

Biochemical Alterations in Blood Glucose and Lipid Profile Among Patients with Type 2 Diabetes Mellitus in Derna City, Libya: A Case Control Study

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التغيرات الكيميائية الحيوية في نسبة جلوكوز الدم ومستويات الدهون لدى مرضى السكري من النوع الثاني في مدينة درنة، ليبيا: دراسة حالة وضبط (مقارنة)

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Abstract:

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin action, or both. Dyslipidemia is one of the most common metabolic complications associated with diabetes and is considered a major risk factor for cardiovascular disease. This study aimed to evaluate biochemical alterations in blood glucose and lipid profile among patients with type 2 diabetes mellitus and to compare the findings with those of healthy individuals. A case-control study was conducted on 120 participants recruited from the Diabetes Clinic in Derna City, Libya, comprising 60 patients diagnosed with type 2 diabetes mellitus and 60 apparently healthy controls (age range 20–80 years). Blood glucose, total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) were measured using standard enzymatic colorimetric methods on a VST-5010 photometer. Data were analyzed using SPSS with Student's t-test; $P < 0.05$ was considered statistically significant. Diabetic patients were predominantly female (65%) and most frequently in the 41–60-year age group (58.3%). Diabetic patients showed markedly higher blood glucose ($P < 0.0001$), total cholesterol (186.4 vs 166.9 mg/dL, $P = 0.02$) and triglyceride levels ($P < 0.0001$) than controls. Female diabetic patients had significantly higher total cholesterol than male diabetic patients ($P = 0.05$). No significant differences were found in HDL-C or LDL-C between diabetic and control groups. Type 2 diabetes mellitus in this population is associated with significant hyperglycemia and dyslipidemia, particularly elevated total cholesterol and triglycerides, while HDL-C and LDL-C remained largely unaffected. Routine lipid profile monitoring in

diabetic patients is recommended for early detection and prevention of cardiovascular complications.

Keywords: Type 2 diabetes mellitus; blood glucose; dyslipidemia; total cholesterol; triglycerides; HDL; LDL; Derna, Libya.

المخلص

داء السكري هو اضطراب استقلابي مزمن يتميز بارتفاع سكر الدم المستمر الناتج عن ضعف إفراز الأنسولين، أو عمل الأنسولين، أو كلاهما. يُعد اضطراب شحوم الدم أحد أكثر المضاعفات الاستقلابية شيوعاً المرتبطة بمرض السكري، ويُعتبر عامل خطر رئيسياً لأمراض القلب والأوعية الدموية. هدفت هذه الدراسة إلى تقييم التغيرات الكيميائية الحيوية في نسبة جلوكوز الدم ومستويات الدهون لدى مرضى السكري من النوع الثاني، ومقارنة النتائج مع الأفراد الأصحاء. أجريت دراسة حالة وضبط على 120 مشاركاً تم اختيارهم من عيادة السكري في مدينة درنة، ليبيا، وشملت 60 مريضاً تم تشخيص إصابتهم بداء السكري من النوع الثاني و60 فرداً ضابطاً يبدون أصحاء (تراوحت أعمارهم بين 20 و80 عاماً). تم قياس جلوكوز الدم، الكوليسترول الكلي (TC)، الدهون الثلاثية (TG)، كوليسترول البروتين الدهني عالي الكثافة (HDL-C)، وكوليسترول البروتين الدهني منخفض الكثافة (LDL-C) باستخدام الطرق اللونية الإنزيمية القياسية على مقياس ضوئي VST-5010. تم تحليل البيانات باستخدام الحزم الإحصائية للعلوم الاجتماعية (SPSS) باستخدام اختبار t للطلبة، واعتبرت قيمة ($P < 0.05$) ذات دلالة إحصائية. كان مرضى السكري في الغالب من الإناث (65%) والأكثر تكراراً في الفئة العمرية 41-60 عاماً. (58.3%) أظهر مرضى السكري مستويات أعلى بكثير من جلوكوز الدم ($P < 0.0001$)، والكوليسترول الكلي (186.4 مقابل 166.9 ملغ/ديسيلتر، $P = 0.02$)، والدهون الثلاثية ($P < 0.0001$) مقارنة بمجموعة الضبط. كانت مريضات السكري من الإناث يعانين من مستويات أعلى ملحوظة في الكوليسترول الكلي مقارنة بمرضى السكري الذكور. ($P = 0.05$) لم تُلاحظ أي فروق ذات دلالة إحصائية في مستويات كوليسترول البروتين الدهني عالي الكثافة (HDL-C) أو منخفض الكثافة (LDL-C) بين مجموعة السكري ومجموعة الضبط. يرتبط داء السكري من النوع الثاني في هذه الفئة السكانية بارتفاع سكر الدم واضطراب شحوم الدم الكبير، لا سيما ارتفاع الكوليسترول الكلي والدهون الثلاثية، بينما ظلت مستويات HDL-C و LDL-C دون تأثر يُذكر. يُوصى بالمراقبة الروتينية لملف الدهون لدى مرضى السكري للاكتشاف المبكر والوقاية من مضاعفات الأوعية الدموية القلبية.

الكلمات المفتاحية: داء السكري من النوع الثاني؛ جلوكوز الدم؛ اضطراب شحوم الدم؛ الكوليسترول الكلي؛ الدهون الثلاثية؛ البروتين الدهني عالي الكثافة (HDL)؛ البروتين الدهني منخفض الكثافة (LDL)؛ درنة، ليبيا.

Introduction

Diabetes mellitus (DM) is one of the most prevalent chronic metabolic diseases worldwide and represents a major public health challenge. The disease is characterized by chronic hyperglycemia resulting from impaired insulin secretion, insulin resistance, or both. Persistent hyperglycemia is associated with long-term damage to multiple organs, including the cardiovascular system, kidneys, retina, and peripheral nervous system.

Type 2 diabetes mellitus (T2DM) accounts for approximately 90% of all diabetes cases and is frequently associated with obesity, insulin resistance, and impaired lipid metabolism. Dyslipidemia is among the most common metabolic abnormalities observed in diabetic patients and is characterized by elevated triglycerides, increased total cholesterol, and alterations in lipoprotein concentrations. These abnormalities substantially increase the risk of atherosclerosis and cardiovascular disease, which remain the leading causes of morbidity and mortality among diabetic individuals.

Abnormal lipid metabolism in diabetes results from insulin deficiency or resistance, leading to enhanced lipolysis, increased hepatic lipid synthesis, and impaired lipoprotein metabolism. Consequently, monitoring lipid profile parameters has become an essential component of diabetes management and cardiovascular risk assessment.

Despite the growing prevalence of diabetes in Libya, limited data are available regarding biochemical changes associated with diabetes among patients in Derna City. Therefore, the present study was conducted to evaluate blood glucose and lipid profile parameters in patients with type 2 diabetes mellitus and to compare them with healthy individuals. The findings may contribute to improving the clinical management of diabetic patients and reducing the risk of cardiovascular complications.

Materials and Methods

Study Design and Participants

A case-control study was conducted to investigate biochemical alterations associated with type 2 diabetes mellitus. The study included a total of 120 participants recruited from the Diabetes Clinic in Derna City, Libya. Sixty participants had previously been diagnosed with type 2 diabetes mellitus, while sixty apparently healthy individuals served as the control group.

Participants ranged in age from 20 to 80 years. The diabetic group consisted of 21 males (35%) and 39 females (65%), whereas the control group included 27 males (45%) and 33 females (55%) (Table 1, Figure 1).

Blood Sample Collection

Venous blood samples (5 mL) were collected under aseptic conditions using sterile disposable syringes. Approximately 1 mL of blood was transferred into fluoride-oxalate tubes for blood glucose determination, while the remaining 4 mL were collected into plain tubes for serum separation.

Samples were centrifuged at 4000 rpm for 10 minutes, and the obtained serum was transferred into sterile Eppendorf tubes (2 mL) and stored until biochemical analysis. Blood glucose analysis was performed immediately after sample collection.

Biochemical Analysis

Serum biochemical parameters were measured using standard commercial diagnostic kits (Crescent Diagnostics) and a VST-5010 photometer at a wavelength of 505 nm (546 nm for glucose).

The following biochemical parameters were determined: blood glucose, total cholesterol (TC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C). Low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula: $LDL-C = Total\ cholesterol - (TG/5) - HDL-C$.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS). Data are presented as mean $\pm$ standard deviation (SD) / mean $\pm$ standard error of the mean (SEM). Comparisons between diabetic patients and healthy controls, as well as between males and females, were carried out using Student's t-test. Statistical significance was accepted at $P < 0.05$.

Results

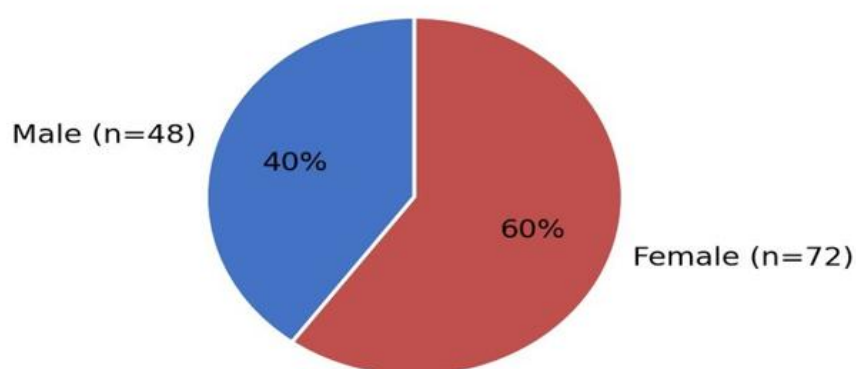
Participant Characteristics

A total of 120 participants were enrolled in this study, including 60 patients with type 2 diabetes mellitus and 60 healthy controls. Overall, females represented 60% ($n = 72$) and males 40% ($n = 48$) of the total study sample (Figure 1). Females represented the majority of diabetic participants (65%), whereas males accounted for 35%. In the control group, females represented 55% and males 45% (Table 1).

Table 1. Distribution of study participants by sex and group

Group	Male (n)	Male (%)	Female (n)	Female (%)	Total
Diabetic group	21	35.0	39	65.0	60
Normal (control) group	27	45.0	33	55.0	60
Total	48	40.0	72	60.0	120

1. Sex distribution of the total study sample (n =

**Figure 1.** Sex distribution of the total study sample (n = 120)

The largest proportion of diabetic patients belonged to the 41–60-year age group (58.3%), followed by participants older than 60 years (33.3%), whereas only 8.3% were between 20 and 40 years of age. In contrast, the largest proportion of the control group belonged to the 20–40-year age group (48.3%) (Table 2).

Table 2. Distribution of study participants by age group

Age group (years)	Normal group (n)	Normal group (%)	Diabetic group (n)	Diabetic group (%)
20–40	29	48.33	5	8.33
41–60	23	38.33	35	58.33
> 60	8	13.33	20	33.33
Total	60	100	60	100

Blood Glucose Levels

Diabetic patients exhibited markedly higher blood glucose concentrations than healthy controls in both sexes (males: 178.85 vs 100.02 mg/dL; females: 166.53 vs 95.78 mg/dL). Statistical analysis demonstrated a highly significant difference between the two groups ($P < 0.0001$), confirming persistent hyperglycemia among diabetic participants (Table 3, Figure 2).

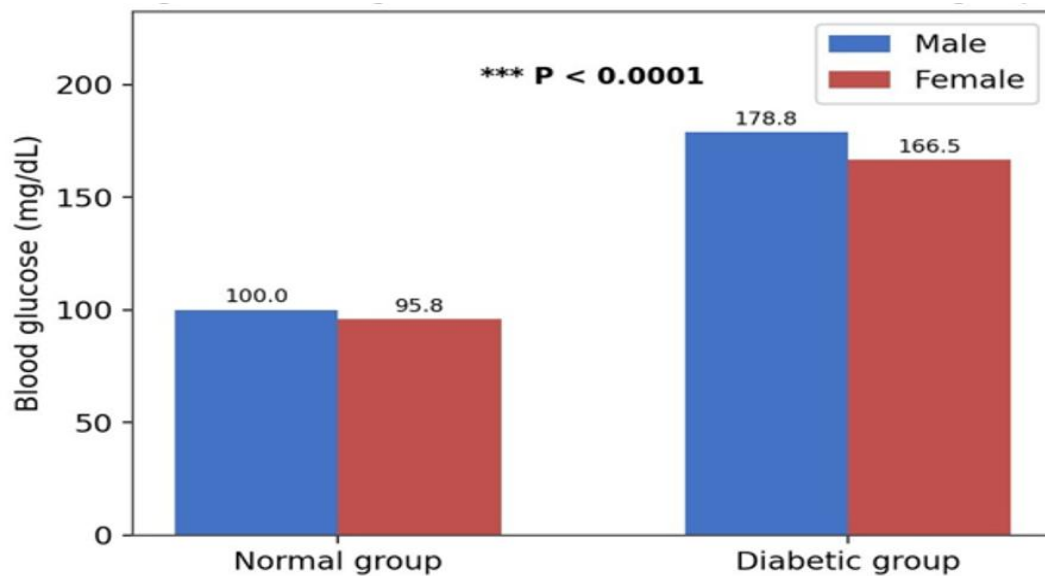


Figure 2. Blood glucose levels in diabetic and normal groups by sex

Total Cholesterol

Serum total cholesterol concentrations were significantly higher in diabetic patients (186.4 mg/dL overall) than in healthy controls (166.9 mg/dL overall) ($P = 0.02$). Female diabetic patients also demonstrated significantly higher cholesterol concentrations (196.5 mg/dL) than diabetic males (173.4 mg/dL) ($P = 0.05$) (Table 3, Figure 3).

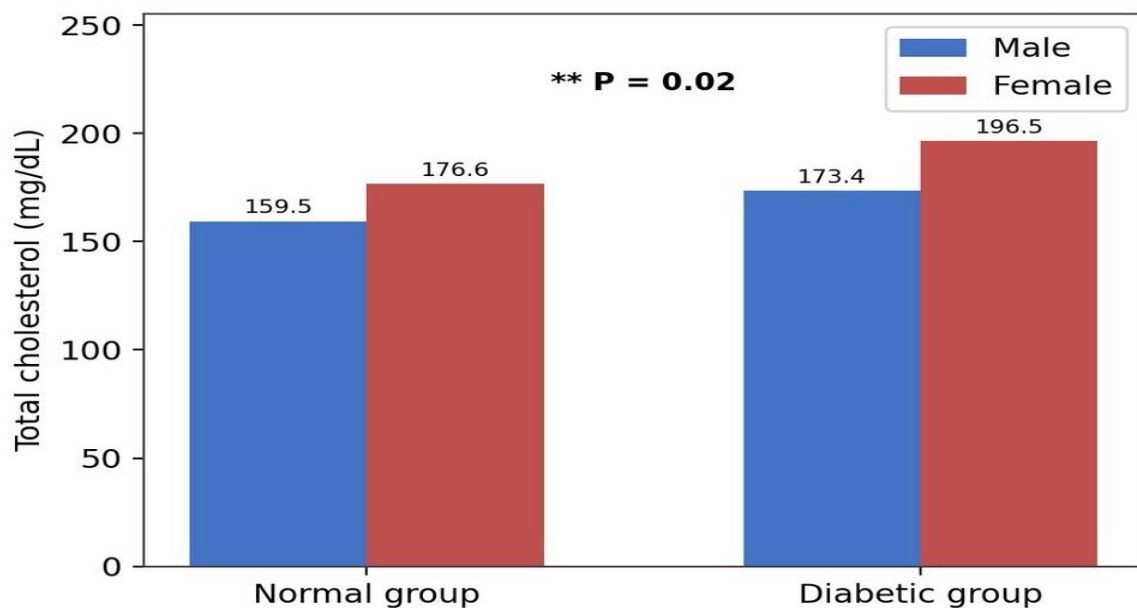


Figure 3. Total cholesterol levels in diabetic and normal groups by sex

HDL-C and LDL-C

No statistically significant differences were observed in HDL-C or LDL-C concentrations between diabetic patients and healthy controls (Table 3, Figures 4 and 5). These findings indicate that, in the studied population, diabetes mainly affected total cholesterol and triglycerides rather than HDL-C or LDL-C.

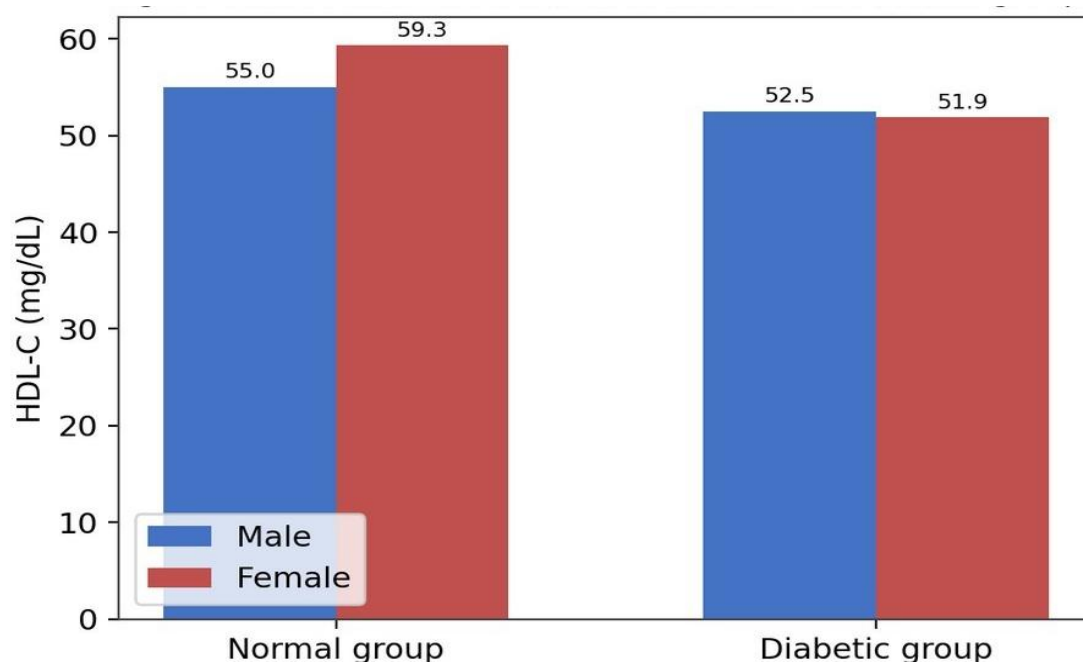


Figure 4. HDL-cholesterol levels in diabetic and normal groups by sex

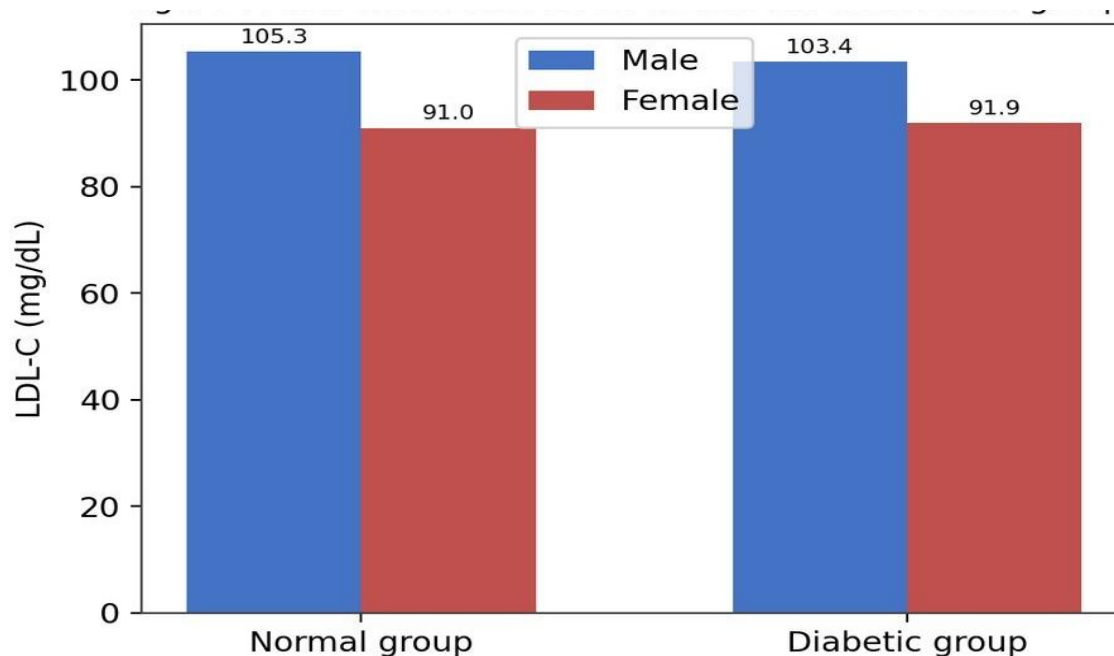


Figure 5. LDL-cholesterol levels in diabetic and normal groups by sex

Triglycerides

Triglyceride concentrations were significantly elevated in diabetic patients compared with healthy individuals in both sexes ($P < 0.0001$), reflecting impaired lipid metabolism associated with diabetes mellitus (Table 3, Figure 6).

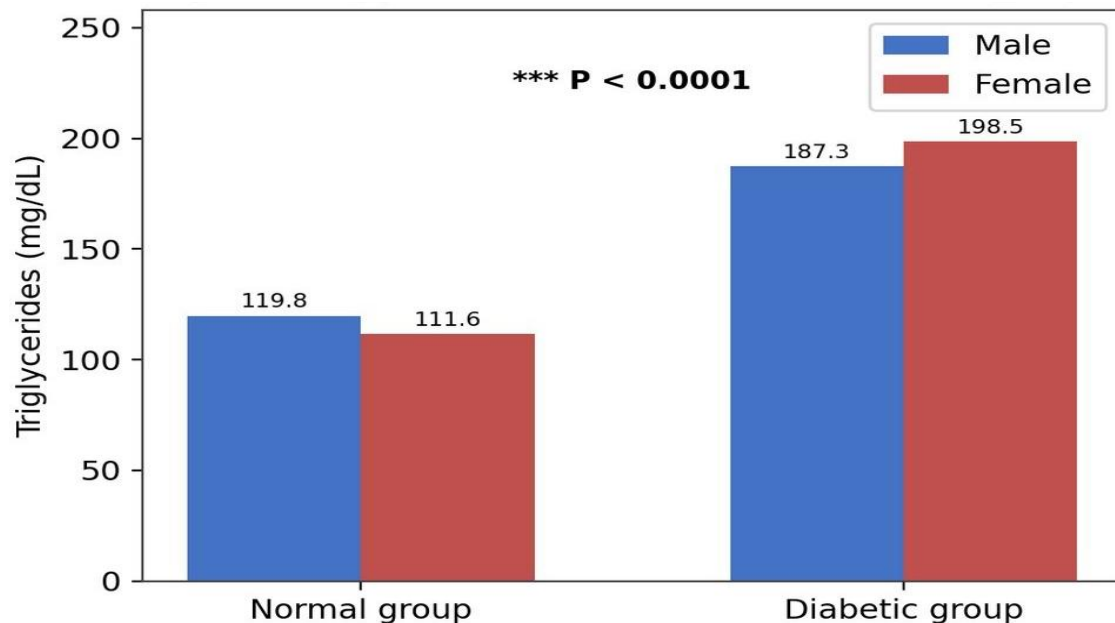


Figure 6. Triglyceride levels in diabetic and normal groups by sex

Table 3. Mean biochemical parameters by sex in the normal and diabetic groups

Biochemical parameter	Normal Male	Normal Female	Diabetic Male	Diabetic Female
Glucose (mg/dL)	100.02	95.78	178.85	166.53
Total cholesterol (mg/dL)	159.5	176.6	173.4	196.5
HDL-C (mg/dL)	55.02	59.33	52.51	51.88
LDL-C (mg/dL)	105.3	91.0	103.4	91.92
Triglycerides (mg/dL)	119.8	111.6	187.3	198.5

HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TG, triglycerides.

Discussion

The present study investigated alterations in blood glucose and lipid profile among patients with type 2 diabetes mellitus in Derna City, Libya. The findings demonstrated significant hyperglycemia accompanied by abnormalities in lipid metabolism, particularly elevated total cholesterol and triglyceride concentrations.

The significantly higher blood glucose levels observed in diabetic patients compared with healthy controls are consistent with the metabolic characteristics of diabetes mellitus. Chronic hyperglycemia results primarily from impaired insulin secretion, insulin resistance, or both,

leading to reduced cellular glucose uptake and persistent elevation of circulating glucose concentrations. These findings agree with recent epidemiological and clinical reports confirming that diabetic patients consistently exhibit significantly higher blood glucose levels than healthy individuals (American Diabetes Association, 2025; International Diabetes Federation, 2025).

The present study also demonstrated a significant increase in serum total cholesterol among diabetic patients. Dyslipidemia is a common metabolic disorder associated with type 2 diabetes mellitus and contributes substantially to the development of cardiovascular disease. Insulin resistance alters hepatic lipid metabolism, resulting in increased cholesterol synthesis and impaired lipoprotein clearance. These findings are consistent with recent reviews describing elevated total cholesterol concentrations in patients with diabetes mellitus (Wu & Parhofer, 2023; Goldberg, 2022).

Serum triglyceride concentrations were also significantly elevated in diabetic patients. Hypertriglyceridemia is frequently associated with insulin resistance because reduced insulin activity enhances lipolysis and increases hepatic production of triglyceride-rich lipoproteins. Persistent elevation of triglycerides is considered an important predictor of cardiovascular complications in diabetic patients, a finding corroborated by contemporary cardiometabolic guidelines (Cosentino et al., 2023; Schofield et al., 2022).

Unlike glucose, total cholesterol, and triglycerides, HDL-C and LDL-C concentrations did not differ significantly between diabetic patients and healthy controls in the present study. Although many previous studies have reported alterations in HDL-C and LDL-C among diabetic patients, the absence of significant differences in the current study may be related to characteristics of the study population, sample size, disease duration, lifestyle factors, or ongoing treatment (Ference et al., 2023).

An additional finding of this study was the significantly higher total cholesterol concentration observed among female diabetic patients compared with diabetic males. This difference may reflect sex-related variation in lipid metabolism, possibly linked to hormonal influences on hepatic lipoprotein synthesis; however, a mechanistic analysis was beyond the scope of the present study.

Overall, the present findings indicate that disturbances in glucose metabolism are accompanied by abnormalities in lipid metabolism among patients with type 2 diabetes mellitus, emphasizing the importance of regular biochemical monitoring to reduce the risk of long-term cardiovascular complications.

Conclusion

Patients with type 2 diabetes mellitus in Derna City exhibited significantly higher blood glucose, total cholesterol, and triglyceride levels than healthy controls. However, no statistically significant differences were observed in HDL-C or LDL-C concentrations between the two groups. Female diabetic patients demonstrated higher total cholesterol concentrations than diabetic males. These findings highlight the importance of routine assessment of both glycemic status and lipid profile for early identification of metabolic abnormalities and prevention of diabetes-related cardiovascular complications.

Recommendations

- Diabetic patients should be educated about the disease and its management, including adherence to diet, physical activity, and prescribed treatment, as patient awareness is fundamental to effective glycemic control.
- The absence of overt symptoms of hyperglycemia should not be relied upon as an indicator of adequate glycemic control, since symptoms typically appear only once blood glucose reaches markedly elevated levels.

- Periodic monitoring of blood glucose and glycated hemoglobin (HbA1c) using appropriate and sensitive methods is recommended for all diabetic patients.
- Regular physical activity, such as 30 minutes of daily walking or 15 minutes of light exercise, is recommended to help lower blood glucose levels.
- Health authorities should establish dedicated diabetes clinics and ensure the availability of HbA1c testing at all primary health centers, given its importance for long-term glycemic monitoring.
- Medical laboratory departments should be provided with HbA1c reagents together with updated scientific references to support ongoing research on diabetes and its complications.

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Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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