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Study of Correlation of Body Visceral Fat Estimation with Serum Lipid Profile and Fasting Blood Sugar in Adults

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Abstract

Background: Visceral adiposity and deranged lipid and glycemic profiles are important predictors of metabolic and cardiovascular diseases. This study aimed to evaluate the distribution of visceral fat and fat mass indices and correlate them with fasting blood glucose, HbA1c, and lipid parameters in an apparently healthy adult population.

Methods: A cross-sectional observational study was conducted from May 2023 to January 2025 at the Department of Medicine, Subharti Medical College, Meerut. A total of 200 participants aged 18–59 years were enrolled after meeting the inclusion criteria. Anthropometric measurements (BMI, waist circumference, waist-to-hip ratio), body composition analysis (visceral fat index and fat mass index), and biochemical assessments (fasting blood sugar, HbA1c, serum lipid profile) were performed. Data were recorded using a structured proforma and analyzed descriptively.

Results: Fasting blood sugar levels indicated that 33% of participants were diabetic and 40% were pre-diabetic, while only 46% had normal glycemic values. Similarly, 37.5% had HbA1c levels in the diabetic range (≥6.5%). Dyslipidemia was prevalent, with 23% having elevated total cholesterol and 24% in the borderline range. LDL-C was elevated (≥100 mg/dL) in 42.5% of the participants, and 97% had suboptimal HDL-C levels. Visceral fat index was ≥10 in 73.5% of individuals, and 26% had high fat mass index values (≥10), suggesting elevated cardiometabolic risk in a substantial portion of the study population.

Conclusion: A significant proportion of the study population exhibited pre-diabetes, diabetes, and dyslipidemia, along with elevated visceral and fat mass indices. These findings highlight the need for routine screening of body composition and metabolic parameters even in apparently healthy individuals for early identification and prevention of metabolic syndrome.

Keywords: Visceral fat index, Fat mass index, Dyslipidemia, Pre-diabetes, HbA1c, Cardiometabolic risk, Body composition, Fasting blood sugar, Lipid profile

Introduction

Since obesity raises mortality rates and is linked to cardiovascular problems, it is a significant global issue.

Excess adipose tissue is the cause of obesity, and a positive energy balance (energy intake > energy expenditure) is the etiology.[1] Additionally, metabolic and vascular problems are linked to obesity. Numerous morbidities, such as cardiovascular disease, coronary heart disease, cerebral infarction, diabetes mellitus type 2, hypertension, dyslipidemia, obstructive sleep apnea (OSA), gastroesophageal reflux disease (GERD), osteoarthritis of the knee, carpal tunnel syndrome, and cancer, are brought on by these physiological effects.[2,3,4]

The body mass index (BMI), which is determined by dividing a person's weight in kilograms by their height in meters squared (kg/m2), is the most widely used technique for diagnosing obesity. The World Health Organization (WHO) definition and the Regional Office for the Western Pacific (WPRO) standard are the two criteria used to diagnose obesity. [5] Overweight is defined by the WPRO as having a BMI between 23.0 and 24.9 kg/m2, class I obesity as having a BMI between 25.0 and 29.9 kg/m2, and class II obesity as having a BMI of 30.0 or higher. Overweight is defined by the WHO as having a BMI between 25.0 and 29.9 kg/m2, class I obesity as having a BMI between 30.0 and 34.9 kg/m2, class II obesity as having a BMI between 35.0 and 39.9 kg/m2, and class III obesity as having a BMI of ≥40.0 kg/m2.[6]

Globally, obesity is on the rise in both prevalence and trend. Obesity prevalence has risen by 25% in women and 65% in men since 1991. According to current trends, 50% of women and 60% of men worldwide will be obese by 2050.[7] The prevalence of obesity class I (BMI 25–29.9 kg/m2) and class II (BMI ≥30.0 kg/m2) among Thai individuals aged ≥20 years was 26.0% and 9.0%, respectively, according to data from the Thai National Health Examination Survey.[8]

Although BMI is the most widely used metric for evaluating obesity, it is not the best way to evaluate metabolic and cardiovascular diseases. In this sense, it has been demonstrated that measuring the waist circumference helps determine BMI and enhances risk assessment for metabolic and cardiovascular disease screening at any BMI level.[9,10]] In addition to being a cause of metabolic and cardiovascular disorders, excess visceral adipose tissue may also be an indicator of defective subcutaneous adipose tissue that results in ectopic fat deposition, which is an unwanted buildup of lipids in the heart, liver, skeletal muscle, pancreas, etc. [11]Notably, visceral adipose tissue contributes to total body fat, and visceral obesity is defined as an excessively high accumulation of visceral adipose tissue. This phenotype of body composition is linked to metabolic and cardiovascular diseases. Therefore, measuring visceral obesity quantitatively is crucial for determining the possible risk of metabolic and cardiovascular diseases.[12-14]

Numerous techniques, including bioelectrical impedance analysis (BIA), ultrasound, dual-energy X-ray absorptiometry (DXA), computed tomography (CT) scans, and magnetic resonance imaging (MRI), can be used to evaluate visceral fat in the abdominal cavity. A noninvasive technique that is readily accessible and does not involve radiation exposure, BIA is used to measure the visceral fat in the abdominal cavity . The visceral fat rating level is determined by BIA after evaluating the visceral fat in the abdominal cavity. The relationship between the serum lipid profile and serum glucose from blood collection and the visceral fat rating in the abdominal cavity as determined by a noninvasive method (BIA) is unknown.[1,2,15]

In order to determine cardiovascular risk in adults, the goal of this study is to examine the relationship between serum lipid profile, serum blood sugar, and visceral fat rating as determined by noninvasive techniques.

Methodology

Study Design

This study was a hospital-based, cross-sectional observational study, which was conducted over a period

extending from May 2023 to January 2025.

Study Setting

The research was carried out in the Inpatient Department (IPD) and Outpatient Department (OPD) of the Department of Medicine at CSS Hospital, Subharti Medical College, Meerut.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee of CSS Hospital, Subharti Medical College, Meerut. Written informed consent was obtained from all participants after the purpose and procedures of the study were explained.

Study Population and Sample Size

A total of 200 participants, aged between 18 and 59 years, were sequentially enrolled in the study based on their eligibility. Participants were selected from individuals attending the IPD/OPD for routine health check-ups or general medical consultation. The required sample size (N) was calculated using the single population proportion formula: $N = Z^2 \times p \times (1 - p) / d^2$, where p represents the prevalence of obesity (26%) based on a previous study, d denotes the desired precision (0.10), and Z corresponds to the statistic for a 95% confidence interval (1.96). The calculated minimum sample size was 74. To account for a potential 20% dropout rate, a total of 90 patients were targeted for enrollment. The study received approval from the Institutional Ethics Committee on Human Rights Related to Research Involving Human Subjects.

Eligibility Criteria

Participants aged 18 to 59 years of either sex, who were apparently healthy or attended the hospital for routine health evaluations, and who had provided written informed consent after fasting for at least 8 hours prior to blood sample collection were included in the study. Individuals were excluded if they had a known history of diabetes mellitus or were on antidiabetic medications, had diagnosed dyslipidemia or were receiving lipid-lowering therapy (e.g., statins), or had chronic systemic illnesses such as chronic kidney disease, liver disease, thyroid disorders, or cardiovascular diseases. Additional exclusion criteria included pregnancy or lactation, recent acute illness within the past month, presence of implanted metallic devices or pacemakers (if bioelectrical impedance analysis was used), current use of long-term corticosteroids or hormonal therapy, and a history of alcohol or substance abuse.

Methodology

Patients attending the general outpatient department (OPD) of the Department of Medicine and the Diabetes Clinic at Subharti Medical College, Meerut, were provided with a patient information sheet and informed consent form in a language they understood. The study details were explained to each potential participant. After obtaining written informed consent, subjects were screened for eligibility based on the inclusion and exclusion criteria.

A brief clinical history was taken, and a complete general physical examination was performed for each enrolled subject. Anthropometric parameters, including height, weight, body mass index (BMI), and waist circumference, were measured. Information from the clinical examination and available medical records was used to confirm eligibility. Subjects fulfilling all inclusion criteria and none of the exclusion criteria

were included in the study. All collected data were recorded on a pre-structured, pre-tested case record form. Only patients with a deranged lipid profile were included in the analysis.
BMI was calculated using the standard formula: weight (kg) divided by height in meters squared (m^2). Biochemical investigations, including serum lipid profile, HbA1c, and random blood sugar (RBS), were conducted for all enrolled participants.

Anthropometric Assessment
Anthropometric measurements included body weight, height, BMI, waist circumference (WC), hip circumference (HC), and waist-to-hip ratio (WHR). Body weight and height were measured with participants in a standing position, barefoot, and wearing light clothing using an electronic digital scale and stadiometer. Height was recorded to the nearest 0.5 c m and weight to the nearest 0.1 kg. BMI was calculated using the formula: weight (kg)/height^2 (m^2).Waist circumference was measured at the midpoint between the lower margin of the rib cage and the iliac crest in the horizontal plane, with the subject standing upright, abdomen relaxed, and arms at the sides. Measurements were taken at the end of a normal expiration and recorded to the nearest 0.1 cm. Hip circumference was measured at the widest point over the buttocks. WHR was calculated by dividing WC by HC. An increased WC was defined as ≥90 cm in men and ≥80 cm in women, while an increased WHR was defined as ≥0.90 in men and ≥0.85 in women.
Statistical Analysis

Result
A total of 90 participants were enrolled in the study after screening for eligibility and obtaining informed consent. All subjects underwent a detailed clinical assessment, anthropometric measurements, and relevant biochemical investigations as per the study protocol. The data were collected systematically using a pre-structured and pre-tested proforma. The study population included individuals from both the general medicine outpatient department and the diabetes clinic at Subharti Medical College, Meerut.

Table 1: Demographic data of Study participants

Age (yrs)	**Count (%)**
20 – 30 yrs	84 (42.00%)
31 – 40 yrs	22 (11.00%)
41 – 50 yrs	43 (21.50%)
51 – 60 Yrs	51 (25.50%)
Sex	
Male	93 (46.50%)
Female	107 (53.50%)
BMI (kg/m^2)	
<18.5 (Underweight)	8 (4.00%)

18.5 - 24.9 (Normal)	84 (42.00%)
25 - 29.9 (Overweight)	77 (38.50%)
>=30 Obesity	31 (15.50%)
Total	200 (100.00%)

Majority of patients i.e. 42.00% patients are between 20 to 30 years old, followed by 25.50% patients are between 51 to 60yrs, 21.50% patients are in the age group of 41 to 50 yrs and remaining 11.00% patients are 31 to 40 years old. Female patients (53.50%) are more in number than male patients (46.50%) and 42.00% patients BMI is normal i.e. between 18.5 to 24.9 kg/m^2, followed by 38.50% patients are overweight having BMI 25 – 29.9 kg/m^2, 15.50% patients have obesity with BMI more than 30 kg/m^2 whereas 4.00% patients are underweighting with BMI less than 18.5 kg/m^2.

Table 2: Distribution of study participants as per Glycemic and Lipid Profile findings

Fasting Blood sugar (mg/dL)	**Count (%)**
<70 (low blood sugar)	2 (1.00%)
70 - 99 (normal)	92 (46.00%)
100 - 125 (pre-diabetic)	40 (40.00%)
>=126 (diabetic)	66 (33.00%)
HBA1C	
<5.7 (normal)	97 (48.50%)
5.7 - 6.4 (pre-diabetic)	28 (14.00%)
>=6.5 (diabetic)	75 (37.50%)
Total Cholesterol (mg/dL)	**Count (%)**
<170 (Ideal)	106 (53.00%)
170 - 199 (Borderline)	48 (24.00%)
>=200 (Too high)	46 (23.00%)
Triglyceride (mg/dL)	
<150 (Normal)	113 (56.50%)
150 - 199 (Borderline)	40 (20.00%)
200 - 499 (High)	44 (22.00%)

>=500 (Very High)	4 (2.00%)
Low-density cholesterol (LDL-C) (mg/dL)	
<100 (Healthy)	115 (57.50%)
100 - 159 (At risk)	80 (40.00%)
>=160 (Too high)	5 (2.50%)
VLDL (Very low-density lipoprotein) (mg/dL)	
<=30	103 (51.50%)
>30	97 (48.50%)
High-density cholesterol (HDL-C) (mg/dL)	**Count (%)**
<60 (At Risk)	194 (97.00%)
>=60 (Healthy)	6 (3.00%)
Total	200 (100.00%)

The analysis of glycemic parameters revealed that 33% of the study population had fasting blood sugar (FBS) levels ≥126 mg/dL, indicating diabetes, while 40% fell into the pre-diabetic range (100–125 mg/dL). Only 46% of participants exhibited normal fasting glucose levels (70–99 mg/dL), and 1% showed hypoglycemia (<70 mg/dL). Correspondingly, HbA1c values further confirmed these trends, with 37.5% of participants in the diabetic range (≥6.5%) and 14% in the pre-diabetic range (5.7–6.4%). Less than half (48.5%) had normal HbA1c levels (<5.7%). These findings suggest a significant burden of impaired glucose regulation in the study cohort. Regarding lipid parameters, elevated total cholesterol levels (≥200 mg/dL) were noted in 23% of participants, while an additional 24% had borderline levels (170–199 mg/dL). Over half (53%) of the participants had ideal total cholesterol (<170 mg/dL). Triglyceride levels were within normal range (<150 mg/dL) in 56.5% of subjects, whereas 20% had borderline values (150–199 mg/dL), 22% were in the high range (200–499 mg/dL), and 2% had very high levels (≥500 mg/dL). Low-density lipoprotein cholesterol (LDL-C) was found to be healthy (<100 mg/dL) in 57.5% of the population, while 40% had moderately elevated LDL-C (100–159 mg/dL), and 2.5% had high LDL-C levels (≥160 mg/dL). Very low-density lipoprotein (VLDL) levels were above the desirable threshold (>30 mg/dL) in 48.5% of subjects, indicating an emerging risk profile. Notably, 97% of participants had suboptimal high-density lipoprotein cholesterol (HDL-C) levels (<60 mg/dL), reinforcing the predominance of atherogenic dyslipidemia in the study cohort.

Table 3: Visceral fat index and Fat mass index of study patients

Visceral fat index	**Count (%)**
1 - 9	53 (26.50%)
10 - 14	111 (55.50%)
>=15	36 (18.00%)
Fat Mass Index	**Count (%)**
<=9	146 (73.00%)
10 - 14	38 (19.00%)
>=15	14 (7.00%)
Total	200 (100.00%)

Assessment of body fat parameters revealed that the majority of participants (55.5%) had a visceral fat index (VFI) in the range of 10–14, indicating moderate visceral adiposity. A considerable proportion (18%) exhibited a VFI of ≥15, reflecting high levels of visceral fat associated with increased cardiometabolic risk. Only 26.5% of the participants had a VFI in the lower range of 1–9, suggesting relatively low visceral fat burden. Regarding fat mass index (FMI), most participants (73%) had values ≤9, which falls within the acceptable range for total body fat relative to height. However, 19% of the population had an FMI between 10–14, and 7% had an FMI ≥15, indicating excess body fat accumulation. Elevated FMI, particularly in conjunction with high visceral fat, suggests an increased risk for metabolic disorders such as insulin resistance, type 2 diabetes, and cardiovascular disease.

Table 4 : Correlation of body visceral fat rating with serum lipid profile and fasting blood sugar of patients

Variables	**Visceral fat rating**	
	Correlation Coefficient	**P-value**
Serum Fasting Blood sugar	0.062	0.38
Serum Total Cholesterol	0.183	0.01
Serum Triglyceride	0.177	0.012
Serum Low-density cholesterol	0.148	0.037
Serum High-density cholesterol	0.159	0.024

Positive but poor correlation found between Fasting Blood sugar and Visceral fat rating. Total Cholesterol, Triglyceride, Low-density cholesterol and High-density cholesterol are showing mild positive correlation with Visceral fat rating. For Fasting Blood sugar and Visceral fat rating, p-value is greater than 0.05,

hence Fasting Blood sugar and Visceral fat rating are statistically not significant. Total Cholesterol, Triglyceride, Low-density cholesterol and High-density cholesterol p-value is less than 0.05, so Total Cholesterol and Visceral fat rating, Triglyceride and Visceral fat rating, Low-density cholesterol and Visceral fat rating and High-density cholesterol and Visceral fat rating are statistically significant.

Discussion

This study investigated the correlation of body visceral fat estimation with serum lipid profile and fasting blood sugar in an adult Indian population. Our findings contribute to the growing body of evidence highlighting the critical role of visceral adiposity in metabolic health, particularly in the context of the unique physiological characteristics and disease susceptibility observed in the Indian subcontinent. Our study population comprised 200 adults, with a slight female predominance (53.50% female vs. 46.50% male). The age distribution showed a majority of participants (42.00%) in the 20-30 years age group, followed by 51-60 years (25.50%), 41-50 years (21.50%), and 31-40 years (11.00%). This age distribution reflects a relatively young adult cohort, which is important when considering the early onset of metabolic disorders often observed in the Indian population. [16]

Regarding body mass index (BMI), 42.00% of our participants had a normal BMI (18.5-24.9 kg/m²), while a significant proportion were overweight (38.50%, BMI 25-29.9 kg/m²) or obese (15.50%, BMI ≥30 kg/m²). Only a small percentage (4.00%) were underweight. These figures underscore the rising prevalence of overweight and obesity in India, a trend that is well-documented and contributes significantly to the burden of non-communicable diseases. [17] The high percentage of overweight and obese individuals in our cohort aligns with national data indicating an increasing prevalence of abdominal obesity in India, affecting approximately 40% of women and 12% of men. [18]

The glycemic profile of our study participants revealed a concerning picture. A substantial 33% of the cohort had fasting blood sugar (FBS) levels indicative of diabetes (≥126 mg/dL), and an additional 40% were in the pre-diabetic range (100-125 mg/dL). This means that a staggering 73% of our study population exhibited some form of impaired glucose regulation. These findings are further supported by HbA1c levels, with 37.5% in the diabetic range (≥6.5%) and 14% in the pre-diabetic range (5.7-6.4%). The high prevalence of pre-diabetes and diabetes in our cohort is consistent with the escalating diabetes epidemic in India, which is home to the second-largest number of people with diabetes globally. [19]

Our lipid profile analysis also highlighted significant dyslipidemia within the study group. Elevated total cholesterol (≥200 mg/dL) was observed in 23% of participants, with another 24% having borderline levels. Triglyceride levels were high (200-499 mg/dL) in 22% and very high (≥500 mg/dL) in 2%. While LDL-C was healthy in 57.5% of the population, 40% had moderately elevated levels. Most notably, a striking 97% of participants had suboptimal HDL-C levels (<60 mg/dL). This widespread low HDL-C, coupled with elevated triglycerides and VLDL (>30 mg/dL in 48.5%), points towards a high prevalence of atherogenic dyslipidemia, a common feature in the Indian population and a significant risk factor for cardiovascular disease. [20] The phenomenon of 'lean-fat' or 'thin-fat' Indians, where individuals with seemingly normal BMI exhibit high body fat percentage and metabolic abnormalities, further emphasizes the importance of assessing body composition beyond BMI. [21]

Our assessment of body fat parameters revealed that 55.5% of participants had a visceral fat index (VFI) between 10-14, indicating moderate visceral adiposity, and 18% had a VFI ≥15, reflecting high levels of visceral fat. Only 26.5% had a VFI in the lower range (1-9). These findings are crucial as visceral fat accumulation is strongly linked to metabolic dysfunction, even in individuals who are not overtly obese

by BMI standards. [22] The majority of participants (73%) had a fat mass index (FMI) ≤9, which is within the acceptable range, but 19% had FMI between 10-14 and 7% had FMI ≥15, indicating excess total body fat. The disproportionate accumulation of visceral fat, even in individuals with normal or slightly elevated BMI, is a characteristic feature of the Indian phenotype, often referred to as the 'Asian Indian Phenotype' or 'South Asian Phenotype', which predisposes them to higher cardiometabolic risk. [23,24] Our study found a mild positive correlation between visceral fat rating and serum total cholesterol (r=0.183, p=0.01), triglycerides (r=0.177, p=0.012), LDL-C (r=0.148, p=0.037), and HDL-C (r=0.159, p=0.024). These correlations were statistically significant ($p<0.05$). This aligns with extensive research demonstrating the detrimental impact of visceral fat on lipid metabolism. Visceral adipose tissue is metabolically active, releasing free fatty acids directly into the portal circulation, leading to increased hepatic triglyceride and VLDL production, and reduced HDL-C. [25,26] Studies in Indian populations have consistently shown a strong association between increased visceral fat and dyslipidemia. [27,28] Interestingly, we observed a positive but statistically non-significant correlation between fasting blood sugar and visceral fat rating (r=0.062, p=0.38). While many studies report a strong association between visceral fat and insulin resistance and type 2 diabetes, [29,30] the lack of statistical significance in our specific correlation might be attributed to several factors. It could be due to the specific characteristics of our study population, the method of visceral fat estimation, or the presence of other confounding factors not accounted for in this direct correlation analysis. However, the high prevalence of impaired glucose regulation (pre-diabetes and diabetes) in our cohort, coupled with significant visceral adiposity, still strongly suggests a clinical link, even if the direct statistical correlation was not significant in this particular analysis. Previous research in Indian adults has indeed highlighted visceral fat as a key predictor of prediabetes and insulin resistance. [31,32]

Conclusion

Our study reinforces the significant association between visceral fat accumulation and adverse lipid profiles in an adult Indian population. The high prevalence of impaired glucose regulation and dyslipidemia, alongside substantial visceral adiposity, underscores the urgent need for targeted interventions. While the direct statistical correlation between visceral fat and fasting blood sugar was not significant in our findings, the overall metabolic profile of the cohort, characterized by high rates of pre-diabetes, diabetes, and atherogenic dyslipidemia, strongly implicates visceral fat as a major contributor to cardiometabolic risk in this population. Future research could explore the interplay of genetic, environmental, and lifestyle factors contributing to visceral fat accumulation and its metabolic consequences in diverse Indian sub-populations, utilizing more advanced imaging techniques for visceral fat quantification and longitudinal study designs to establish causality.

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Tables and Photographs