

Lipid Profile in Type 2 Diabetes Mellitus: A Cross-Sectional Case–Control Study

Jatoth Himabindu*, M. Kirti, M.D. Khaleel Ur Rehman Qureshi

ABSTRACT

Background: Dyslipidemia is a common metabolic abnormality in type 2 diabetes mellitus (T2DM) and contributes to an increased risk of cardiovascular complications. Alterations in lipid metabolism may become more pronounced with prolonged duration and poor glycemic control. **Objectives:** The aim of this study was to compare the serum lipid profile of patients with T2DM and healthy controls and to assess the association of lipid parameters with the duration and severity of diabetes. **Materials and Methods:** A cross-sectional case–control study was conducted at MNR Medical College and Hospital, Sangareddy, from December 2017 to November 2019. Fifty patients with T2DM and 50 age- and sex-matched healthy controls were included. Patients with conditions affecting lipid metabolism, including hypothyroidism, were excluded. Fasting serum total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and very-low-density lipoprotein cholesterol (VLDL-C) were assessed. Glycemic status was evaluated using glycated hemoglobin (HbA1c). Lipid abnormalities were interpreted according to NCEP ATP III criteria. **Results:** The mean age was 58.46 ± 7.73 years in the diabetic group and 58.40 ± 9.08 years in controls. Mean TC, LDL-C, and VLDL-C were significantly higher in diabetics than controls: TC, 203.76 ± 52.84 versus 166.06 ± 39.06 mg/dL ($P < 0.00001$); LDL-C, 135.78 ± 47.90 versus 94.98 ± 35.51 mg/dL ($P = 0.00002$); and VLDL-C, 33.68 ± 9.65 versus 28.64 ± 8.63 mg/dL ($P = 0.0203$). TG and HDL-C differences were not statistically significant in the case–control comparison. With increasing duration of diabetes, TG increased and HDL-C decreased significantly ($P < 0.001$). Increasing HbA1c severity was associated with higher TG, TC, LDL-C, and VLDL-C and lower HDL-C. **Conclusion:** T2DM is associated with significant alterations in lipid metabolism, particularly increased TC, LDL-C, and VLDL-C. Longer duration and poorer glycemic control were associated with worsening lipid abnormalities. Regular lipid assessment and optimal glycemic control may help reduce cardiovascular and vascular complications in patients with T2DM.

Keywords: Cardiovascular risk, Dyslipidemia, Glycated hemoglobin, High-density lipoprotein cholesterol, Lipid profile, Low-density lipoprotein cholesterol, Total cholesterol, Triglycerides, Type 2 diabetes mellitus, Very-low-density lipoprotein cholesterol

Asian Pac. J. Health Sci., (2026); DOI: 10.21276/apjhs.2026.13.4.11

INTRODUCTION

Diabetes mellitus (DM) is a group of metabolic disorders characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Type 2 DM (T2DM) is the most common form and is associated with progressive metabolic abnormalities and vascular complications. Dyslipidemia is one of the important metabolic abnormalities accompanying T2DM and contributes substantially to the development of atherosclerosis and cardiovascular disease.

Diabetic dyslipidemia is characterized by alterations in the concentrations and composition of circulating lipoproteins. Patients with T2DM commonly demonstrate increased triglycerides, total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and very-low-density lipoprotein cholesterol (VLDL-C), together with reduced high-density lipoprotein cholesterol (HDL-C). These abnormalities may vary according to glycemic control, duration of diabetes, and other metabolic factors. The association between T2DM and abnormal lipid metabolism has been demonstrated in comparative studies, emphasizing the importance of lipid assessment in diabetic patients.^[1,2]

Insulin resistance plays a central role in the development of diabetic dyslipidemia. Reduced insulin action promotes increased release of free fatty acids from adipose tissue and enhances hepatic triglyceride synthesis and VLDL secretion. Consequently, abnormalities in triglyceride-rich lipoproteins and other lipid fractions may develop. Hyperglycemia and dyslipidemia together contribute to increased cardiovascular risk in individuals with diabetes.

Department of General Medicine, Government Medical College, Vikarabad, Telangana, India.

Corresponding Author: Jatoth Himabindu, Department of General Medicine, Government Medical College, Vikarabad, Telangana, India. E-mail: bindujatoth3@gmail.com

How to cite this article: Himabindu J, Kirti M, Qureshi MD. Lipid Profile in Type 2 Diabetes Mellitus: A Cross-Sectional Case–Control Study. *Asian Pac. J. Health Sci.*, 2026;13(4):48–52.

Source of support: Nil.

Conflicts of interest: None.

Received: 11-08-2026 **Revised:** 19-09-2026 **Accepted:** 25-09-2026

Poor glycemic control may further aggravate lipid abnormalities. Previous observations have demonstrated an association between diabetes control and serum lipid concentrations, with triglyceride-rich VLDL being an important abnormality in diabetic patients.^[3] The duration of diabetes may also influence lipid metabolism, with longer disease duration being associated with progressive changes in triglyceride and HDL-C levels. In addition, increasing severity of diabetes has been associated with higher concentrations of triglycerides, TC, LDL-C, and VLDL-C and lower HDL-C levels.

Dyslipidemia is clinically important because diabetes itself increases the risk of cardiovascular disease, while abnormalities of cholesterol and lipoproteins further accelerate vascular injury. Cardiovascular complications remain a major cause of morbidity and mortality among individuals with diabetes. Therefore, early recognition of lipid abnormalities, together with adequate

glycemic control and appropriate management, is important in reducing the long-term vascular burden of T2DM.^[4,5]

The present study was undertaken to compare the fasting lipid profile of patients with T2DM with that of age- and sex-matched healthy controls and to evaluate the relationship between lipid parameters, duration, and severity of diabetes. Understanding these associations may help in identifying patients at increased cardiovascular risk and emphasize the importance of regular lipid monitoring in T2DM.

MATERIALS AND METHODS

Study Design

The present study was designed as a cross-sectional case-control clinical study to assess the lipid profile in patients with T2DM and to compare the findings with those of healthy individuals. The study was conducted in the Department of General Medicine, MNR Medical College and Hospital, Sangareddy. Random sampling was used for selection of study participants.

The study population consisted of two groups: A diabetic study group comprising 50 patients with T2DM and a control group comprising 50 non-diabetic healthy individuals with a similar demographic profile. Thus, the total sample size was 100 participants. The diabetic and control groups were comparable with respect to age and sex.

Study Duration

The study was carried out over a period of 2 years, from December 2017 to November 2019. During this period, eligible patients attending or admitted to the Department of General Medicine were assessed according to the predefined selection criteria, and the required clinical and biochemical investigations were performed.

Study Population and Selection Criteria

Patients diagnosed with T2DM and willing to participate in the study were included in the study. Written informed consent was obtained from all participants before enrolment. Patients with concomitant diseases or conditions that could influence serum lipid concentrations, particularly hypothyroidism, were excluded from the study.

Healthy individuals without diabetes and with a similar demographic profile were included as controls. The study population was evaluated for demographic characteristics, diabetic history, duration of diabetes, treatment history, glycemic control, and diabetic complications.

Ethical Considerations

Approval for conducting the study was obtained from the Thesis Approval Committee and Institutional Ethics Committee. All participants were informed regarding the purpose and procedures of the study, and written informed consent was obtained. Participants were also informed of their right to withdraw from the study at any time.

Table 1: Demographic characteristics of study participants

Characteristic	T2DM group (n=50)	Healthy controls (n=50)	Statistical value	P-value
Age, years (mean±SD)	58.46±7.73	58.40±9.08	t=1.338	0.091
Male, n (%)	40 (80)	39 (78)	χ ² =0.0603	0.806
Female, n (%)	10 (20)	11 (22)	—	—

Interpretation: There was no statistically significant difference in age or sex distribution between the two groups ($P>0.05$), indicating adequate demographic comparability. T2DM: Type 2 diabetes mellitus, SD: Standard deviation

Table 2: Clinical characteristics and glycemic control among patients with T2DM

Parameter	Finding
Mean duration of diabetes	7.98 years
Range of duration	4–13 years
Smokers (%)	26 (52)
Obese (%)	26 (52)
HbA1c ≤7%	3 (6)
HbA1c 7.1–8%	15 (30)
HbA1c 8.1–9%	26 (52)
HbA1c >9%	6 (12)

T2DM: Type 2 diabetes mellitus, HbA1c: Glycated hemoglobin

Table 3: Pattern of treatment among patients with T2DM

Treatment modality	Number of patients	Percentage
Oral hypoglycemic drugs alone	24	48
Oral hypoglycemic drugs+insulin	10	20
Insulin alone	16	32
Total	50	100

T2DM: Type 2 diabetes mellitus

Study Protocol

A detailed clinical history was obtained from each participant, including duration of diabetes, mode of treatment, recent blood glucose values, drug history, and symptoms suggestive of diabetic complications. A thorough general physical and systemic examination was performed. Relevant clinical information regarding retinopathy, neuropathy, nephropathy, and macrovascular complications was recorded.

Routine blood and urine investigations were performed. Fasting blood glucose, postprandial blood glucose, glycated hemoglobin (HbA1c), and fasting serum lipid profile were assessed. The lipid profile included TC, triglycerides (TG), HDL-C, LDL-C, and VLDL-C.

Diagnosis of diabetes was based on the stated criteria, including a fasting plasma glucose ≥ 126 mg/dL after a minimum 12-h fast and/or a 2-h postprandial plasma glucose ≥ 200 mg/dL. Previously diagnosed diabetic patients were also reassessed for their current biochemical status.

Blood Sample Collection and Processing

Fasting venous blood samples were collected from the cubital fossa using sterile, dry syringes. The tourniquet was released immediately before collection to minimize possible alterations in serum lipid concentrations. Approximately 10 mL of blood was collected and transferred into appropriate vacutainers.

Serum was separated within 2 h of blood collection. Samples were centrifuged at 5000 rpm for 10 min, following which the clear

Table 4: Comparison of serum lipid profile between T2DM patients and healthy controls

Lipid parameter (mg/dL)	T2DM (mean±SD)	Controls (mean±SD)	t-value	P-value	Significance
Total cholesterol	203.76±52.84	166.06±39.06	-6.2512	<0.00001	Highly significant
Triglycerides	160.80±48.77	147.84±38.15	-1.209	0.232	Not significant
HDL-C	37.34±5.83	41.46±8.86	0.810	0.421	Not significant
LDL-C	135.78±47.90	94.98±35.51	-4.703	0.00002	Highly significant
VLDL-C	33.68±9.65	28.64±8.63	-2.398	0.0203	Significant

T2DM: Type 2 diabetes mellitus, HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol, VLDL-C: Very-low-density lipoprotein cholesterol, SD: Standard deviation. $P < 0.0001$ was considered highly significant.

Table 5: Association between duration of diabetes and serum lipid levels

Duration of diabetes	TG (mg/dL), mean±SD	TC (mg/dL), mean±SD	HDL-C (mg/dL), mean±SD
4–6 years	160.86±46.91	131.93±46.41	32.73±1.03
7–9 years	191.35±43.80	158.25±47.16	31.60±6.30
10–12 years	200.08±43.28	216.00±8.40	31.00±0.00
>12 years	207.50±3.50	183.16±41.91	30.23±0.00
Overall P-value	<0.001	<0.001	<0.001

TG: Triglycerides, TC: Total cholesterol, HDL-C: High-density lipoprotein cholesterol, SD: Standard deviation

supernatant serum was transferred into dry vials. Samples were analyzed on the same day, and hemolyzed samples were excluded from analysis.

Biochemical Analysis

Biochemical estimations were performed using RFCL reagent kits on a Microlab-300 semi-autoanalyzer supplied by Merck. Fasting and postprandial serum glucose was estimated by the GOD/POD method.

Serum TC was estimated quantitatively by the CHOD-PAP method, while serum triglycerides were estimated by the GPO-ESPAS method. HDL-C was estimated using the PEG-PAP method.

VLDL-C was derived from serum triglyceride concentration using the Friedewald formula, while LDL-C was calculated by subtracting HDL-C and VLDL-C from TC.

For interpretation of lipid abnormalities, the NCEP Adult Treatment Panel III (ATP III) criteria were used. According to the study protocol, TC >200 mg/dL was considered hypercholesterolemia, LDL-C >100 mg/dL as high LDL-C, triglycerides >150 mg/dL as hypertriglyceridemia, and HDL-C <40 mg/dL as low HDL-C.

Assessment of Glycemic Control and Diabetes Severity

Glycemic control was assessed using HbA1c. Participants with diabetes were categorized according to their HbA1c levels. The study classified patients with HbA1c ≤7%, 7.1–8%, 8.1–9%, and >9% into increasing grades of glycemic severity. The lipid parameters were subsequently compared across these categories to determine the relationship between glycemic severity and lipid abnormalities.

The relationship between the duration of diabetes and lipid parameters was also assessed. Patients were categorized according to duration of diabetes, and serum TG, TC, and HDL-C values were compared across these groups.

Statistical Analysis

The collected data were entered into Microsoft Excel and subsequently analyzed using IBM Statistical Package for the

Social Sciences Statistics (version 23). Continuous variables were expressed as mean ± standard deviation (SD). The means of different clinical and biochemical parameters between the diabetic and control groups were compared using the two-tailed Student's *t*-test.

The *t*-test was also used for comparison of quantitative parameters between relevant groups and for assessment of differences in lipid parameters according to the duration and severity of diabetes. The level of statistical significance was set at $P < 0.05$. $P < 0.05$ was considered statistically significant, while $P < 0.0001$ was considered highly significant.

The principal outcome measures were differences in serum TC, TG, HDL-C, LDL-C, and VLDL-C between patients with T2DM and healthy controls, together with their association with duration of diabetes and degree of glycemic control. This methodology enabled assessment of the extent of dyslipidemia in T2DM and its relationship with the clinical severity of the disease.

RESULTS

A total of 100 participants were included in the study, comprising 50 patients with T2DM and 50 healthy controls. The mean age of the diabetic group was 58.46 ± 7.73 years and that of the control group was 58.40 ± 9.08 years. The two groups were comparable with respect to age and sex. The mean duration of diabetes among the patients was 7.98 years, with a range of 4–13 years.

Only three patients had HbA1c ≤7%, whereas 32 patients (64%) had HbA1c >8%, indicating poor glycemic control in a substantial proportion of the study population.

Almost half of the diabetic patients (48%) were receiving oral hypoglycemic drugs alone, while 32% were receiving insulin alone and 20% were receiving combined oral hypoglycemic drugs and insulin.

The diabetic group demonstrated significantly higher TC, LDL-C, and VLDL-C compared with healthy controls. The differences in TC and LDL-C were highly significant. Although TG was higher and HDL-C lower in the diabetic group, these differences were not statistically significant.

There was a statistically significant association between duration of diabetes and lipid parameters. Triglyceride levels increased progressively, from 160.86 mg/dL in patients with 4–6 years of diabetes to 207.50 mg/dL in those with >12 years. HDL-C showed a significant downward trend with increasing duration of diabetes ($P < 0.001$).

A clear relationship was observed between poor glycemic control and worsening lipid abnormalities. With increasing HbA1c, TG, TC, LDL-C, and VLDL-C increased significantly, whereas HDL-C decreased significantly. All five lipid parameters showed statistically significant differences across the HbA1c categories. The demographic characteristics of the study

Table 6: Serum lipid profile according to glycemic severity (HbA1c)

HbA1c (%)	TG (mg/dL)	TC (mg/dL)	LDL-C (mg/dL)	HDL-C (mg/dL)	VLDL-C (mg/dL)
≤7	153.50±9.19	180.66±18.30	118.60±67.88	33.66±6.70	29.00±11.30
7.1–8	171.77±33.76	192.88±33.83	133.22±51.57	32.72±5.67	26.94±10.17
8.1–9	197.04±44.00	241.63±37.83	176.72±52.61	27.60±5.60	37.31±9.09
>9	224.20±23.19	250.05±57.51	186.40±29.21	24.50±4.50	39.60±6.50
Overall <i>P</i> -value	<0.01	<0.001	<0.01	<0.001	<0.001

HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol, VLDL-C: Very-low-density lipoprotein cholesterol, TG: Triglycerides, TC: Total cholesterol, HbA1c: Glycated hemoglobin

participants are presented in Table 1. The clinical characteristics and glycemic control among patients with T2DM are presented in Table 2. The pattern of treatment among patients with T2DM is presented in Table 3. The comparison of serum lipid profiles between T2DM patients and healthy controls is shown in Table 4. The association between duration of diabetes and serum lipid levels is presented in Table 5. The serum lipid profile according to glycemic severity based on HbA1c is presented in Table 6.

Diabetic Complications

Among the 50 patients with T2DM, diabetic retinopathy was the most common complication (50%), followed by ischemic heart disease (42%), neuropathy (40%), nephropathy (28%), and cerebrovascular accident (16%).

Overall, the findings demonstrate that T2DM was associated with significant abnormalities in TC, LDL-C, and VLDL-C, while increasing duration and worsening glycemic control were associated with progressive deterioration of the lipid profile. The most statistically significant findings were observed for TC, LDL-C, VLDL-C, and the relationship of lipid parameters with duration and HbA1c.

DISCUSSION

T2DM is commonly associated with abnormalities of lipid metabolism. Diabetic dyslipidemia results from alterations in both the quantity and quality of circulating lipoproteins and is an important contributor to atherosclerosis and coronary heart disease. Insulin resistance promotes increased free fatty acid flux to the liver, enhanced triglyceride synthesis, and increased VLDL secretion, thereby contributing to the characteristic lipid abnormalities observed in T2DM.^[6,7]

In the present study, 50 patients with T2DM were compared with 50 age- and sex-matched healthy controls. The mean age of diabetic patients was 58.46 ± 7.73 years compared with 58.40 ± 9.08 years in controls. The diabetic group consisted of 40 males and 10 females, while the control group had 39 males and 11 females. The groups were therefore comparable with respect to age and sex. The predominance of males in the diabetic group has also been reported in previous studies.^[8]

The present study demonstrated significantly higher TC, LDL-C, and VLDL-C in diabetic patients compared with healthy controls. Mean TC was 203.76 ± 52.84 mg/dL in diabetics compared with 166.06 ± 39.06 mg/dL in controls ($P < 0.00001$). LDL-C was 135.78 ± 47.90 versus 94.98 ± 35.51 mg/dL ($P = 0.00002$), while VLDL-C was 33.68 ± 9.65 versus 28.64 ± 8.63 mg/dL ($P = 0.0203$). These findings support the presence of significant dyslipidemia in T2DM.^[9,10]

Although triglycerides were higher and HDL-C was lower in

the diabetic group, the differences between diabetic patients and controls were not statistically significant. This finding is important because previous studies have reported variable associations between individual lipid fractions and diabetes. Some investigators have reported the typical diabetic pattern of elevated triglycerides and reduced HDL-C, whereas others have not demonstrated significant correlations for all lipid parameters.^[3]

A significant association was observed between the duration of diabetes and lipid abnormalities. Triglyceride levels increased progressively from 160.86 ± 46.91 mg/dL in patients with 4–6 years of diabetes to 207.50 ± 3.50 mg/dL in those with more than 12 years of diabetes ($P < 0.001$). HDL-C showed a progressive decline with increasing duration, also reaching statistical significance ($P < 0.001$). These findings suggest that prolonged exposure to the diabetic state may progressively worsen lipid metabolism.^[1]

Glycemic control also showed a strong relationship with lipid abnormalities. With increasing HbA1c, there was a progressive increase in triglycerides, TC, LDL-C, and VLDL-C, while HDL-C decreased. The differences were statistically significant, with $P < 0.01$ for triglycerides and LDL-C and $P < 0.001$ for TC, HDL-C, and VLDL-C. Similar associations between glycemic control and serum lipid abnormalities have been described previously.^[11,12]

The cardiovascular significance of these findings is considerable. Diabetes is associated with accelerated atherosclerosis, and lipid abnormalities constitute an important modifiable cardiovascular risk factor. NCEP ATP III emphasizes LDL-C reduction as a primary therapeutic target and recommends lifestyle measures such as weight reduction, dietary modification, and increased physical activity.^[13] In the present study, the mean LDL-C of 135.78 mg/dL was above the target of <130 mg/dL discussed for patients with multiple cardiovascular risk factors.

Limitations of the Study

The study has certain limitations. The sample size was small, comprising only 50 diabetic patients and 50 controls, which limits the generalizability of the findings. The cross-sectional design permits assessment of associations but does not establish causality. The diabetic group was predominantly male, with only 10 female participants, limiting reliable sex-wise comparisons. In addition, differences in antidiabetic treatment, diet, physical activity, and other metabolic risk factors may have influenced lipid levels. Larger prospective studies with a more balanced sex distribution and longer follow-up are therefore required to validate these observations.

CONCLUSION

T2DM was associated with significant alterations in the lipid profile, particularly increased TC, LDL-C, and VLDL-C. The

duration of diabetes showed a significant association with increasing triglyceride levels and decreasing HDL-C levels. Poor glycemic control, reflected by higher HbA1c, was associated with progressively worsening lipid abnormalities. These findings indicate an increased cardiovascular risk among patients with T2DM. Regular monitoring of lipid profile and optimal glycemic control are important in preventing long-term vascular complications. Larger prospective studies are required to confirm these findings and establish stronger associations.

ETHICAL CLEARANCE

Ethical clearance was obtained from the Institutional Ethics Committee before commencement of the study.

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