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# Demographic Influences on Ultrasound-Determined Visceral Fat Thickness and Pregnancy Outcomes

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## Abstract

**Background:** Ultrasound quantification of fat distribution is emerging as a critical tool in prenatal care. Visceral fat thickness (VFT) is a robust biomarker for central adiposity, which has been associated with gestational diabetes mellitus (GDM) and adverse pregnancy outcomes.

**Objective:** To evaluate the demographic distribution of VFT in early pregnancy and its relationship with pregnancy outcomes and GDM risk, emphasizing the roles of maternal age, socioeconomic status, gestational age, and body mass index (BMI).

**Methods:** In this observational study, 150 pregnant women with gestational ages <13 weeks were recruited at Subharti Medical College Hospital, Meerut, India, between February 2023 and March 2024 using a consecutive sampling technique. Ultrasonographic measurements of subcutaneous fat thickness (SCFT) and VFT were obtained using a Philips Affiniti 50 Ultrasound machine-SAMSUNG HS50 and HS70A. Maternal demographics, BMI, and metabolic parameters were recorded. Laboratory testing—including a 75 g oral glucose tolerance test (OGTT), HbA1c, lipid profiles, and thyroid function tests—was performed at the Subharti Medical College Hospital Laboratory. Statistical analysis was carried out using SPSS version 21, with significance set at $P < 0.05$.

**Results:** The mean maternal age was 27.95 ± 4.91 years, with the 25–29-year group being the most frequent (36.3%). Nearly 46.7% of pregnancies were between 9 and 12 weeks' gestation, and approximately 20% of participants were classified as having low socioeconomic status. Mean BMI was 24.86 ± 3.64 kg/m$^2$. Overall, the mean SCFT and VFT were 2.12 cm and 3.76 cm, respectively. Notably, women aged ≥30 years had a higher mean VFT (5.1 cm) compared to those aged <30 years (4.8 cm, $P = 0.04$), and low socioeconomic status was associated with a higher mean VFT (5.2 cm vs. 4.7 cm, $P = 0.01$). The GDM group exhibited a significantly higher mean VFT (4.15 cm) compared with the non-GDM group (3.22 cm). VFT correlated significantly with HbA1c ($r = 0.327$, $P = 0.001$), LDL ($r = 0.254$, $P = 0.001$), BMI ($r = 0.342$, $P = 0.005$), and all OGTT values. ROC analysis for VFT predicting elevated HbA1c (≥5.7%) yielded an AUC of 0.78, and a combined model using SCFT and VFT achieved an AUC of 0.82 for predicting diabetes (based on the 2 hr OGTT threshold).

**Conclusion:** Ultrasound-measured VFT, when integrated with demographic factors such as maternal age, socioeconomic status, gestational age, and BMI, is a significant predictor of adverse pregnancy outcomes and GDM risk. We recommend incorporating quantitative VFT assessments into routine prenatal ultrasound protocols to enable early risk stratification and guide timely clinical interventions.

**Keywords:** Visceral Fat Thickness; Ultrasound; Gestational Diabetes Mellitus; Pregnancy Outcomes; BMI; Socioeconomic Status; Gestational Age

## Abbreviations

VFT: Visceral Fat Thickness; SCFT: Subcutaneous Fat Thickness; GDM: Gestational Diabetes Mellitus; OGTT: Oral Glucose Tolerance Test; BMI: Body Mass Index; HbA1c: Glycated Hemoglobin; LDL: Low-Density Lipoprotein; HDL: High-Density Lipoprotein; VLDL: Very Low-Density Lipoprotein; SCFT: Subcutaneous Fat Thickness; VFT: Visceral Fat Thickness; POG: Period of Gestation; SES: Socioeconomic Status; BMI: Body Mass Index; NS: Non Significant.

## Introduction

The distribution of abdominal fat, particularly visceral fat, in early gestation is a critical indicator of maternal metabolic health.

Unlike BMI, which is a crude measure of overall adiposity, ultrasound-derived measurements of visceral fat thickness (VFT) provide a direct assessment of central adiposity-a key determinant of insulin resistance.

Elevated VFT has been associated with gestational diabetes mellitus (GDM) and adverse pregnancy outcomes. Furthermore, demographic factors such as maternal age, socioeconomic status, period of gestation, and BMI may influence fat distribution and subsequent metabolic risk.

Early detection of at-risk pregnancies through the distribution analysis of abdominal fat thickness can facilitate timely interventions and potentially improve maternal and fetal outcomes.

This study investigates the correlations between demographic factors and ultrasound-measured VFT and examines their impact on pregnancy outcomes and GDM risk [1].

## Materials and Methods

### Study Design and Location

This prospective observational study was conducted at the Department of Radiodiagnosis, Subharti Medical College & Hospital, Meerut, India, from February 2023 to March 2024.

### Sample Size and Selection Criteria

A total of 150 pregnant women in their first trimester (<13 weeks gestation) were enrolled.

**Inclusion Criteria:**

- Pregnant women aged 18–40 years
- Singleton pregnancy confirmed by ultrasonography
- No pre-existing diabetes, metabolic, or chronic illnesses

**Exclusion Criteria:**

- Multifetal pregnancies
- Participants with pre-existing diabetes

### Sampling and Randomization

Participants were selected using a simple random sampling technique, ensuring a representative distribution of maternal age and BMI categories.

## Procedure

- Ultrasound Measurements: Subcutaneous and visceral fat thickness was measured using a Ultrasound Samsung HS50 and Samsung HS70A machines [2].
- Anthropometric Data: Height, weight, and BMI were recorded using calibrated equipment.
- Laboratory Testing: Blood glucose levels and lipid profiles were analyzed at the Subharti Medical College Hospital Laboratory.

### Statistical Analysis

- Data were analyzed using SPSS v21. Statistical tests included:
- Independent t-tests for comparing SFT/VFT between GDM and non-GDM groups
- Chi-square tests for categorical variables
- Pearson's correlation analysis for associations between fat thickness and metabolic markers
- P-values < 0.05 were considered statistically significant

## Results and Discussion

### Demographic and Anthropometric Distribution

- Maternal Age: The mean age was 27.95 ± 4.91 years, with 36.3% of participants aged 25–29 years.
- Gestational Age: 46.7% of pregnancies were between 9 and 12 weeks.
- Socioeconomic Status: Approximately 20% of the cohort was classified as low socioeconomic status.
- BMI: The mean BMI was 24.86 ± 3.64 kg/m$^2$ (range: 19.7–35.9 kg/m$^2$).
- Impact on VFT: Women aged ≥30 years had a higher mean VFT (5.1 cm) compared with those aged <30 years (4.8 cm, P = 0.04). Additionally, patients with low socioeconomic status had a higher mean VFT (5.2 cm) relative to those in middle/high socioeconomic groups (4.7 cm, P = 0.01).

**Mean SCFT and VFT by Demographic Groups**

| Demographic Factor | Group | Mean SCFT (cm) | Mean VFT (cm) | p-value (VFT) |
|---|---|---|---|---|
| Maternal Age | < 30 years | 2.1 | 4.8 | 0.04* |
| | ≥ 30 years | 2.12 | 5.1 | |
| Period of Gestation | 5–8 weeks | 2.05 | 3.65 | NS |
| | 9–12 weeks | 2.1 | 3.76 | NS |
| | 13 weeks | 2.2 | 3.9 | NS |
| Socioeconomic Status | Middle/High | 2.11 | 4.7 | 0.01* |
| | Low | 2.12 | 5.2 | |
| BMI Category | Normal | 2.05 | 3.5 | NS |
| | Overweight | 2.15 | 3.9 | NS |
| | Obese | 2.3 | 4.3 | 0.005 |

*p < 0.05 indicates statistical significance.
**Table 1:** Statistical Significance.

This table presents the mean values of subcutaneous fat thickness (SCFT) and visceral fat thickness (VFT) measured via ultrasound across several key demographic groups.

It shows that while SCFT remains relatively consistent across these groups, VFT varies significantly. In particular, women aged ≥30 years and those of low socioeconomic status have higher mean VFT values (5.1 cm and 5.2 cm, respectively) compared with their counterparts, indicating that central adiposity may be influenced by these demographic factors and could serve as a valuable indicator of increased metabolic risk in early pregnancy [3].

## Fat Thickness and Pregnancy Outcomes

- Overall mean SCFT was 2.12 cm and mean VFT was 3.76 cm.
- The GDM group had a significantly higher mean VFT (4.15 cm) compared to the non-GDM group (3.22 cm), while SCFT values were similar across groups.
- Pregnancy outcomes were: 63.09% successful, 18.79% aborted, and 18.12% lost to follow-up.

## Correlation Analyses

| Fat Type | Parameter | Correlation Coefficient | p-value |
|---|---|---|---|
| Visceral Fat | HbA1c | 0.327 | 0.001 |
| | LDL | 0.254 | 0.001 |
| | BMI | 0.342 | 0.005 |
| | OGTT (Fasting) | 0.165 | 0.044 |
| | 1hr OGTT | 0.358 | <0.00001 |
| | 2hr OGTT | 0.322 | <0.0001 |
| | 3hr OGTT | 0.24 | 0.003 |
| Subcutaneous Fat | HbA1c | 0.219 | 0.007 |
| | BMI | 0.246 | 0.002 |
| | 3hr OGTT | 0.225 | 0.006 |

**Table 2:** Fat Types vs. Metabolic Parameters.

The table summarizes the correlation coefficients between fat thickness measurements and various clinical parameters. Visceral fat thickness (VFT) showed a significant positive correlation with HbA1c, indicating a strong association between visceral adiposity and long-term glucose control. Additionally, VFT was positively correlated with LDL (Low-Density Lipoprotein), suggesting a link between central adiposity and lipid metabolism. Body Mass Index (BMI)

demonstrated a stronger association with VFT than with subcutaneous fat thickness (SCFT), reinforcing the role of visceral adiposity in metabolic dysfunction. Postprandial glucose levels (OGTT) correlated significantly with VFT, particularly 1-hour OGTT, suggesting that visceral fat may be a key determinant of postprandial glycemic response. In contrast, SCFT exhibited a significant correlation only with 3-hour OGTT, indicating a weaker relationship with glucose metabolism.

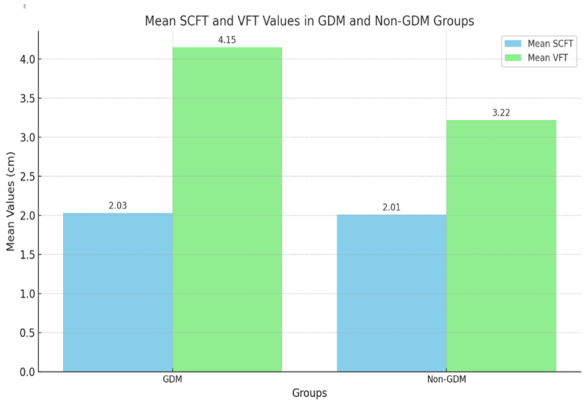


**Figure 1:** SCFT and VFT Values in GDM (Gestational Diabetes) and Non- GDM Groups.

## Predictive Analyses

- ROC analysis for VFT predicting elevated HbA1c (threshold 5.7%) produced an AUC of ~0.78.
- A combined logistic regression model incorporating both SCFT and VFT achieved an AUC of 0.82 for predicting diabetes (using the 2 hr OGTT threshold).
- For lipid parameters, VFT was a better predictor for triglyceride levels (AUC = 0.63), while SCFT performed marginally better for LDL and total cholesterol (AUC ~0.57–0.60).

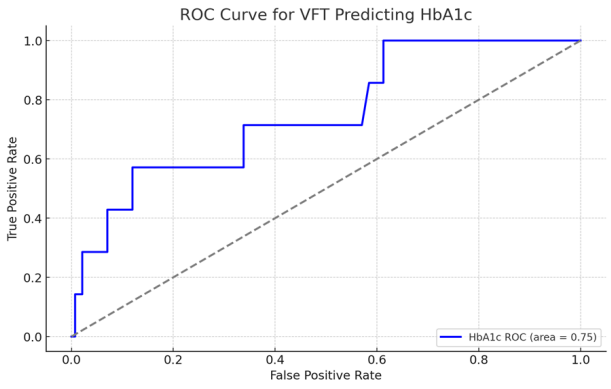


**Figure 2:** ROC Curve for VFT Predicting risk of Diabetes via HbA1c.

## Regression Analysis

- Regression modeling indicated that age and VLDL explain 16.1% of the variance in HbA1c ($R^2$ = 0.161; P = 0.008 and P = 0.045, respectively), and TSH, VLDL, and LDL account for 18.4% of the variance in BMI ($R^2$ = 0.184; P = 0.041, P = 0.017, and P = 0.001, respectively).

# Discussion

Our findings demonstrate that ultrasound-derived visceral fat thickness (VFT) is a powerful radiologic biomarker for predicting metabolic risk in early pregnancy. In our study, several key aspects emerged:

## Demographic Influence

Women aged ≥30 years and those of low socioeconomic status exhibited significantly higher VFT values (mean VFT of 5.1 cm and 5.2 cm, respectively) compared with their counterparts (4.8 cm and 4.7 cm, respectively; P = 0.04 and P = 0.01). This indicates that demographic factors, such as maternal age and socioeconomic status, play a crucial role in central adiposity and, by extension, in metabolic risk assessment during pregnancy [4].

## Metabolic Correlations

VFT was significantly correlated with multiple metabolic parameters. Specifically, higher VFT was associated with increased HbA1c (r = 0.327, P = 0.001), elevated LDL cholesterol (r = 0.254, P = 0.001), higher BMI (r = 0.342, P = 0.005), and adverse OGTT measures at all time points (fasting: r = 0.165, P = 0.044; 1 hr: r = 0.358, P < 0.00001; 2 hr: r = 0.322, P < 0.0001; 3 hr: r = 0.240, P = 0.003). These strong associations reinforce the role of VFT as a sensitive indicator of central adiposity and metabolic dysfunction, which are critical factors in the pathogenesis of gestational diabetes mellitus (GDM) and adverse pregnancy outcomes [5].

## Predictive Performance

ROC curve analysis confirmed the robust predictive ability of VFT. The analysis for VFT predicting elevated HbA1c (using a threshold of 5.7%) yielded an AUC of approximately 0.78. Furthermore, a logistic regression model combining both subcutaneous fat thickness (SCFT) and VFT achieved an AUC of 0.82 for predicting diabetes based on the 2 hr OGTT threshold. These results highlight that VFT, alone or in combination with SCFT, is a strong predictor of metabolic risk.

## Implications

The significant correlations and high predictive performance of VFT suggest that it can serve as an early radiologic

marker for identifying pregnant women at risk for GDM and adverse pregnancy outcomes. When combined with other demographic factors—-as maternal age, socioeconomic status, gestational age, and BMI-quantitative VFT measurement can enhance early risk stratification. Early identification of high-risk patients could prompt timely nutritional counseling, lifestyle modifications, and medical interventions, ultimately improving maternal and fetal outcomes.

## Conclusion and Recommendations

Based on these findings, we recommend that radiologists incorporate quantitative VFT assessments into routine prenatal ultrasound protocols. Such integration, in conjunction with consideration of key demographic factors, will facilitate early identification of pregnancies at risk for metabolic complications, enabling timely and targeted clinical interventions. Further prospective studies are warranted to validate these findings and to refine intervention strategies based on ultrasound-derived fat measurements.

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## Conflict of Interest

The authors declare no conflict of interest.

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