00001
No History of Previous GDM	17	184	201	
Column Totals	52	236	288	
	GDM Diagnosed	No GDM Diagnosed	Row Totals	p value
Birth of previous macrosomic baby	24	98	122	0.54
No Birth of previous macrosomic baby	28	138	166	
Column Totals	52	236	288	

DISCUSSION

GDM affects pregnancies worldwide, with prevalence varying from2% to 38%. Factors such as country, ethnicity, and diagnostic criteria influence its occurrence. Rising obesity rates and older maternal age contribute to increased GDM incidence.[2,29,30]

The 75-gram 2-hour OGTT is a widely recommended screening method for GDM, typically administered by healthcare professionals between the 24th and 28th weeks of gestation.[16] However, early detection of GDM remains difficult, primarily due to the ongoing debate regarding the optimal timing for this test.[4,13]

Our study aimed to identify GDM predictors in pregnant women. We examined maternal age, ASFT, pregnancy weight gain, pre-pregnancy BMI, family history of gestational diabetes, history of previous gestational diabetes and history of birth of a macrosomic baby in past pregnancy as potential risk factors for occurrence of GDM in our study cohort. Recent research indicates higher GDM risk in the second trimester, particularly among women with elevated pre-pregnancy BMI.[3]

Ultrasound measurement of abdominal fat thickness has gained attention for its applicability to pregnant women.[1] A number of studies have reported that ASFT could independently predict GDM. Recent research has explored central obesity's connection to GDM progression.[31–33]

Our study found that the average ASFT depth was 2.2±0.4 cm, which is consistent with the findings of De Souza *et al*. and Yang *et al*.[11,34] We observed a significant correlation between ASFT and GDM: A cut-off value of 2.1 cm for ASFT was determined, with an AUC of 0.88 and a *p*-value of less than 0.001. High ASFT was strongly linked to positive GDM cases, with an unadjusted odds ratio of 14.13 [95% CI, 7.02 to 28.47; *p*=0.0001]. Therefore, an ASFT measurement of 2.1 cm or greater in the first trimester should prompt careful management and increased monitoring for GDM during pregnancy.

Our study has limitations, including a non-representative sample from only two Pakistani hospitals. We also lacked standardized ASFT measurement methods, highlighting the need for consistent techniques. Future research should employ uniform methods across larger, diverse populations. Additionally, the pre-pregnancy BMI could not be calculated correctly for the study participants because of absence of recorded body weights, and recall-bias could not be eliminated.

CONCLUSION

This research indicates that assessing maternal abdominal subcutaneous fat thickness (ASFT) through ultrasound during the first trimester serves as a reliable predictor of gestational diabetes mellitus (GDM) onset in the second trimester. An ASFT threshold value of 2.1 cm was identified, which provides high sensitivity and specificity for GDM prediction. This finding suggests that maternal ASFT measurement can be a valuable additional diagnostic tool for early risk assessment of GDM, potentially leading to earlier interventions and better management of maternal and neonatal health outcomes.

Further Recommendations

Future research should validate these findings in larger and more diverse populations to ensure the generalizability of the results. Establishing standardized methods for measuring ASFT is essential to reduce inter-observer variability and improve the reliability of the measurement. Exploring the integration of ASFT with other predictive markers could enhance early detection and management strategies for GDM. Conducting multicenter studies involving various demographic groups would provide a more comprehensive understanding of the role of ASFT in predicting GDM. Additionally, investigating the long-term outcomes for mothers and children based on early ASFT measurements and GDM management can offer insights into improving prenatal care and reducing adverse health impacts.

AUTHORS' CONTRIBUTION

AA, SA, SK: Conceptualization of study design, literature search, write-up. SS, GS: Literature search, data collection, data analysis and interpretation.

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Address for Correspondence:
Dr. Ghana Shahid, Fazaia Medical College, Islamabad-Pakistan
Email: ghana_83@hotmail.com