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Biochemical Analysis of Lipid Profile in Patients with Diabetes Mellitus at the Diabetes and Endocrinology Hospital, Tripoli, Libya (January – May 2026)

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التحليل البيوكيميائي لمستوى الدهون لدى مرضى داء السكري في مستشفى السكري والغدد الصماء، طرابلس، ليبيا (يناير – مايو 2026)

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Abstract:

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia and disturbances in carbohydrate, protein, and lipid metabolism. Diabetic dyslipidemia is one of its most common complications and a major contributor to cardiovascular disease, the leading cause of morbidity and mortality among diabetic patients. This study aimed to evaluate biochemical alterations of lipid profile parameters among patients with diabetes mellitus attending the Diabetes and Endocrinology Hospital in Tripoli, Libya, and to compare them with healthy individuals. Data were collected between January and May 2026 from 367 participants, comprising 305 patients with diabetes mellitus and 62 apparently healthy controls. Venous blood samples were collected after an overnight fast. Serum total cholesterol (TC), triglycerides (TAG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) were determined using enzymatic colorimetric methods, and glycated hemoglobin (HbA1c) was measured to assess long-term glycemic control. Results were expressed as frequencies and percentages. The diabetic group comprised 213 females (69.8%) and 92 males (30.2%), and most patients (43.3%) were aged 41–60 years. Poor glycemic control was common, with 215 patients (70.5%) having HbA1c above 6.4%.

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Dyslipidemia was highly prevalent: elevated TC (>200 mg/dL) in 239 patients (78.4%), elevated TAG (>150 mg/dL) in 196 (64.3%), elevated LDL-C (>100 mg/dL) in 249 (81.6%), and reduced HDL-C (<50 mg/dL) in 263 (86.2%). Low HDL-C was the most frequent abnormality. These abnormalities are closely associated with poor glycemic control and may substantially increase cardiovascular risk. Routine lipid assessment, strict glycemic control, lifestyle modification, and early lipid-lowering therapy should be integral components of diabetes management.

Keywords: Diabetes mellitus; Dyslipidemia; Lipid profile; Total cholesterol; Triglycerides; LDL cholesterol; HDL cholesterol; HbA1c; Cardiovascular disease; Libya.

الملخص

يُعد داء السكري اضطرابًا أيضيًا مزمنًا يرتبط باضطرابات استقلاب الدهون، مما يزيد من خطر الإصابة بأمراض القلب والأوعية الدموية. هدفت هذه الدراسة إلى تقييم اضطرابات الدهون لدى مرضى السكري المراجعين لمستشفى السكري والغدد الصماء في طرابلس، ليبيا، ومقارنتها بالأفراد الأصحاء. المواد وطرق العمل: أُجريت الدراسة خلال الفترة من يناير إلى مايو 2026، وشملت 367 مشاركًا، منهم 305 مرضى مصابين بالسكري و62 فردًا ضمن المجموعة الضابطة. جُمعت عينات الدم بعد صيام ليلة كاملة، وقِيست مستويات الكوليسترول الكلي (TC)، والدهون الثلاثية (TG)، والكوليسترول عالي الكثافة (HDL-C)، والكوليسترول منخفض الكثافة (LDL-C)، بالإضافة إلى الهيموجلوبين السكري (HbA1c). حُللت البيانات باستخدام الإحصاء الوصفي، وعُرضت النتائج في صورة تكرارات ونسب مئوية. النتائج: أظهرت النتائج أن الإناث شكّلن 69.8% من مجموعة مرضى السكري، بينما بلغت نسبة الذكور 30.2%. وكانت الفئة العمرية من 41 إلى 60 عامًا الأكثر تمثيلًا بين المرضى (43.3%). كما سجل 70.5% من المرضى مستويات HbA1c أعلى من 6.4%. وكشف تحليل الدهون عن ارتفاع الكوليسترول الكلي لدى 78.4% من المرضى، والدهون الثلاثية لدى 64.3%، والكوليسترول منخفض الكثافة لدى 81.6%، في حين سُجل انخفاض الكوليسترول عالي الكثافة لدى 86.2%. وكان انخفاض HDL-C أكثر اضطرابات الدهون شيوعًا، يليه ارتفاع LDL-C. الخلاصة: كشفت الدراسة عن ارتفاع معدل انتشار اضطرابات الدهون بين مرضى السكري في طرابلس، تمثلت بصورة رئيسية في انخفاض HDL-C وارتفاع LDL-C والكوليسترول الكلي والدهون الثلاثية. وتبرز هذه النتائج أهمية الفحص الدوري لمستويات الدهون، وتحسين التحكم في سكر الدم، وتعديل نمط الحياة، واستخدام العلاج المناسب لخفض الدهون، بهدف الحد من مخاطر مضاعفات القلب والأوعية الدموية لدى مرضى السكري.

الكلمات المفتاحية: داء السكري، اضطراب شحوم الدم، صورة الدهون، الكوليسترول الكلي، الدهون الثلاثية، الكوليسترول منخفض الكثافة، الكوليسترول عالي الكثافة، الهيموجلوبين السكري، أمراض القلب والأوعية الدموية، ليبيا.

Introduction

Diabetes mellitus (DM) is a prevalent chronic metabolic disorder characterized by persistent hyperglycemia caused by impaired insulin secretion, reduced insulin sensitivity, or both. It disrupts carbohydrate, lipid, and protein metabolism and can progressively damage multiple organs, including the heart, kidneys, eyes, nerves, and blood vessels. The increasing global prevalence of diabetes represents a major public health challenge because of its considerable effects on morbidity, mortality, healthcare costs, and quality of life (American Diabetes Association Professional Practice Committee [ADA PPC], 2025a; International Diabetes Federation [IDF], 2025; World Health Organization [WHO], 2025). Under normal physiological conditions, glucose homeostasis is maintained through the coordinated actions of insulin and glucagon. Insulin, secreted by pancreatic β-cells, promotes glucose uptake by

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skeletal muscle and adipose tissue and inhibits hepatic glucose production. In diabetes, impaired insulin function disrupts these regulatory mechanisms, resulting in chronic hyperglycemia and metabolic abnormalities that contribute to microvascular and macrovascular complications (ADA PPC, 2025a; DeFronzo et al., 2021). In addition to affecting glucose regulation, diabetes significantly alters lipid metabolism. Insulin normally inhibits the breakdown of stored fat and promotes the clearance of triglyceride-rich lipoproteins from the circulation. Insulin deficiency or resistance impairs these processes, increasing free fatty acid release, hepatic very-low-density lipoprotein (VLDL) production, and circulating triglyceride levels. These changes also affect low-density lipoprotein (LDL) and high-density lipoprotein (HDL) metabolism, resulting in diabetic dyslipidemia (Goldberg & Bornfeldt, 2021; Taskinen, 2022). Diabetic dyslipidemia is typically characterized by elevated triglycerides, increased small dense LDL particles, reduced HDL cholesterol, and qualitative changes in lipoproteins. This abnormal lipid profile promotes atherosclerosis and increases the risk of coronary artery disease, stroke, and peripheral arterial disease. Consequently, cardiovascular disease remains a major cause of mortality among individuals with diabetes (Ference et al., 2022; Taskinen, 2022; Visseren et al., 2021). The relationship between diabetes mellitus and lipid abnormalities is complex, with each condition contributing to the progression of the other. Chronic hyperglycemia promotes oxidative stress, inflammation, endothelial dysfunction, and lipoprotein glycation, whereas increased circulating free fatty acids worsen insulin resistance by disrupting insulin signaling in the liver and skeletal muscle. This interaction creates a self-perpetuating metabolic cycle that increases cardiovascular risk, making lipid profile assessment an essential component of diabetes management (Giacco & Brownlee, 2021; Goldberg & Bornfeldt, 2021; Visseren et al., 2021). At the molecular level, insulin resistance contributes to diabetic dyslipidemia by increasing hepatic lipid synthesis through sterol regulatory element-binding protein-1c (SREBP-1c) and enhancing the secretion of VLDL particles. Reduced lipoprotein lipase activity and increased cholesteryl ester transfer protein (CETP) activity further alter LDL and HDL composition and function. These changes favor the formation of small, dense LDL particles and reduce the protective properties of HDL, thereby increasing atherogenic risk (Czech, 2021; Ginsberg et al., 2021; Taskinen & Borén, 2022). Oxidative stress and chronic inflammation also play important roles in diabetes-associated vascular complications. Hyperglycemia increases reactive oxygen species production, promotes advanced glycation end product formation, and activates inflammatory pathways. Oxidized LDL can be taken up by macrophages within the arterial wall, leading to foam cell formation and the development of atherosclerotic plaques (Forbes & Cooper, 2022; Giacco & Brownlee, 2021; Schmidt, 2022). Furthermore, dysfunctional adipose tissue releases pro-inflammatory mediators, including tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6), and monocyte chemoattractant protein-1 (MCP-1). These mediators aggravate insulin resistance, stimulate hepatic lipid synthesis, and impair vascular function, linking obesity, dyslipidemia, and cardiovascular disease (Czech, 2021; Ginsberg et al., 2021; Kahn et al., 2021).

Global Burden of Diabetes Mellitus

Diabetes mellitus has become a major global public health challenge, with its prevalence increasing substantially over recent decades. According to the International Diabetes Federation (IDF), approximately 537 million adults aged 20–79 years were living with diabetes in 2021, and this number was projected to rise to 643 million by 2030 and 783 million by 2045. A substantial proportion of affected individuals remain undiagnosed, increasing their risk of developing serious complications (IDF, 2025). The rising prevalence of diabetes is associated with population aging, urbanization, physical inactivity, obesity, unhealthy dietary patterns, and socioeconomic changes. The burden is particularly significant in low- and middle-income countries, where limited healthcare resources can hinder early diagnosis and effective disease

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management. Diabetes contributes substantially to blindness, chronic kidney disease, cardiovascular disease, stroke, and lower-limb amputations, while also placing considerable pressure on healthcare systems and national economies (IDF, 2025; Saeedi et al., 2021; WHO, 2025). Type 2 diabetes accounts for approximately 90–95% of all diabetes cases and is strongly associated with obesity, sedentary behavior, and insulin resistance. Type 1 diabetes and gestational diabetes also represent important public health concerns because of their increasing incidence and potential long-term complications (ADA PPC, 2025a; ADA PPC, 2025b; IDF, 2025). Obesity, particularly the accumulation of visceral fat, plays a central role in diabetes development by promoting insulin resistance through increased free fatty acid release and the production of pro-inflammatory mediators. When combined with hypertension and dyslipidemia, these metabolic disturbances substantially increase cardiovascular risk. Therefore, effective diabetes management requires not only glycemic control but also early detection and treatment of associated lipid abnormalities and other cardiovascular risk factors (Czech, 2021; Eckel et al., 2021; Kahn et al., 2021).

Diabetes Mellitus in Libya

Diabetes mellitus represents a major public health concern in Libya, reflecting the increasing burden of non-communicable diseases across the Middle East and North Africa (MENA) region. Urbanization, population aging, physical inactivity, unhealthy dietary habits, and rising obesity rates have contributed to the growing prevalence of type 2 diabetes mellitus (T2DM). Although reported estimates vary according to the population studied and diagnostic criteria, diabetes affects a substantial proportion of Libyan adults, while undiagnosed cases may further increase the overall burden (Elmehdawi et al., 2021; IDF, 2022; IDF, 2025). Obesity, particularly visceral fat accumulation, is a major contributor to insulin resistance and the development of T2DM. Furthermore, hypertension, dyslipidemia, smoking, and sedentary behavior frequently coexist with diabetes, increasing the risk of cardiovascular disease, chronic kidney disease, diabetic retinopathy, and peripheral vascular complications (Abouserwel et al., 2023; Elmehdawi & Albarsha, 2022; Elmehdawi et al., 2021; Kahn et al., 2021). Dyslipidemia is an important metabolic abnormality among patients with T2DM in Libya. Common findings include elevated triglycerides, total cholesterol, and low-density lipoprotein cholesterol (LDL-C), together with reduced high-density lipoprotein cholesterol (HDL-C). These alterations may be associated with poor glycemic control, obesity, hypertension, and longer disease duration, emphasizing the importance of regular biochemical monitoring (Abouserwel et al., 2023; Elmehdawi & Albarsha, 2022; Elmehdawi et al., 2021). The increasing burden of diabetes-related complications also places considerable pressure on Libya's healthcare resources. Early detection and appropriate management of lipid abnormalities may help reduce cardiovascular risk and improve long-term outcomes. Therefore, routine assessment of total cholesterol, triglycerides, LDL-C, and HDL-C is an essential component of comprehensive diabetes care. Investigating lipid profile alterations among Libyan patients with diabetes is consequently important for improving clinical management and informing preventive healthcare strategies (IDF, 2022; IDF, 2025; WHO, 2025).

Pathophysiology of Diabetes Mellitus

The pathophysiology of diabetes mellitus involves interactions among genetic predisposition, environmental factors, insulin resistance, pancreatic β-cell dysfunction, oxidative stress, and chronic inflammation. The disease develops when insulin secretion is insufficient or insulin action is impaired, resulting in persistent hyperglycemia and disturbances in carbohydrate, lipid, and protein metabolism. Insulin normally promotes glucose uptake, suppresses hepatic glucose production and adipose tissue lipolysis, and supports glycogen and protein synthesis. Impaired insulin function therefore increases hepatic glucose production, circulating free fatty acids, fat breakdown, and protein degradation, contributing to progressive metabolic abnormalities (ADA PPC, 2025a; Czech, 2021; Goldberg & Bornfeldt, 2021). Chronic

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hyperglycemia also activates several damaging biochemical pathways, including oxidative stress, advanced glycation end-product (AGE) formation, protein kinase C activation, and the polyol pathway. These mechanisms promote inflammation and vascular injury, contributing to diabetic complications. Alterations in lipid metabolism further increase the risk of cardiovascular disease and associated mortality (Forbes & Cooper, 2022; Giacco & Brownlee, 2021; Petersen & Shulman, 2023). The underlying mechanisms differ between type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM). In T1DM, autoimmune destruction of pancreatic β-cells leads to an absolute deficiency of insulin. This process involves autoreactive immune cells and the development of autoantibodies against β-cell antigens, including GAD65, IA-2, insulin, and ZnT8. Progressive β-cell loss impairs glucose regulation and may lead to diabetic ketoacidosis if insulin deficiency remains untreated (ADA PPC, 2025c; Holt et al., 2021).

In contrast, T2DM is primarily characterized by insulin resistance in skeletal muscle, adipose tissue, and the liver, followed by progressive pancreatic β-cell dysfunction. Initially, increased insulin secretion may compensate for reduced insulin sensitivity. However, prolonged exposure to elevated glucose and free fatty acid concentrations, together with oxidative stress and inflammatory mediators, gradually impairs β-cell function. Consequently, insulin secretion becomes inadequate to maintain normal glucose levels, resulting in persistent hyperglycemia and associated metabolic complications (Czech, 2021; Del Prato et al., 2021; Kahn et al., 2021; Taylor, 2021).

Lipid Metabolism

Lipid metabolism involves the digestion, absorption, synthesis, transport, storage, and breakdown of lipids, including triglycerides, cholesterol, phospholipids, and free fatty acids. These substances are essential for energy production, cell membrane structure, hormone synthesis, and cellular signaling. Lipid homeostasis depends on the coordinated functions of the intestine, liver, adipose tissue, and peripheral organs (Feingold, 2023; Goldberg & Bornfeldt, 2021). Dietary triglycerides are digested in the small intestine by pancreatic lipase and absorbed by intestinal cells. They are then packaged into chylomicrons, which transport dietary lipids through the lymphatic system into the bloodstream. Lipoprotein lipase breaks down chylomicron triglycerides, releasing fatty acids for energy production or storage in muscle and adipose tissue. The liver regulates endogenous lipid transport by synthesizing triglycerides and cholesterol and packaging them into very-low-density lipoproteins (VLDL). As VLDL loses triglycerides, it is converted into intermediate-density lipoproteins (IDL) and subsequently low-density lipoproteins (LDL), which deliver cholesterol to peripheral tissues (Feingold, 2023; Goldberg & Bornfeldt, 2021). High-density lipoprotein (HDL) contributes to cardiovascular protection by transporting excess cholesterol from peripheral tissues back to the liver through reverse cholesterol transport. HDL also possesses antioxidant and anti-inflammatory properties that help maintain vascular health (Ference et al., 2022; Mach et al., 2023). Insulin is a major regulator of lipid metabolism. Under normal conditions, it suppresses fat breakdown in adipose tissue, promotes triglyceride clearance through lipoprotein lipase, and limits hepatic VLDL production. However, insulin deficiency or resistance disrupts these processes, increasing circulating free fatty acids, hepatic triglyceride synthesis, and VLDL secretion. Impaired triglyceride clearance and alterations in lipoprotein composition further contribute to diabetic dyslipidemia (Czech, 2021; Ginsberg et al., 2021; Goldberg & Bornfeldt, 2021; Taskinen & Borén, 2022). These disturbances commonly result in elevated triglyceride concentrations, reduced HDL cholesterol, and increased levels of small, dense LDL particles. Small, dense LDL particles are particularly atherogenic because they can more readily enter the arterial wall and undergo oxidation, promoting atherosclerotic plaque formation. Meanwhile, reduced HDL levels and impaired cholesterol transport weaken the protective mechanisms that normally help remove excess cholesterol from tissues. Collectively, these

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lipid abnormalities substantially increase cardiovascular risk in individuals with diabetes (Ference et al., 2022; Mach et al., 2023; Taskinen & Borén, 2022).

Diabetic Dyslipidemia

Diabetic dyslipidemia is a common metabolic complication of diabetes mellitus, characterized by abnormalities in plasma lipid and lipoprotein levels. It primarily results from insulin deficiency or resistance and associated disturbances in lipid metabolism. These changes promote atherosclerosis and contribute significantly to the increased risk of cardiovascular disease among individuals with diabetes (Czech, 2021; Ference et al., 2022; Taskinen & Borén, 2022). The characteristics of diabetic dyslipidemia vary between type 1 and type 2 diabetes mellitus. In type 1 diabetes, lipid levels may remain normal when glycemic control is adequate and insulin therapy is effective. However, poor glucose control can increase fat breakdown, elevate circulating free fatty acids, and stimulate hepatic triglyceride and VLDL production, resulting in hypertriglyceridemia and alterations in other lipoproteins (Feingold, 2023; Holt et al., 2021). In type 2 diabetes, insulin resistance commonly disrupts lipid metabolism, producing a characteristic lipid profile consisting of elevated triglycerides (TG), resulting from increased hepatic VLDL production and impaired triglyceride clearance; reduced high-density lipoprotein cholesterol (HDL-C), associated with accelerated HDL breakdown and impaired cholesterol transport; and increased small, dense low-density lipoprotein (sdLDL) particles, which have greater atherogenic potential and contribute to plaque formation in arterial walls. Together, these abnormalities increase the likelihood of atherosclerosis and cardiovascular complications, highlighting the importance of routine lipid assessment and effective metabolic management in patients with diabetes (Czech, 2021; Ference et al., 2022; Taskinen & Borén, 2022).

Relationship Between Glycemic Control and Lipid Profile

Glycemic control is closely associated with lipid metabolism in patients with diabetes mellitus. Elevated glycated hemoglobin (HbA1c) levels are often linked to increased total cholesterol, triglycerides, LDL-C, non-HDL cholesterol, and apolipoprotein B, alongside reduced HDL-C. Poor glucose control may also increase small, dense LDL particles and oxidative stress, contributing to a higher risk of cardiovascular complications (Soran et al., 2022; Taskinen, 2022). Improving glycemic control through lifestyle changes and appropriate anti-diabetic treatment can help reduce lipid abnormalities. However, dyslipidemia may persist even when target glucose levels are achieved. Therefore, regular lipid profile assessment and appropriate lipid-lowering treatment, when indicated, remain essential for reducing cardiovascular risk in individuals with diabetes (ADA PPC, 2025a; ADA PPC, 2025c).

Aim of the Study

This study aims to assess lipid profile alterations in patients with diabetes mellitus by comparing serum lipid parameters with those of healthy non-diabetic individuals. It also seeks to determine the prevalence and pattern of dyslipidemia by evaluating total cholesterol, triglycerides, HDL-C, and LDL-C.

Material and methods

Study design, setting and participants

This study was conducted at the Diabetes and Endocrinology Hospital in Tripoli, Libya, between January and May 2026. A total of 367 participants aged 18–85 years were included, comprising 305 patients with diabetes mellitus and 62 apparently healthy controls. The diabetic group consisted of 213 females and 92 males, while the control group included 45 females and 17 males.

Biochemical analysis

Venous blood samples were collected after an overnight fast. Serum lipid profiles were assessed by measuring triglycerides (TG), total cholesterol (TC), high-density lipoprotein

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cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) using enzymatic colorimetric methods according to the manufacturer's protocols. Glycated hemoglobin (HbA1c) was measured to assess long-term glycemic control.

Statistical analysis

Data were analyzed using Microsoft Excel 2019. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to summarize the study findings.

Results and discussion

Distribution of the study population

A total of 367 participants were included in the study. Of these, 305 (83.1%) were patients with diabetes mellitus, while 62 (16.9%) were apparently healthy individuals who served as the control group (Figure 1).

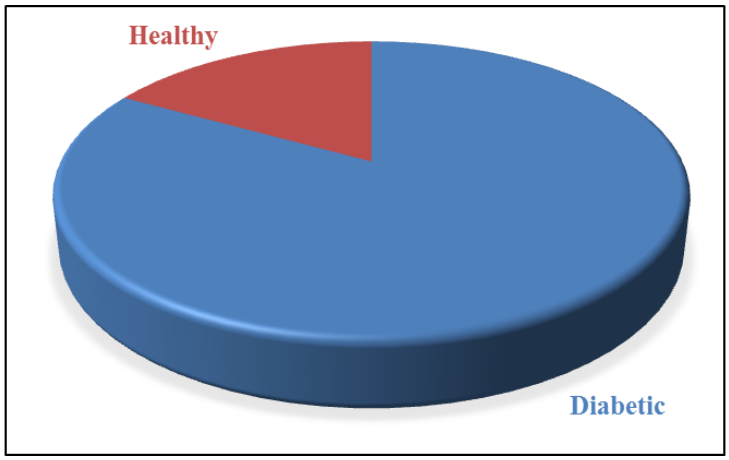

Figure 1: Distribution of diabetic patients versus healthy controls

Among the diabetic patients, 213 (69.8%) were females and 92 (30.2%) were males, giving a female-to-male ratio of 2.32:1. Similarly, the control group consisted of 45 (72.6%) females and 17 (27.4%) males, corresponding to a female-to-male ratio of 2.26:1 (Table 1).

Table 1: Distribution of the study population according to sex

Variable	Diabetic patients (n = 305)	Healthy controls (n = 62)	Total (n = 367)
Female	213 (69.8%)	45 (72.6%)	258 (70.3%)
Male	92 (30.2%)	17 (27.4%)	109 (29.7%)
Total	**305 (83.1%)**	**62 (16.9%)**	**367 (100%)**

Across the whole study population, females represented 258 participants (70.3%), while males accounted for 109 (29.7%) (Figure 2). The nearly identical sex distribution observed in both the diabetic and control groups suggests that the groups were well matched with respect to sex, thereby minimizing the potential influence of sex as a confounding factor in subsequent comparisons of biochemical parameters.

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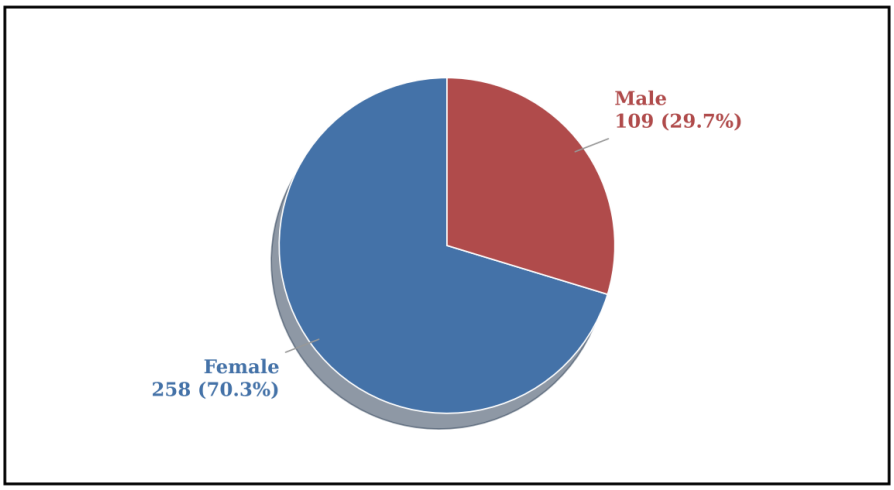

Figure 2: Sex distribution of the whole study population

Age distribution of diabetic patients

Participants' ages ranged between 18 and 85 years, and diabetes mellitus was observed across all adult age categories. Among the 305 diabetic patients, the largest proportion was found in the 41–60 years age group, accounting for 132 cases (43.3%). The 61–85 years age group represented 94 cases (30.8%), while patients aged 18–40 years constituted the smallest group, with 79 cases (25.9%) (Table 2).

Table 2: Distribution of age groups among diabetic patients

Age group (years)	Frequency (n)	Percentage (%)
18 – 40	79	25.9
41 – 60	132	43.3
61 – 85	94	30.8
Total	**305**	**100.0**

The majority of diabetic patients (74.1%) were aged above 40 years, indicating that diabetes was more prevalent among middle-aged and elderly individuals in the studied population (Figure 3). The predominance of cases among older age groups reflects the established association between increasing age and the development of metabolic abnormalities, particularly insulin resistance and progressive pancreatic β-cell dysfunction.

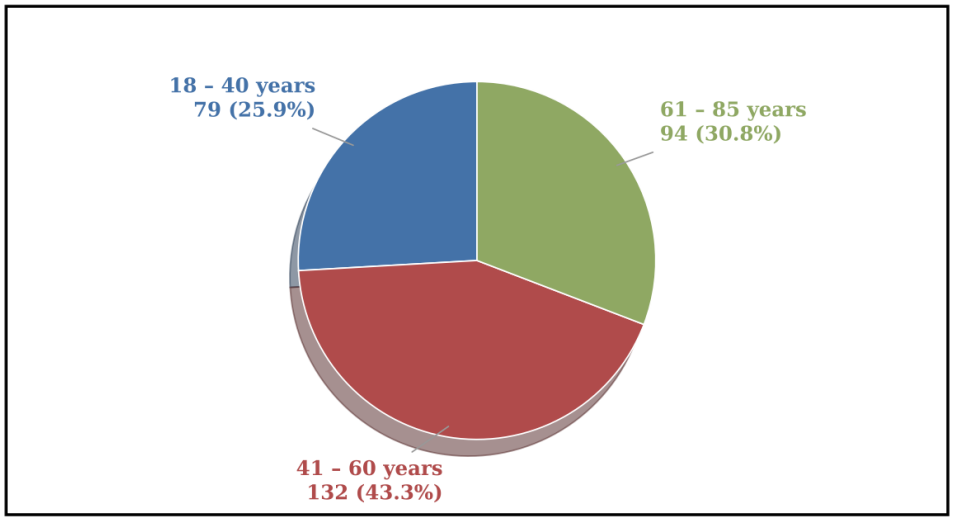

Figure 3: Age distribution of diabetic patients

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Distribution of diabetic patients according to HbA1c categories

The diabetic patients were classified into three groups according to their glycated hemoglobin (HbA1c) levels to evaluate long-term glycemic control. Among the 305 diabetic patients, 38 patients (12.5%) had HbA1c levels below 6.0%, 52 patients (17.0%) had HbA1c levels between 6.0% and 6.4%, while the majority, 215 patients (70.5%), had HbA1c levels greater than 6.4% (Table 3, Figure 4). Overall, 87.5% of the diabetic patients had HbA1c levels above 6.0%, demonstrating that elevated HbA1c was common in the study population.

Table 3: Distribution of diabetic patients according to HbA1c categories

HbA1c category (%)	Frequency (n)	Percentage (%)
< 6.0	38	12.5
6.0 – 6.4	52	17.0
> 6.4	215	70.5
Total	**305**	**100.0**

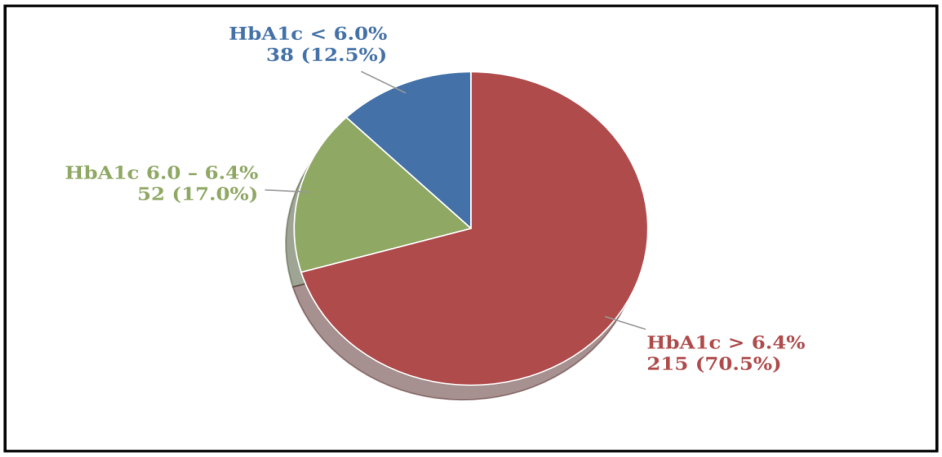

Figure 4: Distribution of diabetic patients according to HbA1c categories

Lipid profile parameters among diabetic patients

Table 4 summarizes the distribution of normal and abnormal lipid profile parameters among the 305 diabetic patients included in the study. The findings demonstrate a high prevalence of dyslipidemia, characterized by elevated total cholesterol, triglycerides, and LDL cholesterol, together with reduced HDL cholesterol.

Table 4: Distribution of normal and abnormal lipid profile parameters among diabetic patients

Lipid parameter	Normal, n (%)	Abnormal, n (%)
Total cholesterol	< 200 mg/dL: 66 (21.6%)	> 200 mg/dL: 239 (78.4%)
Triglycerides	< 150 mg/dL: 109 (35.7%)	> 150 mg/dL: 196 (64.3%)
LDL cholesterol	< 100 mg/dL: 56 (18.4%)	> 100 mg/dL: 249 (81.6%)
HDL cholesterol	50 – 80 mg/dL: 42 (13.8%)	< 50 mg/dL: 263 (86.2%)

The majority of diabetic patients (239 of 305, 78.4%) had elevated total cholesterol levels (>200 mg/dL), whereas only 66 patients (21.6%) had cholesterol concentrations within the normal range (<200 mg/dL) (Figure 5). This indicates that hypercholesterolemia is highly prevalent among the study population and may contribute to the increased cardiovascular risk associated with diabetes mellitus.

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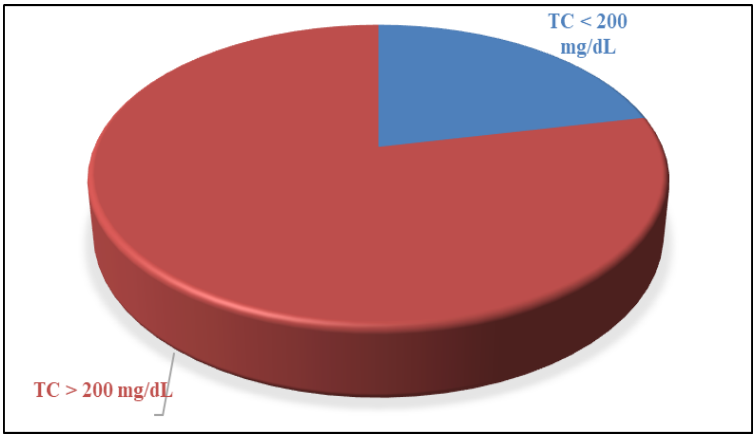

Figure 5: Level of total cholesterol among diabetic patients

Similarly, triglyceride (TAG) levels were elevated (>150 mg/dL) in 196 patients (64.3%), while only 109 patients (35.7%) had normal triglyceride concentrations (Figure 6). Hypertriglyceridemia is a common metabolic abnormality in diabetes and reflects impaired lipid metabolism secondary to insulin resistance and poor glycemic control.

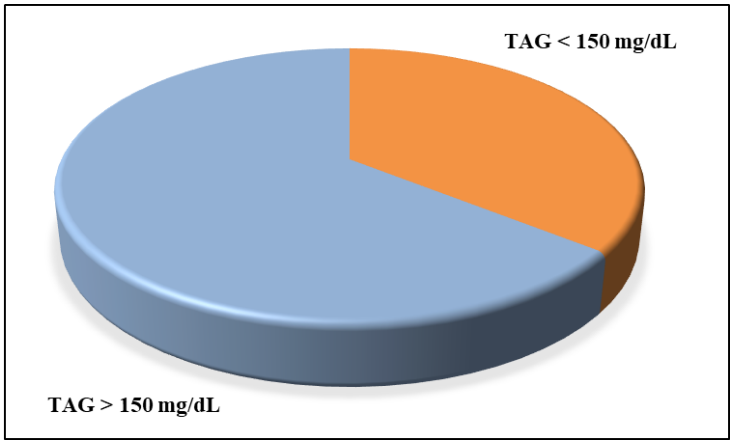

Figure 6: Level of triglycerides (TAG) among diabetic patients

The highest prevalence of abnormality was observed in low-density lipoprotein (LDL) cholesterol. A total of 249 patients (81.6%) had LDL concentrations above 100 mg/dL, whereas only 56 patients (18.4%) had LDL levels within the recommended range (Figure 7).

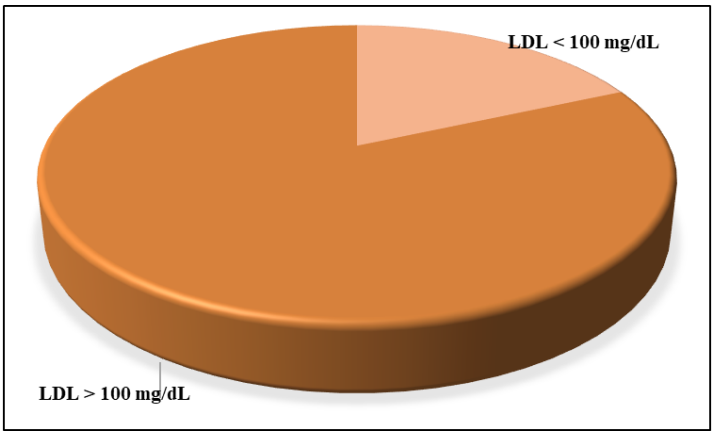

Figure 7: Level of LDL cholesterol among diabetic patients

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High-density lipoprotein (HDL) cholesterol, the protective lipoprotein, was found to be reduced in most diabetic patients. Low HDL levels (<50 mg/dL) were observed in 263 patients (86.2%), while only 42 patients (13.8%) had normal HDL concentrations (50–80 mg/dL) (Figure 8). The high prevalence of reduced HDL cholesterol further emphasizes the characteristic pattern of diabetic dyslipidemia and its contribution to cardiovascular morbidity.

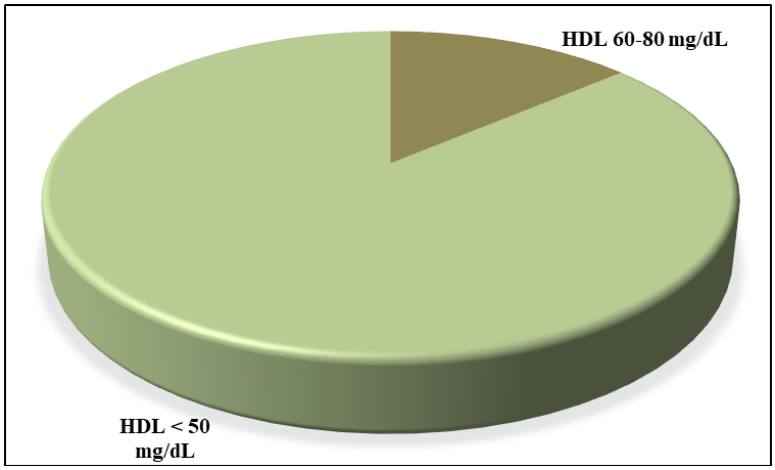

Figure 8: Level of HDL cholesterol among diabetic patients

Overall, these findings demonstrate that the majority of diabetic patients exhibited significant lipid abnormalities. The most common abnormality was low HDL cholesterol (86.2%), followed by elevated LDL cholesterol (81.6%), high total cholesterol (78.4%), and hypertriglyceridemia (64.3%). This pattern is consistent with the typical diabetic dyslipidemia characterized by increased atherogenic lipoproteins and decreased cardioprotective HDL cholesterol, highlighting the need for routine lipid monitoring and aggressive lipid-lowering interventions to reduce the risk of cardiovascular complications.

Discussion

The present study revealed a high prevalence of dyslipidemia among diabetic patients attending the Diabetes and Endocrinology Hospital in Tripoli, Libya. Elevated LDL cholesterol and total cholesterol were observed in 81.6% and 78.4% of patients, respectively, while 64.3% had hypertriglyceridemia and 86.2% had reduced HDL cholesterol. These findings indicate that lipid abnormalities are common among diabetic patients and reflect the characteristic atherogenic profile associated with an increased risk of cardiovascular complications (ADA PPC, 2025a; DeFronzo et al., 2021; IDF, 2025; WHO, 2025). Hypercholesterolemia and elevated LDL cholesterol are important cardiovascular risk factors because they promote cholesterol accumulation in arterial walls and accelerate atherosclerotic plaque formation (Ference et al., 2022; Goldberg & Bornfeldt, 2021). In diabetes mellitus, insulin resistance and chronic hyperglycemia contribute to abnormal lipid metabolism by increasing hepatic lipoprotein production and impairing lipid clearance (Czech, 2021). The high prevalence of these abnormalities in the present study is consistent with findings from previous investigations conducted in several countries, including Saudi Arabia, Egypt, Ethiopia, Nigeria, and India (Giacco & Brownlee, 2021; Taskinen, 2022; Taskinen & Borén, 2022; Visseren et al., 2021). Hypertriglyceridemia, identified in 64.3% of patients, represents another important feature of diabetic dyslipidemia. Insulin resistance reduces the effective clearance of triglyceride-rich lipoproteins while increasing hepatic VLDL production, resulting in elevated circulating triglyceride concentrations (Forbes & Cooper, 2022; Ginsberg et al., 2021). This abnormality may further increase cardiovascular risk, particularly when associated with low HDL cholesterol (Schmidt, 2022). Reduced HDL cholesterol was the most prevalent lipid

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abnormality in this study, affecting 86.2% of patients. HDL contributes to cardiovascular protection through reverse cholesterol transport and its antioxidant and anti-inflammatory properties (Elmehdawi et al., 2021; IDF, 2022). The coexistence of low HDL cholesterol and elevated triglycerides is characteristic of diabetic dyslipidemia and is associated with altered lipoprotein metabolism resulting from insulin resistance (Elmehdawi & Albarsha, 2022; Ginsberg et al., 2021). Furthermore, diabetes can promote the formation of small, dense LDL particles, which are more susceptible to oxidation and contribute to endothelial dysfunction, inflammation, and atherosclerosis (Kahn et al., 2021; Saeedi et al., 2021). The lipid abnormalities identified in this study are broadly consistent with patterns reported in international epidemiological studies, suggesting that diabetic dyslipidemia is a common complication across different populations (Abouserwel et al., 2023; Giacco & Brownlee, 2021; Taskinen, 2022; Taskinen & Borén, 2022; Visseren et al., 2021). Inadequate glycemic control may partly explain these findings, as 70.5% of the diabetic patients reportedly had HbA1c levels above 6.4%. Previous research has linked poor glycemic control with disturbances in lipid metabolism, including increased triglycerides and LDL cholesterol and reduced HDL cholesterol (ADA PPC, 2025c; Holt et al., 2021). Nevertheless, the present findings do not establish a direct causal relationship between glycemic control and dyslipidemia. Clinically, these results emphasize the importance of regular lipid assessment and comprehensive cardiovascular risk management in patients with diabetes. Appropriate interventions include dietary modification, regular physical activity, weight management, smoking cessation, and improved glycemic control. Lipid-lowering medications, particularly statins, should be considered according to individual cardiovascular risk and applicable clinical guidelines, with additional therapies used when indicated (ADA PPC, 2025a; ADA PPC, 2025b; Del Prato et al., 2021; Eckel et al., 2021; WHO, 2025).

This study has limitations. It was conducted at a single centre with a descriptive design and without inferential statistical comparison between the diabetic and control groups, so no causal inference can be drawn. Further studies examining the relationships between glycemic control, demographic characteristics, treatment patterns, and lipid abnormalities would provide additional insight into the factors contributing to this burden.

Conclusion

The present study revealed a high prevalence of dyslipidemia among diabetic patients attending the Diabetes and Endocrinology Hospital in Tripoli, Libya. Elevated total cholesterol, LDL cholesterol, and triglyceride levels were common, while reduced HDL cholesterol was the most frequent abnormality. These findings highlight the substantial burden of diabetic dyslipidemia and its potential contribution to increased cardiovascular risk. Insulin resistance and inadequate glycemic control may contribute to these lipid disturbances. The findings emphasize the importance of routine lipid profile monitoring, effective glycemic control, lifestyle modification, and appropriate lipid-lowering therapy in diabetes management. Strengthening screening programs and patient education may help reduce cardiovascular complications among diabetic patients in Libya. Further multicenter studies are recommended to establish the wider prevalence of dyslipidemia and identify effective strategies for improving lipid control and long-term health outcomes.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

Statement of ethical approval

Ethical approval for this study was obtained from the relevant institutional review board, and the study was conducted in accordance with the Declaration of Helsinki.

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Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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