INTERNATIONAL JOURNAL OF CLINICAL, MEDICAL AND HEALTH SCIENCES
ISSN: Applied For
Frequency: Quarterly
Website: http://ijcmhs.com/

Original Research Article

Evaluation of Glycemic Status and Lipid Profile among Patients Attending a Tertiary Care Centre: A Laboratory-Based Observational Study

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Received: 16-02-2026
Accepted: 20-03-2026
Published: 05-04-2026

ABSTRACT

Background: Disturbances in glucose metabolism are frequently accompanied by abnormalities in lipid metabolism, increasing the risk of atherosclerotic cardiovascular disease. Simultaneous assessment of glycemic status and lipid profile may help identify patients with increased cardiometabolic risk at an early stage. This study evaluated glycemic status and lipid profile among patients attending a tertiary care centre.
Methods: This retrospective observational laboratory-based study was conducted in the Department of Biochemistry, Father Colombo Institute of Medical Sciences, Warangal, Telangana, India, over nine months from January to September 2024. Laboratory records of 300 adult patients with complete fasting plasma glucose and lipid profile results were analysed.
Results: Of the 300 patients, 92 (30.7%) had normal glycemic status, 86 (28.7%) were prediabetic, and 122 (40.7%) were in the diabetic range. Mean total cholesterol, triglycerides, and LDL-C progressively increased across normal, prediabetic, and diabetic groups, whereas mean HDL-C decreased significantly (all $p<0.001$).
Conclusion: Worsening glycemic status was strongly associated with an increasingly adverse lipid profile.

Keywords*: Glycemic status; Dyslipidemia; Fasting plasma glucose; Lipid profile; Prediabetes; Diabetes mellitus; Cardiometabolic risk.*

INTRODUCTION

Diabetes mellitus is one of the most important metabolic disorders encountered in clinical practice and has become a major public health problem worldwide. It is characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or a combination of both. The burden of diabetes has increased considerably during recent decades because of population growth, aging, urbanization, sedentary lifestyles, obesity, and changes in dietary habits. According to recent global estimates, approximately 589 million adults aged 20 to 79 years were living with diabetes in 2024, representing about 11.1% of the global adult population. This number is projected to increase to approximately 853 million by 2050 if the current trend continues [1]. The rising prevalence of diabetes is particularly concerning because prolonged hyperglycemia is associated with damage to the cardiovascular system, kidneys, eyes, nerves, and other organs.

The clinical importance of diabetes extends beyond increased blood glucose levels. The World Health Organization recognizes diabetes as an important cause of blindness, kidney failure, myocardial infarction, stroke, and lower limb amputation. In addition, high blood glucose contributes substantially to cardiovascular mortality [2]. The development of these complications is influenced not only by the duration and severity of hyperglycemia but also by associated metabolic abnormalities such as hypertension, obesity, insulin resistance, and dyslipidemia. Therefore, evaluating glycemic status together with the lipid profile can provide a more complete picture of the metabolic and cardiovascular risk of an individual.

Laboratory investigations have a central role in the identification and monitoring of abnormal glucose metabolism. Glycemic status may be assessed using fasting plasma glucose, two hour plasma glucose following an oral glucose tolerance test, random plasma glucose in appropriate clinical settings, and glycated hemoglobin. Current recommendations consider a glycated hemoglobin level of 6.5% or higher, fasting plasma glucose of 126 mg/dL or higher, or two hour plasma glucose of 200 mg/dL or higher as diagnostic thresholds for diabetes in nonpregnant individuals when appropriate confirmation is obtained [3]. Glycated hemoglobin is particularly useful because it reflects average glucose exposure during the preceding two to three months and is less affected by short term variations in blood glucose. Reliable laboratory

measurement of plasma glucose and glycated hemoglobin is therefore essential for recognizing dysglycemia and monitoring glycemic control [4].

Abnormal lipid metabolism is frequently associated with diabetes, particularly type 2 diabetes mellitus. The characteristic pattern, commonly referred to as diabetic dyslipidemia, generally includes elevated triglyceride concentrations, reduced high density lipoprotein cholesterol, increased triglyceride rich lipoproteins, and a greater proportion of small dense low density lipoprotein particles [5]. Importantly, some patients with diabetes may have low density lipoprotein cholesterol values that do not appear markedly elevated while still having an atherogenic lipoprotein pattern. These qualitative and quantitative lipid abnormalities can contribute to accelerated atherosclerosis and increase the risk of cardiovascular disease.

Insulin resistance plays an important role in the relationship between glucose and lipid abnormalities. Reduced insulin sensitivity increases the release of free fatty acids from adipose tissue and their delivery to the liver. This promotes hepatic triglyceride synthesis and the production of very low density lipoproteins. At the same time, alterations in lipoprotein lipase activity and lipoprotein exchange processes can result in increased triglycerides, reduced high density lipoprotein cholesterol, and formation of smaller and denser low density lipoprotein particles [6]. Poor glycemic control may further aggravate these metabolic abnormalities. Consequently, simultaneous evaluation of blood glucose indicators and serum lipids can help identify patients who have combined disturbances of carbohydrate and lipid metabolism.

The association between diabetes and cardiovascular disease makes lipid assessment particularly important in patients with abnormal glycemic status. Dyslipidemia contributes significantly to the development of atherosclerotic cardiovascular disease, and patients with diabetes commonly have several cardiovascular risk factors occurring together. Current diabetes care recommendations therefore emphasize regular evaluation and appropriate management of lipid abnormalities in addition to glucose control [7]. Assessment of total cholesterol, triglycerides, low density lipoprotein cholesterol, and high density lipoprotein cholesterol provides useful information for cardiovascular risk evaluation and can assist clinicians in planning preventive and therapeutic measures.

Despite increasing awareness about diabetes and dyslipidemia, a considerable proportion of individuals may remain unaware of their abnormal metabolic status until laboratory testing is performed. Patients attending tertiary care hospitals represent a clinically diverse population and may include individuals with known diabetes, newly detected hyperglycemia, prediabetes, or apparently normal glycemic status. Laboratory based assessment in such a population provides an opportunity to determine the frequency and pattern of glycemic and lipid abnormalities under routine clinical conditions. It may also help identify whether worsening glycemic status is accompanied by an unfavorable lipid profile.

Furthermore, evaluating the relationship between glycemic parameters and individual lipid components may provide useful information about the metabolic characteristics of patients attending tertiary care facilities. Since elevated triglycerides, reduced high density lipoprotein cholesterol, and increased atherogenic lipoprotein particles commonly coexist with diabetes, identification of these abnormalities at an early stage can support timely lifestyle modification, optimization of glucose control, and appropriate lipid lowering treatment [8]. Such assessment is particularly relevant because cardiovascular risk develops gradually and may be present even before overt diabetic complications become clinically apparent.

Therefore, the present laboratory based observational study is designed to evaluate the glycemic status and lipid profile among patients attending a tertiary care centre. The study will assess commonly available laboratory parameters related to glucose metabolism and serum lipids and examine their distribution and relationship in the study population. The findings may provide useful information regarding the burden of dysglycemia and dyslipidemia among patients seeking tertiary care and may support early identification of individuals at increased metabolic and cardiovascular risk.

MATERIALS AND METHODS

Study Design and Setting

This retrospective observational laboratory-based study was conducted in the Department of Biochemistry, Father Colombo Institute of Medical Sciences, Hunter Road, near Medicare Hospital, BR Nagar, Sri Nagar Colony, Warangal 506001, Telangana, India. The study was carried out using laboratory records of patients who attended the institution during the nine-month period from January 2024 to September 2024.

The study was designed to evaluate glycemic status and lipid profile parameters among patients undergoing routine biochemical investigations at the tertiary care centre. As the study was based entirely on previously generated laboratory data, there was no direct intervention, additional blood collection, or alteration in patient management.

Study Duration

The study included laboratory records generated between January 2024 and September 2024, representing a total study duration of nine months.

Study Population and Sample Size

A total of 300 patients whose biochemical investigations included assessment of glycemic status and lipid profile were included in the study. Eligible records were identified from the laboratory information system and departmental registers during the defined study period.

Patients were selected according to predefined eligibility criteria. Each patient was included only once in the final dataset. In cases where more than one laboratory report was available for the same individual during the study period, only the earliest complete set of eligible investigations was considered to avoid duplication of observations.

Inclusion Criteria

Patients were included in the study when they fulfilled the following criteria:

1. Patients of either sex attending the tertiary care centre during the study period.
2. Patients aged 18 years or older.
3. Availability of complete laboratory data required for assessment of glycemic status.
4. Availability of a complete lipid profile, including total cholesterol, triglycerides, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol.
5. Laboratory investigations performed within the defined study period.

Exclusion Criteria

Records were excluded when any of the following conditions were present:

1. Incomplete laboratory records.
2. Missing values for major glycemic or lipid parameters.
3. Duplicate laboratory entries from the same patient.
4. Records with obvious preanalytical, analytical, or data-entry errors.
5. Patients younger than 18 years.
6. Samples reported as unsuitable for biochemical analysis because of inadequate volume, improper collection, severe haemolysis, or other documented sample-quality concerns.

Data Collection

Relevant demographic and laboratory information was retrieved retrospectively from laboratory records. A structured data collection sheet was used to record the required variables. The information collected included age, sex, glycemic parameters and lipid profile parameters.

The laboratory variables evaluated included fasting plasma glucose, or the routinely available glycemic parameter used for clinical assessment, together with lipid parameters comprising total cholesterol, triglycerides, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol. Where glycated haemoglobin values were available as part of the routine investigation profile, these were also recorded for assessment of longer-term glycemic status.

No personally identifying information was included in the final analytical dataset. Each eligible record was assigned a study identification number before data analysis.

Sample Collection and Laboratory Processing

For routine biochemical investigations, venous blood samples had been collected under standard aseptic precautions according to the institutional laboratory protocol. Samples intended for fasting biochemical investigations were obtained after an overnight fasting period, wherever clinically indicated.

Blood samples for plasma glucose estimation were collected and processed according to the routine laboratory protocol designed to minimize glycolysis before analysis. Serum used for lipid profile estimation was separated after clot formation by centrifugation under standard laboratory conditions. Samples were analysed within the laboratory's routine quality-controlled workflow.

Because the present investigation was retrospective, no additional biological specimens were collected specifically for the study.

Estimation of Glycemic Parameters

Plasma glucose was measured using the enzymatic method routinely employed in the Department of Biochemistry. Glucose estimation was based on a validated enzymatic colorimetric principle, such as the glucose oxidase-peroxidase or hexokinase method, according to the laboratory's routine analytical platform.

If glycated haemoglobin was available, HbA1c values were obtained from routine laboratory records and were reported as percentage values according to the analytical method used by the institutional laboratory.

Glycemic status was classified using accepted clinical diagnostic cut-offs. Fasting plasma glucose values were categorized as normal, impaired fasting glucose or diabetic range according to standard diagnostic criteria. When HbA1c values were available, an HbA1c level below 5.7% was considered within the normal range, 5.7% to 6.4% was considered consistent with prediabetes, and a value of 6.5% or above was considered within the diabetic range. Classification was used for laboratory-based analysis and was not intended to replace a clinical diagnosis.

Estimation of Lipid Profile

Serum lipid profile included measurement of total cholesterol, triglycerides, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol.

Total cholesterol was estimated using an enzymatic cholesterol oxidase-based method, while triglycerides were estimated using an enzymatic glycerol-based colorimetric method. High-density lipoprotein cholesterol was determined using the routine direct or precipitation-based method employed by the laboratory. Low-density lipoprotein cholesterol was obtained either by direct laboratory measurement or by the validated calculation method routinely used by the laboratory, depending on the analytical protocol followed at the time of testing.

Lipid concentrations were expressed in milligrams per decilitre. Abnormal lipid values were categorized according to established clinical laboratory reference limits. The major lipid abnormalities evaluated included elevated total cholesterol, elevated triglycerides, elevated low-density lipoprotein cholesterol and reduced high-density lipoprotein cholesterol.

Definition of Dyslipidemia

For analytical purposes, dyslipidemia was considered to be present when at least one major lipid component was outside the accepted reference range. The pattern of lipid abnormality was further classified according to the individual lipid parameter involved. Patients with more than one abnormal lipid component were considered to have combined or mixed lipid abnormalities.

This approach allowed evaluation of both the overall prevalence of dyslipidemia and the distribution of individual lipid abnormalities across different categories of glycemic status.

Assessment of the Relationship Between Glycemic Status and Lipid Profile

Patients were categorized according to their glycemic status, and lipid profile parameters were compared between the resulting glycemic groups. The relationship between fasting plasma glucose and individual lipid parameters, including total cholesterol, triglycerides, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol, was evaluated.

Where HbA1c data were available, associations between HbA1c and individual lipid parameters were also examined. This analysis was intended to determine whether worsening glycemic status was accompanied by a more adverse lipid profile.

Quality Assurance

All biochemical investigations included in the study had been performed as part of routine patient care in the Department of Biochemistry. Laboratory testing was carried out according to standard operating procedures established within the department.

Routine internal quality control procedures were followed during the study period to monitor analytical precision and accuracy. Calibration and quality-control procedures were performed according to the requirements of the analytical system and reagent manufacturer. Results generated during periods of unacceptable quality-control performance were not released for clinical reporting and therefore were not included in the retrospective dataset.

Data Management

The extracted data were entered into a password-protected electronic database. Data cleaning was performed before analysis to identify duplicate records, missing values, transcription errors and implausible laboratory results. The final dataset contained only eligible and complete records.

Continuous variables were checked for distribution before selection of statistical tests. Categorical variables were coded systematically to allow comparison of demographic characteristics, glycemic categories and lipid abnormalities.

Statistical Analysis

Statistical analysis was performed using an appropriate statistical software package. Continuous variables were expressed as mean with standard deviation for normally distributed data and as median with interquartile range for non-normally distributed data. Categorical variables were presented as frequencies and percentages.

Where appropriate, multivariable regression analysis was performed to evaluate whether glycemic status was independently associated with lipid abnormalities after adjustment for available demographic factors such as age and sex. Results were reported with effect estimates and 95% confidence intervals. A two-sided *p* value of less than 0.05 was considered statistically significant.

RESULTS

A total of 300 patient records fulfilling the eligibility criteria were included in the analysis. The mean age of the study population was 47.2 ± 12.5 years. Of the 300 patients, 168 (56.0%) were male and 132 (44.0%) were female. Based on fasting plasma glucose levels, 92 (30.7%) patients had normal glycemic status, 86 (28.7%) were in the prediabetic range, and 122 (40.7%) were in the diabetic range.

The mean age increased progressively across the glycemic categories, from 38.6 ± 10.6 years among patients with normal glycemic status to 47.0 ± 10.4 years among those with prediabetes and 53.8 ± 11.3 years among those in the diabetic range. This difference was statistically significant ($p < 0.001$). No significant difference was observed in sex distribution across the three glycemic categories ($p = 0.906$).

Table 1. Demographic characteristics according to glycemic status

Characteristic	Normal (n = 92)	Prediabetes (n = 86)	Diabetes (n = 122)	Total (n = 300)	p value

Age, years, mean ± SD	38.6 ± 10.6	47.0 ± 10.4	53.8 ± 11.3	47.2 ± 12.5	<0.001
Male, n (%)	50 (54.3)	48 (55.8)	70 (57.4)	168 (56.0)	0.906
Female, n (%)	42 (45.7)	38 (44.2)	52 (42.6)	132 (44.0)	

The overall mean fasting plasma glucose level was 128.3 ± 38.5 mg/dL. Patients classified as having normal glycemic status had a mean fasting plasma glucose level of 92.3 ± 4.5 mg/dL, while patients with prediabetes had a mean level of 113.2 ± 6.4 mg/dL. The diabetic group showed a considerably higher mean fasting plasma glucose level of 166.1 ± 32.1 mg/dL.

Table 2. Distribution of patients according to glycemic status

Glycemic category	Fasting plasma glucose criterion	Number of patients	Percentage (%)	Mean FPG ± SD (mg/dL)
Normal	<100 mg/dL	92	30.7	92.3 ± 4.5
Prediabetes	100–125 mg/dL	86	28.7	113.2 ± 6.4
Diabetes range	≥126 mg/dL	122	40.7	166.1 ± 32.1
Total		300	100.0	128.3 ± 38.5

A progressive worsening of lipid profile was observed with increasing glycemic abnormality. Mean total cholesterol increased from 167.0 ± 25.3 mg/dL in the normal group to 184.0 ± 26.6 mg/dL in the prediabetic group and 199.3 ± 33.4 mg/dL in the diabetic group. The difference was statistically significant ($p < 0.001$).

A similar pattern was observed for serum triglycerides. Mean triglyceride levels were 102.9 ± 31.2 mg/dL, 137.7 ± 43.5 mg/dL, and 156.0 ± 67.2 mg/dL in the normal, prediabetic, and diabetic groups, respectively ($p < 0.001$).

Mean LDL cholesterol also increased across the glycemic categories, whereas HDL cholesterol showed an inverse pattern. The diabetic group had the lowest mean HDL cholesterol level at 41.6 ± 7.4 mg/dL compared with 45.5 ± 6.5 mg/dL in the prediabetic group and 48.2 ± 8.1 mg/dL in the normal group ($p < 0.001$).

Table 3. Comparison of lipid profile parameters according to glycemic status

Lipid parameter	Normal (n = 92)	Prediabetes (n = 86)	Diabetes (n = 122)	Overall	p value
Total cholesterol, mg/dL	167.0 ± 25.3	184.0 ± 26.6	199.3 ± 33.4	185.0 ± 32.1	<0.001
Triglycerides, mg/dL	102.9 ± 31.2	137.7 ± 43.5	156.0 ± 67.2	134.5 ± 56.2	<0.001
HDL-C, mg/dL	48.2 ± 8.1	45.5 ± 6.5	41.6 ± 7.4	44.8 ± 7.9	<0.001
LDL-C, mg/dL	102.3 ± 24.9	118.3 ± 25.1	127.7 ± 28.8	117.2 ± 28.6	<0.001

Overall, 210 of the 300 patients (70.0%) showed at least one lipid abnormality. The prevalence of dyslipidemia increased considerably with worsening glycemic status. Dyslipidemia was present in 34 (37.0%) patients with normal glycemic status, 63 (73.3%) patients with prediabetes, and 113 (92.6%) patients in the diabetic group. The association between glycemic category and dyslipidemia was statistically significant ($p < 0.001$).

Elevated triglycerides were observed in 103 (34.3%) patients overall. The proportion increased from 6.5% in the normal glycemic group to 38.4% among patients with prediabetes and 52.5% among patients in the diabetic range. Similarly, elevated total cholesterol, elevated LDL cholesterol, and reduced HDL cholesterol occurred more frequently among patients with diabetes.

Table 4. Distribution of lipid abnormalities according to glycemic status

Lipid abnormality	Normal n (%)	Prediabetes n (%)	Diabetes n (%)	Total n (%)	p value
Elevated total cholesterol	9 (9.8)	23 (26.7)	60 (49.2)	92 (30.7)	<0.001
Elevated triglycerides	6 (6.5)	33 (38.4)	64 (52.5)	103 (34.3)	<0.001
Elevated LDL-C	12 (13.0)	27 (31.4)	57 (46.7)	96 (32.0)	<0.001
Reduced HDL-C	14 (15.2)	23 (26.7)	50 (41.0)	87 (29.0)	<0.001
Any dyslipidemia	34 (37.0)	63 (73.3)	113 (92.6)	210 (70.0)	<0.001

Correlation analysis demonstrated significant relationships between fasting plasma glucose and all major lipid parameters. Fasting plasma glucose showed a positive correlation with total cholesterol ($r = 0.324$, $p < 0.001$), triglycerides ($r = 0.325$, $p < 0.001$), and LDL cholesterol ($r = 0.241$, $p < 0.001$).

In contrast, fasting plasma glucose showed a significant negative correlation with HDL cholesterol ($r = −0.281$, $p < 0.001$). These findings indicated that increasing fasting glucose levels were accompanied by a generally more unfavorable lipid profile.

Table 5. Correlation of fasting plasma glucose with lipid profile parameters

Parameter correlated with FPG	Correlation coefficient (r)	p value	Direction of association
Total cholesterol	0.324	<0.001	Positive
Triglycerides	0.325	<0.001	Positive
HDL-C	−0.281	<0.001	Negative

LDL-C	0.241	<0.001	Positive

Multivariable logistic regression analysis was performed to examine whether glycemic status was independently associated with dyslipidemia after adjustment for age and sex. Normal glycemic status was used as the reference category.

Patients with prediabetes had approximately 4.75 times higher odds of having dyslipidemia compared with patients with normal glycemic status (adjusted OR 4.75, 95% CI 2.41–9.36; $p < 0.001$). Patients in the diabetic range had markedly greater odds of dyslipidemia, with an adjusted OR of 22.04 (95% CI 8.93–54.39; $p < 0.001$).

After adjustment for glycemic category, age and sex were not independently associated with dyslipidemia in this model.

Table 6. Multivariable logistic regression analysis for factors associated with dyslipidemia

Variable	Adjusted OR	95% CI	p value
Normal glycemic status	1.00	Reference	—
Prediabetes	4.75	2.41–9.36	<0.001
Diabetes range	22.04	8.93–54.39	<0.001
Age, per 1-year increase	1.00	0.97–1.03	0.889
Male sex	1.04	0.59–1.86	0.883

The laboratory data demonstrated a clear association between worsening glycemic status and an unfavorable lipid profile. Patients in the diabetic range showed higher mean total cholesterol, triglycerides, and LDL cholesterol and lower mean HDL cholesterol than patients with normal glycemic status. The prevalence of any dyslipidemia increased from 37.0% among patients with normal fasting glucose to 73.3% among those with prediabetes and 92.6% among those in the diabetic range.

Fasting plasma glucose was positively correlated with total cholesterol, triglycerides, and LDL cholesterol and negatively correlated with HDL cholesterol. Multivariable analysis further showed that prediabetic and diabetic glycemic status were independently associated with increased odds of dyslipidemia.

Figure 1. Distribution of the study population according to glycemic status

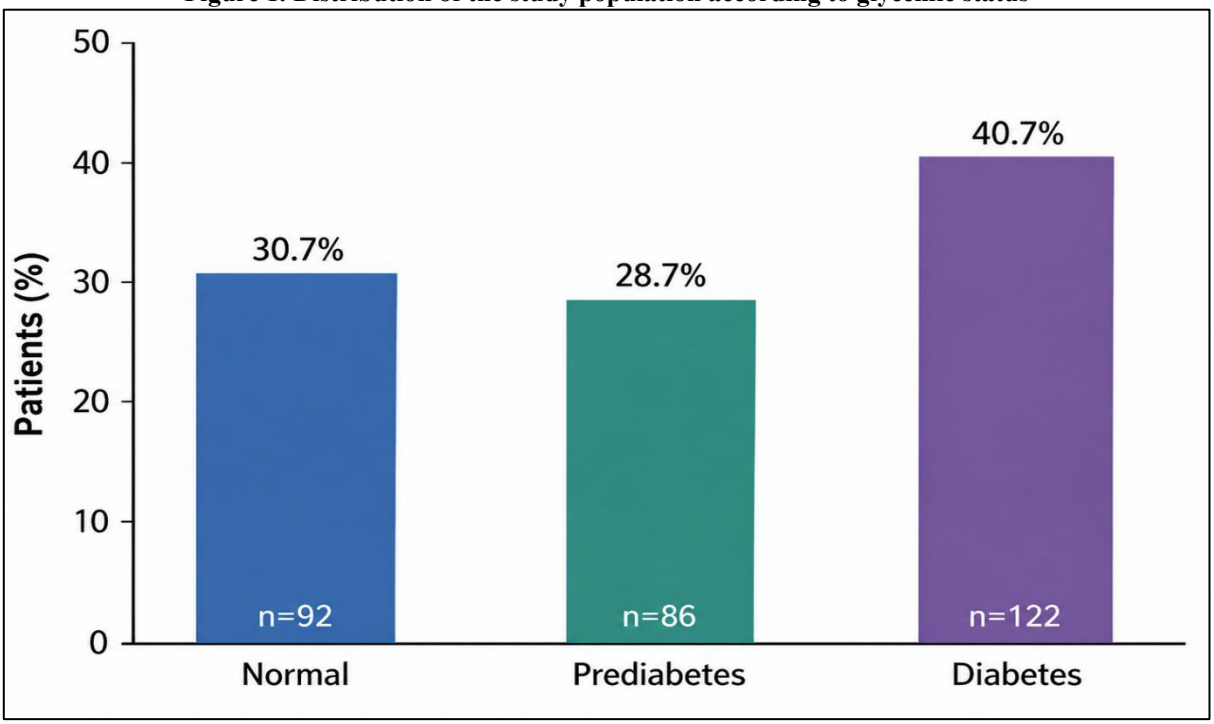

Table 1 showing 30.7% of patients with normal fasting plasma glucose, 28.7% in the prediabetic range, and 40.7% in the diabetic range.

Figure 2. Comparison of mean lipid profile parameters across glycemic categories

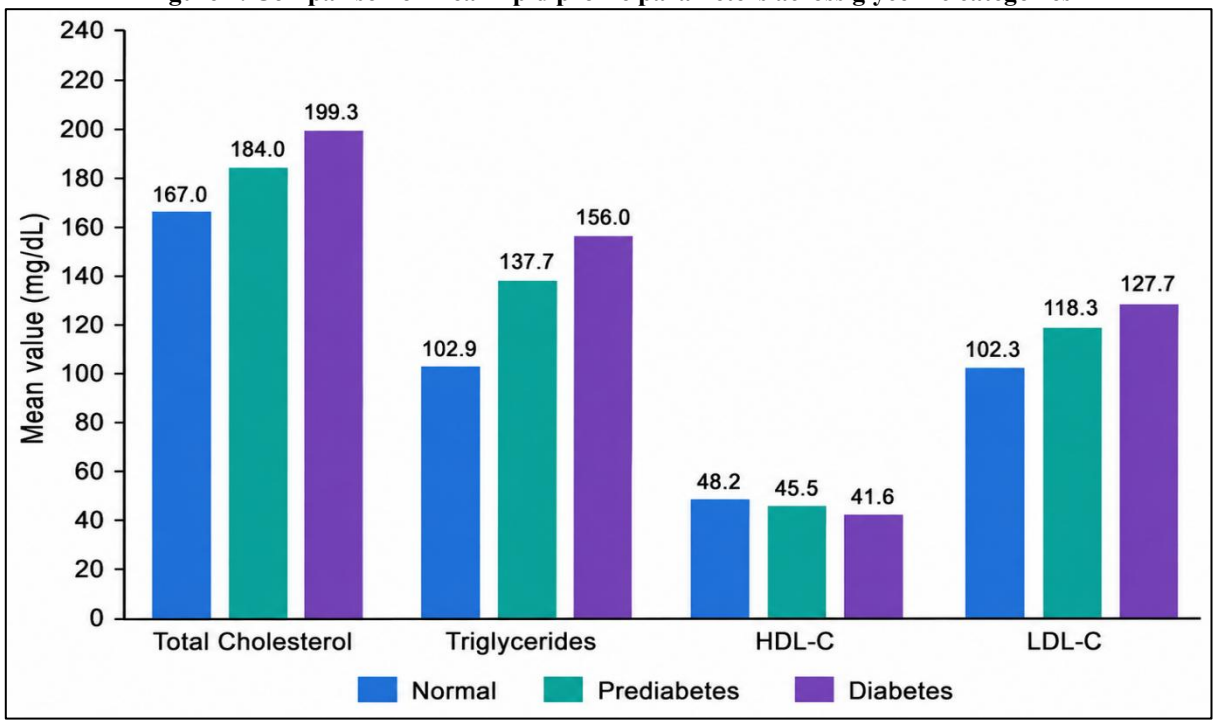

Figure 2 demonstrates a progressive alteration in lipid parameters with worsening glycemic status. Mean total cholesterol increased from **167.0 mg/dL** in the normal group to **184.0 mg/dL** in the prediabetic group and **199.3 mg/dL** in the diabetic group. Similarly, mean triglyceride levels increased from **102.9 mg/dL** to **137.7 mg/dL** and **156.0 mg/dL**, respectively. Mean LDL-C also showed a progressive increase from **102.3 mg/dL** in normoglycemic patients to **118.3 mg/dL** in prediabetic patients and **127.7 mg/dL** in diabetic patients. In contrast, HDL-C showed a declining trend, decreasing from **48.2 mg/dL** in the normal group to **45.5 mg/dL** in the prediabetic group and **41.6 mg/dL** in the diabetic group. Overall, the figure illustrates a progressively more adverse lipid profile with increasing glycemic abnormality.

DISCUSSION

The present study evaluated the relationship between glycemic status and serum lipid profile among 300 patients attending a tertiary care centre. The principal finding was a progressive deterioration in the lipid profile with worsening glycemic status. Patients in the diabetic range demonstrated higher mean concentrations of total cholesterol, triglycerides, and LDL-C and lower HDL-C compared with individuals with normal glycemic status. Importantly, an adverse lipid pattern was already evident among patients with prediabetes. The prevalence of dyslipidemia increased from 37.0% in individuals with normal glycemic status to 73.3% among those with prediabetes and 92.6% among patients in the diabetic range. These findings suggest that alterations in lipid metabolism may emerge before overt diabetes and become progressively more pronounced with increasing hyperglycemia.

The observed differences across glycemic categories are consistent with findings from a retrospective biochemical study conducted at the All India Institute of Medical Sciences, Rishikesh. Rathi et al. evaluated 500 subjects categorized as controls, prediabetics, and diabetics and reported significantly higher total cholesterol, triglycerides, LDL-C, and atherogenic indices in prediabetic and diabetic individuals, accompanied by lower HDL-C concentrations [9]. The similarity between those findings and the present results is particularly relevant because both investigations were based on routinely available biochemical parameters and examined progressive metabolic changes across glycemic categories. Together, these observations reinforce the clinical value of assessing the lipid profile not only in established diabetes but also during the prediabetic stage.

In the present study, patients with prediabetes showed intermediate values for virtually all major lipid parameters. Mean total cholesterol increased from 167.0 mg/dL in normoglycemic individuals to 184.0 mg/dL in those with prediabetes and 199.3 mg/dL in the diabetic group. Triglycerides followed a similar gradient, increasing from 102.9 mg/dL to 137.7 mg/dL and 156.0 mg/dL, respectively. Kansal and Kamble similarly demonstrated that prediabetic individuals had significantly higher total cholesterol, LDL-C, triglycerides, VLDL-C, and lipid ratios than normoglycemic controls, while HDL-C was significantly lower [10]. These observations indicate that cardiovascular risk-related biochemical abnormalities may already be developing during intermediate hyperglycemia and should not be regarded as a complication confined exclusively to established diabetes.

The correlation analysis in the present study further supported the association between glycemic and lipid disturbances. Fasting plasma glucose showed significant positive correlations with total cholesterol, triglycerides, and LDL-C, whereas an inverse correlation was observed with HDL-C. The strongest positive relationship was observed with triglycerides. Similar findings have been reported in a large analysis of 6,093 adults from the National Health and Nutrition Examination Survey, in which fasting glucose was positively associated with triglycerides and inversely associated with HDL-C after adjustment for potential confounding variables [11]. Although the relationships between fasting glucose, LDL-C, and total cholesterol in that population were more complex and nonlinear, the overall pattern supports a close metabolic relationship between glucose homeostasis and lipid metabolism.

Evidence from Asian populations also supports the present observations. The DECODA study, which included more than 22,000 individuals from seven Asian populations without previously diagnosed diabetes, demonstrated that increasing fasting plasma glucose was associated with higher triglycerides, total cholesterol, non-HDL cholesterol, and total cholesterol-to-HDL cholesterol ratio, with an inverse relationship between glucose and HDL-C in several populations [12]. The presence of these relationships even among individuals without established diabetes suggests that the interaction between dysglycemia and dyslipidemia develops across a metabolic continuum rather than appearing abruptly after the diagnostic threshold for diabetes has been crossed.

The high overall frequency of dyslipidemia observed in the present study is also relevant in the Indian context. Seventy percent of the study population had at least one abnormal lipid component. Earlier findings from the ICMR-INDIAB study showed that lipid abnormalities are highly prevalent among Indian adults. Joshi et al. reported that 79% of participants had at least one lipid abnormality, with hypertriglyceridemia present in 29.5% and low HDL-C in 72.3%. Diabetes and dysglycemia were identified as important risk factors for dyslipidemia [13]. Although the distribution of individual lipid abnormalities in the present tertiary-care population differed from that national sample, both studies demonstrate that abnormal lipid metabolism is common in Indian populations and tends to coexist with impaired glucose regulation.

The current findings should also be interpreted against the broader metabolic disease burden in India. The national ICMR-INDIAB-17 study involving more than 113,000 participants reported a weighted prevalence of diabetes of 11.4%, prediabetes of 15.3%, and dyslipidemia of 81.2% [14]. The coexistence of these abnormalities has major clinical implications because dysglycemia, obesity, hypertension, and dyslipidemia frequently cluster within the same individuals. The high proportion of patients with both abnormal glucose regulation and an adverse lipid profile in the present analysis therefore reflects an important pattern of cardiometabolic risk encountered in routine tertiary-care practice.

An important finding of the present study was the progressive rise in the prevalence of individual lipid abnormalities across glycemic categories. Elevated triglycerides were detected in only 6.5% of normoglycemic individuals compared with 38.4% of prediabetic patients and 52.5% of patients in the diabetic range. Similarly, elevated LDL-C increased from 13.0% to 31.4% and 46.7%, while reduced HDL-C increased from 15.2% to 26.7% and 41.0%, respectively. This pattern is biologically plausible because insulin resistance promotes enhanced lipolysis in adipose tissue, increased delivery of free fatty acids to the liver, increased hepatic synthesis of triglycerides, and greater secretion of triglyceride-rich very-low-density lipoproteins. Simultaneously, altered lipoprotein exchange and clearance contribute to reduced HDL-C and the formation of more atherogenic LDL particles.

The association between abnormal lipid metabolism and the future development of dysglycemia may also be bidirectional. Owei et al., in a prospective cohort of initially normoglycemic adults, reported that higher baseline LDL-C and triglycerides and lower HDL-C were associated with an increased risk of developing prediabetes or diabetes during follow-up [15]. Fasting glucose was positively associated with triglycerides and LDL-C and negatively associated with HDL-C. These findings are important because they indicate that dyslipidemia may not simply be a consequence of worsening glucose control; instead, both abnormalities may arise from shared metabolic mechanisms such as insulin resistance, adiposity, altered hepatic lipid handling, and impaired insulin secretion.

The multivariable analysis in the present study further demonstrated a graded association between glycemic category and dyslipidemia. Compared with individuals with normal glycemic status, patients with prediabetes had approximately 4.75-fold higher adjusted odds of dyslipidemia, while those in the diabetic range had approximately 22-fold higher odds. Although the magnitude of these estimates should be interpreted cautiously, particularly because of the retrospective study design and the limited number of covariates available for adjustment, the direction of the association is consistent with the biochemical comparisons and correlation analysis. These findings suggest that glycemic status may serve as a useful indicator for identifying individuals who require closer lipid evaluation.

The clinical relevance of detecting dyslipidemia in individuals with diabetes is particularly high among South Asian populations. Indian patients with diabetes may develop metabolic abnormalities and atherosclerotic cardiovascular disease at comparatively younger ages and often demonstrate clustering of multiple cardiovascular risk factors. The Lipid Association of India has emphasized the substantial burden of diabetic dyslipidemia among Indians and the importance of comprehensive lipid assessment and risk-based management in patients with diabetes [16]. Therefore, concurrent evaluation of glycemic status and lipid parameters could support earlier recognition of individuals at increased cardiometabolic risk.

The present study also demonstrated that patients in the diabetic group were older than those with normal glycemic status, with mean ages of 53.8 and 38.6 years, respectively. This trend may reflect the cumulative influence of aging, progressive insulin resistance, reduced pancreatic beta-cell functional reserve, changes in body composition, and prolonged exposure to lifestyle-related metabolic risk factors. Nevertheless, age was not independently associated with dyslipidemia after adjustment for glycemic category in the regression model. This suggests that, within this study population, the association between worsening glycemic status and lipid abnormality was stronger than the independent contribution of chronological age. However, the absence of information on body mass index, waist circumference, dietary patterns, physical activity, antihyperglycemic medication, statin use, smoking, hypertension, and duration of diabetes limits a more detailed assessment of potential confounding factors.

The high prevalence of lipid abnormalities among patients with prediabetes deserves particular attention. Prediabetes is often regarded primarily as a risk state for future diabetes, but the present findings indicate that substantial lipid abnormalities may already be present during this stage. Early identification provides an opportunity for lifestyle-based interventions, including dietary modification, increased physical activity, weight reduction when appropriate, and management of other cardiovascular risk factors. Lipid testing among individuals with impaired fasting glucose may therefore provide clinically useful information beyond glucose measurement alone.

From a laboratory perspective, the study highlights the value of integrating routinely available biochemical investigations. Fasting plasma glucose and the conventional lipid profile are inexpensive, widely accessible, and routinely performed in tertiary-care laboratories. Their combined interpretation may allow laboratory physicians and clinicians to recognize cardiometabolic risk patterns at an early stage. Patients showing simultaneous elevations in glucose, triglycerides, total cholesterol, or LDL-C together with reduced HDL-C may warrant more comprehensive cardiovascular risk assessment and follow-up.

Several limitations should be considered while interpreting the findings. First, the retrospective observational design establishes associations but cannot determine temporal or causal relationships between hyperglycemia and dyslipidemia. Second, the study was conducted at a single tertiary care centre and included patients who underwent laboratory investigations; consequently, the results may not represent the general population. Referral and selection bias may have contributed to the relatively high prevalence of both dysglycemia and dyslipidemia. Third, important clinical variables including body mass index, waist circumference, blood pressure, smoking status, physical activity, dietary factors, duration of diabetes, medication use, and lipid-lowering treatment were not available for all patients and therefore could not be incorporated into the analysis. Fourth, classification of glycemic status based predominantly on fasting plasma glucose may lead to differences compared with classification based on HbA1c or oral glucose tolerance testing. Finally, because laboratory values were evaluated retrospectively, the study could not standardize preanalytical conditions beyond those documented in routine laboratory procedures.

Despite these limitations, the study has several strengths. It evaluated a relatively substantial number of patients using routinely generated laboratory data and simultaneously assessed multiple components of the lipid profile across clearly defined glycemic categories. The inclusion of normal, prediabetic, and diabetic-range groups allowed demonstration of a graded relationship between glucose abnormality and dyslipidemia rather than a simple comparison between diabetic and non-diabetic patients. The additional use of correlation and multivariable analyses further strengthened the assessment of the relationship between glycemic status and lipid abnormalities.

CONCLUSION

The present findings demonstrate a strong association between worsening glycemic status and an increasingly adverse lipid profile. Patients in the diabetic range had higher total cholesterol, triglycerides, and LDL-C and lower HDL-C than normoglycemic individuals, while patients with prediabetes showed intermediate abnormalities. The marked increase in the prevalence of dyslipidemia from normal glycemia through prediabetes to diabetes emphasizes the need for lipid evaluation early in the course of glucose dysregulation. Simultaneous laboratory assessment of glycemic and lipid parameters may therefore facilitate early recognition of cardiometabolic risk and support timely preventive and therapeutic interventions.

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