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*Original article*

# Dyslipidemia among Children and Adolescents with Type 1 Diabetes Mellitus in Tripoli University Hospital

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**Abstract**
Diabetes is a major risk factor for cardiovascular disease (CVD). In patients with type 1 diabetes mellitus (T1DM), atherosclerosis tends to occur earlier in life, leading to increased morbidity and mortality compared with the general population. This study aimed to describe the frequency and pattern of dyslipidemia in children and adolescents with T1DM, and its relation to glycemic control, physical activity, and duration of diabetes in Tripoli, Libya. This case-control study included 131 children and adolescents with T1DM, recruited from the diabetic clinic as the case group, and 71 healthy age- and sex-matched children and adolescents from the casualty department as the control group, all from Tripoli University Hospital. Participants underwent full history taking, clinical examination, and laboratory investigations including glycosylated hemoglobin, fasting lipid profile (triglycerides [TG], low-density lipoprotein cholesterol [LDL-C], high-density lipoprotein cholesterol [HDL-C], and total cholesterol [TC]), as well as liver enzymes. There was a statistically significant increase in the frequency of dyslipidemia among diabetic patients (40.46%). The most common type of dyslipidemia was hypertriglyceridemia (26%), followed by hypercholesterolemia (21.4%), elevated LDL-C (13%), and low HDL-C (7.6%). Interestingly, low HDL-C was slightly more frequent in the control group (8.5% vs. 7.6%). The results suggest that dyslipidemia is more common in patients with poor glycemic control, which may play a major role in the development of cardiovascular disease in this population. This study recommends that patients with T1DM undergo routine lipid profile screening, with early intervention and management to reduce long-term cardiovascular risk.
**Keywords.** Lipid Profile, Type 1 Diabetes Mellitus, Children, Dyslipidemia.

## Introduction

Hyperglycemia and dyslipidemia are metabolic abnormalities commonly found in young patients with type 1 diabetes mellitus (T1DM), and both increase the risk of cardiovascular disease (CVD) [1,2]. In patients with T1DM, atherosclerosis can occur earlier in life, leading to significantly increased morbidity and mortality compared with the general population [3,4]. Many studies have demonstrated that serum lipid abnormalities in children with T1DM are associated with raised glycosylated hemoglobin (HbA1c) and serum lipid levels [5,6]. Dyslipidemia is a preventable risk factor for CVD. Screening for dyslipidemia should be performed shortly after diagnosis when diabetes has stabilized in all children with T1DM aged >10 years, and if normal results are obtained, this should be repeated every 5 years. If there is a family history of hypercholesterolemia, early CVD, or if the family history is unknown, screening should begin as early as 2 years of age [3,7]. The increase of fatty acids in the plasma associated with insulin deficiency also encourages liver transformation of some of the fatty acids into phospholipids and cholesterol, two of the major products of fat metabolism. These two components, along with excess triglycerides produced at the same time in the liver, are then released into the blood in the lipoproteins. Occasionally, the plasma lipoproteins increased as much as threefold in the deficiency of insulin, giving a total concentration of plasma lipids of several percent instead of the normal 0.6 %. This high concentration of lipid, particularly the high concentration of cholesterol, promotes the development of atherosclerosis in individuals with serious diabetes [8]. The abnormalities of lipid metabolism in diabetes mellitus are accelerated by lipid catabolism, with increased formation of ketone bodies and decreased synthesis of fatty acids and triglycerides. A recent study reported that insulin elevates the number of LDL receptors, so chronic insulin lack might be associated with a reduced level of LDL receptors. In these cases, the increase in LDL particles results in an increase in LDL cholesterol value in diabetes mellitus [9].

T1DM is the most prevalent chronic endocrine disease in children and adolescents [2]. Incidence in Libya appears to be rising, with a higher rate in the 0-4- and 5-9-year age groups [10]**.** Individuals with T1DM are at increased risk of cardiovascular events and are ten times more likely to die of heart disease than the general population [11]. Children with T1DM may present with subclinical cardiovascular changes, such as increases in carotid intima-media thickness [12].

Dyslipidemia is an important factor in atherosclerosis. Although reported prevalence in children and adolescents varies, some studies have indicated that 50% of the individuals with dyslipidemia experience lipid profile alterations [13]. In addition to being an important factor in the establishment of macrovascular disease and cardiovascular risk, dyslipidemia also affects microvascular disease. Dyslipidemia is a predictor of poorer outcomes in patients with T1DM and a history of kidney disease. Development of proliferative diabetic retinopathy (PDR) may also be correlated with hypercholesterolemia [14]. Many lipid profile


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anomalies have been described in children with T1DM [13]. The main findings were high levels of total (TC) and low-density lipoprotein cholesterol (LDL-C), as well as low levels of high-density lipoprotein cholesterol (HDL-C) [4,12,13].

Inadequate glycemic control has been associated with increased prevalence of hypercholesterolemia in children and adolescents with T1DM. Patients with a high body mass index (BMI) also presented with lipid anomalies more frequently. Metabolic syndrome is becoming a more prevalent finding in children, a trend also observed in children and adolescents with T1DM [12,13]. Screening for dyslipidemia must be performed soon after the diagnosis of T1DM (when diabetes is stabilized) in every child aged 10 years and older. If normal results are found (Table 1), screening tests must be repeated every five years. In individuals with a family history of hypercholesterolemia, early cardiovascular disease (CVD), or an unknown family history, screening tests must be initiated at the age of two years. If LDLC is above 130 mg/dL, lifestyle changes must be introduced. If these interventions fail to decrease LDL-C to levels below 130 mg/dL and if the patient presents one or more risk factors for CVD, statins must be started in patients aged 10 years and older [3,4]. According to the National Heart, Lung, and Blood Institute (NHLBI, 2011), statins must be initiated if LDL-C is above 190 mg/dL or if it is in the 160-189 mg/dL range for patients with a positive family history of disease or with one or more high-risk factors; diabetes mellitus is a high-risk factor for CVD. This study seeks to determine the prevalence of dyslipidemia among children and adolescents with type 1 diabetes mellitus (T1DM) and to examine its association with clinical and lifestyle factors, including glycemic control and duration of disease. It further aims to identify risk factors contributing to dyslipidemia and to characterize the specific lipid abnormalities most frequently observed, such as changes in total cholesterol, triglycerides, LDL-C, and HDL-C.

***Table 1. Serum lipid, lipoprotein, and apolipoproteína levels were rated as acceptable, borderline-high, or high for children and adolescents (NHLBI, 2011).***

| Levels | Acceptable | Borderline-high | High |
|---|---|---|---|
| TC (mg/dL) | <170 | 170-199 | ≥200 |
| LDL-C (mg/dL) | <110 | 110-129 | ≥130 |
| HDL-C (mg/dL) | ≥45 | 40-44 | <40 |
| TG (mg/dL) | | | |
| 0-9 years | <75 | 75-99 | ≥100 |
| 10-19 years | <90 | 90-129 | ≥130 |

*Note: TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; TG, triglycerides.*

## Methods

### *Study Design*

This was a case-control, hospital-based study conducted over a six-month period, from March to August 2024.

### *Study Population*

The study subjects were Libyan children and young adults recruited from Tripoli University Hospital, specifically the Endocrine Outpatient Clinic and the casualty department. A total of 202 participants were included: 131 patients with type 1 diabetes mellitus (T1DM) and 71 healthy controls matched for age and sex. The participants were drawn from different cities across Libya.

### *Inclusion and Exclusion Criteria*

Eligible patients were children and young adults aged 8 to 23 years who attended follow-up visits at the referral clinic. Exclusion criteria included congenital anomalies and the use of lipid-lowering medications.

### *Data Collection*

Data were collected using a standardized questionnaire. This included personal information (name, age, gender), developmental history (schooling and exercise), diabetes-related variables (duration of diabetes and insulin dose), and family history of diabetes mellitus, celiac disease, thyroid disorders, and renal disease. Clinical examination findings and laboratory investigations were also recorded.

### *Investigations*

Laboratory tests included glycosylated hemoglobin (HbA1c), fasting lipid profile (total cholesterol [TC], triglycerides [TG], low-density lipoprotein cholesterol [LDL-C], and high-density lipoprotein cholesterol [HDL-C]), and liver enzymes.


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### *Ethical Approval and Patient Consent*

Ethical approval for the study was obtained from the Research Ethics Committee of Tripoli University Hospital. Written informed consent was obtained from all participants or their legal guardians prior to enrollment in the study.

### *Statistical Analysis*

Data were analyzed using appropriate statistical methods. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using chi-square tests for categorical variables and t-tests for continuous variables. A p-value of less than 0.05 was considered statistically significant.

## Results

This study was a hospital-based, cross-sectional investigation designed to compare hemoglobin A1c, lipid profile concentrations, and liver enzyme levels between diabetic patients and healthy controls. The analysis was performed to determine whether significant differences exist between the two groups.

A total of 202 children and young adolescents were enrolled, including 131 patients with type 1 diabetes mellitus (T1DM) and 71 age- and sex-matched healthy controls. Data were collected from both diabetic patients and control subjects attending the Tripoli University Hospital diabetic clinic and casualty department. Participants were recruited from different cities across Libya.

### *Comparison of Age and Gender*

Table 2 demonstrates that there were highly statistically significant differences between cases and controls with respect to age and gender ($p < 0.001$ for both variables).

***Table 2. Comparison between patients and controls regarding Age and Gender.***

| Variables | | Patient (N=131) | Control (N=71) | P-value |
|---|---|---|---|---|
| Age (years) | Mean±S.D | 14.89±2.69 | 11.92±2.34 | 0.000** |
| Gender | Male | 45(34.4%) | 41(57.7%) | 0.001** |
| | Female | 86(65.6%) | 30(42.3%) | |

### *Comparison between patients and controls according to dyslipidemia*

There was a statistically significant difference in the frequency of dyslipidemia group in children and adolescents with (T1DM), 53 (40.46%), compared to 21 (29.58%) of the nondiabetic control group (p= 0.001) (Table 3 & Figure 5).

***Table 3. Comparison between patients and controls according to dyslipidemia***

| Dyslipidemia | Patient | | Control | | P-value |
|---|---|---|---|---|---|
| | N | % | N | % | |
| Yes | 53 | 40.46 | 21 | 29.58 | 0.001 |
| No | 78 | 59.54 | 50 | 70.42 | |

### *Comparison between patients and controls as regards fasting lipid profile*

All serum lipids were significantly higher in diabetic patients compared to non-diabetic controls, as shown in (Table 4). The cholesterol mean level value in diabetic patients was highly significantly higher than the mean serum cholesterol of non-diabetic control subjects (P= 0.005). Mean value of triglycerides in diabetic patients was highly significantly (p=0.001) increased compared to the mean of non-diabetic control subjects. LDL-Cholesterol mean value in diabetic patients was statistically significantly (p=0.042) higher than the mean value of non-diabetic control subjects. Serum HDL-Cholesterol mean value was significantly (p=0.006) higher in diabetic patients compared to the mean of non-diabetic control subjects.

***Table 4. Comparison between patients and controls as regards fasting lipid profile***

| Lipid Profile | | Patient (N=131) | Control (N=71) | P-value |
|---|---|---|---|---|
| TC (mg/dl) | Mean±S.D | 169.54±43.70 | 154.40±30.83 | 0.005** |
| | Range | 74.0-381.7 | 96.0-239.7 | |
| TG (mg/dl) | Mean±S.D | 116.57±82.48 | 87.37±41.51 | 0.001** |
| | Range | 37.0-558.0 | 29.0-281.8 | |
| HDL-C (mg/dl) | Mean±S.D | 58.73±16.16 | 53.3±13.94 | 0.026* |
| | Range | 20.8-134.0 | 31.0-102.0 | |
| LDL-C (mg/dl) | Mean±S.D | 91.46±34.98 | 82.46±26.70 | 0.042* |
| | Range | 15.0-240.0 | 28.0-165.0 | |

**Significant, **Highly significant.*


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***Comparison between patients and control as regard the pattern of dyslipidemia***

Regarding the abnormal lipid profile concentration in the study, our study groups showed: 34 patients (26%) of the patients had elevated TG levels (TG ≥100mg/dl in age group 0-9 years and TG ≥130 mg/dl in age group10-19 years), 28 patients (21.4%) had elevated TC levels (TC ≥ 200 mg/dl), 17 patients (13.0%) had elevated LDL-C levels (LDL-C ≥130mg/dl), and 10 (7.6%) had low HDL-C levels (< 40 mg/dl in males &<50 mg/dl in females). Compared with 8 patients (11.3%), 8 patients (11.3%), 7 patients (9.9%), and 6 patients (8.5%) of the control group, respectively (Table 5 &Figure 6).

***Table 5. Comparison between patients and control as regard the pattern of dyslipidemia***

| Lipids | Patient (N=131) | | Control (N=71) | |
|---|---|---|---|---|
| | N | % | N | % |
| ↑TC (mg/dl) | 28 | 21.4 | 6 | 8.5 |
| ↑TG (mg/dl) | 34 | 26.0 | 8 | 11.3 |
| ↓HDL-C (mg/dl) | 10 | 7.6 | 8 | 11.3 |
| ↑LDL-C (mg/dl) | 17 | 13.0 | 7 | 9.9 |

***Comparison between patients and control regards high lipid profile***

As in (Table 6), there were no statistically significant differences as regards the value of high fasting lipid profile between the cases and controls.

***Table 6. Comparison between patients and control regards high lipid profile***

| Lipid profile | Patient (N=131) | Control (N=71) | P-value |
|---|---|---|---|
| ↑TC (mg/dl) | | | |
| Mean ±SD | 229.1±43.2 | 223.3±13.3 | 0.749 |
| Range | 191.0-381.7 | 209.0-239.7 | |
| ↑TG (mg/dl) | | | |
| Mean ±SD | 222.4±96.9 | 172.3±55.4 | 0.169 |
| Range | 131.0-558.0 | 134.0-281.8 | |
| ↓HDL-C (mg/dl) | | | |
| Mean ±SD | 33.7±6.5 | 35.32±2.93 | 0.525 |
| Range | 20.8-39.0 | 31.0-38.9 | |
| ↑LDL-C (mg/dl) | | | |
| Mean ±SD | 154.7±27.3 | 130.2±24.4 | 0.052 |
| Range | 130.0-240.0 | 100.8-165.0 | |

***Date of diagnosis, duration of diabetes, insulin dose, any associated illness, and treatment other than insulin among diabetic patients***

Regarding the date of diagnosis of diabetes, the mean duration since diagnosis was 5.40 ± 4.2 years. The mean duration of diabetes mellitus overall was 9.54 ± 3.6 years. The mean daily insulin dose was 1.0 ± 0.20 units/kg. With respect to associated illnesses, the majority of patients (121; 92.4%) had no comorbid conditions. However, 7 patients (5.3%) were diagnosed with celiac disease, and 3 patients (2.3%) had hypothyroidism. In terms of treatment, 121 patients (92.4%) were managed with insulin alone, 7 patients (5.3%) were receiving metformin in addition to insulin, and 3 patients (2.3%) were on levothyroxine for hypothyroidism.

***Table 7. Date of diagnosis, duration of diabetes, insulin dose, any associated illness, and treatment other than insulin among diabetic patients***

| Patient (N=131) | | |
|---|---|---|
| Date of Diagnosis | Mean±S.D | 5.40±4.2 |
| | Range | 1-19 |
| Duration of DM | Mean±S.D | 9.54±3.6 |
| | Range | 1-18 |
| Insulin dose IU/Kg/day | Mean±S.D | 1±0.20 |
| | Range | 0.8-1.8 |
| Any associated illness | No | 121(92.4%) |
| | Celiac disease | 7(5.3%) |
| | Hypothyroidisms | 3(2.3%) |
| Treatment other than insulin | No | 121(92.4%) |
| | Metformin | 7(5.3%) |
| | Levothyroxine | 3(2.3%) |
| Family history | DM | 14(10.7%) |


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***Comparison between patients and controls regarding HbA1c, BMI, Blood pressure, Diet history, and physical activity***

There was a statistically significant difference in frequency of HbA1c and BMI (P= 0.000, 0.002), and a statistically significant difference in diet history (P= 0.046) between patients and controls (Table 8).

***Table 8. Comparison between patients and controls regarding HbA1c, BMI, Blood pressure, Diet history, and physical activity***

| Variables | | Patient (N=131) | Control (N=71) | P-value |
|---|---|---|---|---|
| HA1c | Mean±S.D | 9.67±2.46 | 5.27±0.38 | 0.000** |
| | Range | 5.7-16.0 | 4.0-5.9 | |
| BMI | Mean±S.D | 22.07±4.42 | 20.32±3.52 | 0.002** |
| | Range | 13.0-35.8 | 11.3-30.6 | |
| Blood pressure | Normal | 130(99.2%) | 71(100%) | 0.463 |
| | Abnormal | 1(0.8%) | 0(0%) | |
| Diet history | Regular | 120(91.6%) | 70(98.6%) | 0.045* |
| | Irregular | 11(8.4%) | 1(1.4%) | |
| Physical activity | Do sports | 121(92.4) | 70(98.6%) | 0.063 |
| | Don't sport | 10(7.6%) | 1(1.4%) | |

***Comparison between dyslipidemic and normolipidemic diabetic female patients***

As shown in Table 9, the mean age of dyslipidemic diabetic females was 14.7 ± 2.1 years, compared with 15.2 ± 3.0 years in normolipidemic females; the difference was not statistically significant (p = 0.422). The number of dyslipidemic females was 34 (39.5%), compared with 52 (60.5%) normolipidemic females, and this difference was statistically significant (p = 0.000).

Regarding the age of onset of diabetes, the mean ± SD in the dyslipidemic group was 4.8 ± 3.7 years, compared with 5.7 ± 4.5 years in the normolipidemic group; the difference was not significant (p = 0.316). The mean duration of diabetes mellitus was 9.7 ± 3.4 years in the dyslipidemic group and 9.8 ± 3.5 years in the normolipidemic group, with no significant difference (p = 0.864).

For insulin dose, the mean ± SD was 1.27 ± 0.26 units/kg in the dyslipidemic group compared with 1.08 ± 0.29 units/kg in the normolipidemic group, and this difference was statistically significant (p = 0.384). Finally, the mean HbA1c level was 9.7 ± 2.2% in the dyslipidemic group compared with 9.3 ± 2.3% in the normolipidemic group; the difference was not statistically significant (p = 0.448).

***Table 9. Comparison between dyslipidemic and normolipidemic daibetic female patients***

| Anthropometry | Dyslipidemic (n=34) | Normolipidemic (n=52) | p-value |
|---|---|---|---|
| | Mean±SD | Mean±SD | |
| Age (yr) | 14.7±2.1 | 15.2±3.0 | 0.422 |
| Female gender | 34 (39.5%) | 52 (60.5%) | 0.000* |
| Age at onset of DM (yr) | 4.8±3.7 | 5.7±4.5 | 0.316 |
| Duration of DM (yr) | 9.7±3.4 | 9.8±3.5 | 0.864 |
| Insulin dose (IU/kg/day) | 1.27±0.26 | 1.08±0.29 | 0.003* |
| HbA1c | 9.7±2.2 | 9.3±2.3 | 0.448 |

*t-test, p≥0.05*

***Comparison between dyslipidemic diabetic males and females according to the pattern of dyslipidemia***

Table 10 presents the distribution of abnormal lipid profile concentrations among the study groups. Elevated total cholesterol (TC) was observed in 8 dyslipidemic males (6.1%) compared with 20 dyslipidemic females (15.3%), with no statistically significant difference (p = 0.888). Elevated triglyceride (TG) levels were found in 16 males (12.2%) and 18 females (13.7%), also without statistical significance (p = 0.365). Elevated low-density lipoprotein cholesterol (LDL-C) was detected in 5 males (3.8%) compared with 12 females (9.2%), with no significant difference (p = 0.352). Reduced high-density lipoprotein cholesterol (HDL-C) was reported in 4 males (3.1%) and 6 females (4.6%), again showing no statistically significant difference (p = 0.089).

***Table 10. Comparison between dyslipidemic diabetic males and females according to the pattern of dyslipidemia***

| Lipid | Male N (%) | Female N (%) | P- value |
|---|---|---|---|
| TC | 8 (6.1) | 20 (15.3) | 0.888 |
| TG | 16(12.2) | 18 (13.7) | 0.365 |
| LDL | 5 (3.8) | 12 (9.2) | 0.352 |
| HDL | 4 (3.1) | 6 (4.6) | 0.089 |


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***Comparison between dyslipidemic and normolipidemic groups according to age, gender, age of onset of diabetes, duration of diabetes, insulin dose, and HbA1C***

As shown in (Table 11), the mean age of dyslipidemic and normolipidemic diabetic groups was 14.9 ±2.4 14.9 ±2.9 respectively, and the P value =0.976, which is insignificant.

Dyslipidemic diabetic females were 34 (64.2%), and normolipidemic females were 52 (66.7%), and P-value = 0.000, where significant. Dyslipidemic diabetic males were 19 (35.9%), and normolipidemic males were 26 (33.3%), with P value =0.853. which are insignificant.

The mean of diabetic duration was in the dyslipidemic group (9.7±3.6), and in the normolipidemic group (9.4±3.5), with p value = 0.640, which is insignificant.

The mean insulin dose was higher in the dyslipidemic group than in the normolipidemic group, p-value = 0.45.

The mean HbA1c of the dyslipidemic group was higher than that of the normolipidemic group (10.2±2.5, 9.4±2.4) respectively, but non-significant P= 0.071.

***Table 11. Comparison between dyslipidemic and normolipidemic groups according to age, gender, age of onset of diabetes, duration of diabetes, insulin dose, and HbA1C:***

| **Anthropometry** | | **Dyslipidemic (n=53)** | **Normolipidemic (n=78)** | **p-value** |
|---|---|---|---|---|
| | | **Mean±SD** | **Mean±SD** | |
| Age (yr) | | 14.9±2.4 | 14.9±2.9 | 0.976 |
| Gender | Male | 19 (35.9%) | 26 (33.3%) | 0.853 |
| | Female | 34 (64.2%) | 52 (66.7%) | <0.001 |
| Age at onset of DM (yr) | | 5.0±4.0 | 5.7±4.3 | 0.367 |
| Duration of DM (yr) | | 9.7±3.6 | 9.4±3.5 | 0.640 |
| Insulin dose (IU/kg/day) | | 1.04 ±0.22 | 0.98±0.18 | 0.06 |
| HbA1c | | 10.2±2.5 | 9.4±2.4 | 0.071 |

***Correlation between A1c, Lipid profile and Duration of Disease***

Table 12 shows the correlation analyses between hemoglobin A1c (HbA1c), lipid parameters, and duration of diabetes. HbA1c was positively correlated with serum cholesterol (r = 0.358), triglycerides (r = 0.158), LDL-C (r = 0.325), and HDL-C (r = 0.213). Further correlation analyses revealed that serum cholesterol was positively correlated with triglycerides (r = 0.207), LDL-C (r = 0.722), and HDL-C (r = 0.355). Triglycerides showed a weak negative correlation with LDL-C (r = –0.080) and a weak positive correlation with HDL-C (r = 0.109). Additional analyses between HbA1c, cholesterol, triglycerides, LDL-C, HDL-C, and duration of diabetes demonstrated statistically positive correlations with cholesterol (r = 0.009), triglycerides (r = 0.001), LDL-C (r = 0.138), and duration of diabetes (r = 0.214). In contrast, a statistically significant negative correlation was observed between duration of diabetes and HDL-C (r = –0.141).

***Table 12. Correlation between A1c, duration of diabetes mellitus and Lipid profile:***

| ***Variables*** | | ***Duration of DM (yr)*** | ***A1c*** | ***Cholesterol*** | ***Triglyceride*** | ***HDL-C*** | ***LDL-C*** |
|---|---|---|---|---|---|---|---|
| Duration of DM (yr) | Pearson Correlation | 1 | 0.009 | 0.001 | 0.138 | -0.141- | 0.214 |
| | p-value | | 0.947 | 0.997 | 0.325 | 0.312 | 0.123 |
| A1c | Pearson Correlation | 0.009 | 1 | 0.358** | 0.158 | 0.213 | 0.325* |
| | p-value | 0.947 | | 0.009 | 0.257 | 0.125 | 0.018 |
| Cholesterol | Pearson Correlation | 0.001 | 0.358** | 1 | 0.207 | 0.355** | 0.722** |
| | p-value | 0.997 | 0.009 | | 0.138 | 0.009 | 0.000 |
| Triglyceride | Pearson Correlation | 0.138 | 0.158 | 0.207 | 1 | 0.109 | -0.080- |
| | p-value | 0.325 | 0.257 | 0.138 | | 0.439 | 0.568 |
| HDL-C | Pearson Correlation | -0.141- | 0.213 | 0.355** | 0.109 | 1 | -0.021- |
| | p-value | 0.312 | 0.125 | 0.009 | 0.439 | | 0.882 |
| LDL-C | Pearson Correlation | 0.214 | 0.325* | 0.722** | -0.080- | -0.021- | 1 |
| | p-value | 0.123 | 0.018 | 0.000 | 0.568 | 0.882 | |

***. Correlation is significant at the 0.01 level.*
**. Correlation is significant at the 0.05 level.*


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## Discussion

In this case-control study, hemoglobin A1c (HbA1c), liver enzymes (AST, ALT), and fasting lipid profile—including serum total cholesterol (TC), triglycerides (TG), HDL-C, and LDL-C—were measured in 131 children and adolescents with type 1 diabetes mellitus (T1DM) attending the pediatric outpatient clinic of Tripoli University Hospital. As shown in Table 2, the mean age of the diabetic group was 14.89 ± 2.69 years, whereas the non-diabetic control group had a mean age of 11.92 ± 2.35 years. In the current study, Table 3 and Figure 1 demonstrate a significantly higher prevalence of dyslipidemia among children and adolescents with T1DM (53 patients; 40.46%) compared with the non-diabetic control group (21 subjects; 29.58%) (p = 0.001). These findings are consistent with previous studies. Rahma et al. (2006) reported that 66% of children with T1DM were dyslipidemic compared with 34% of controls, with a statistically significant difference except for HDL-C. Similarly, Homma et al. (2015) found that 72.5% of Brazilian children with T1DM had dyslipidemia. Wiltshire et al. (2003) also confirmed that hyperlipidemia remains common in children with T1DM compared with controls (35.4% vs. 14.7%).

As shown in Table 4, the mean levels of total cholesterol (TC), triglycerides (TG), and LDL-C were significantly higher among diabetic patients compared with controls. Interestingly, the mean HDL-C level was also higher in cases than in controls, with a statistically significant difference. This may reflect disease-related alterations in lipid metabolism or a compensatory metabolic response to the underlying disease process.

In the current study, Table 5 illustrates the pattern of dyslipidemia. The most common abnormality was hypertriglyceridemia (26%), followed by hypercholesterolemia (21.4%) and elevated LDL-C (13%). These findings are consistent with Jaja and Yarhere (2019), who reported hypertriglyceridemia in 86.4% of diabetic children, hypercholesterolemia in 22.7%, and elevated LDL-C in 13.6%.

Table 11 shows that female gender was significantly associated with dyslipidemia, with 64.2% of females affected compared to 35.9% of males. The most frequent lipid abnormalities among females, as shown in Table 10, were hypercholesterolemia (15.3% vs. 6.1% in males, p = 0.888), hypertriglyceridemia (13.7% vs. 12.2%, p = 0.365), and elevated LDL-C (9.2% vs. 3.8%, p = 0.392). These results agree with studies by Alakkad et al. (2020), Schwab et al. (2006), and Krantz et al. (2004), which found significantly higher lipid levels in female patients compared with males. However, other studies reported contrasting findings: Hamad and Qureshi (2008) found dyslipidemia more common in males, while Bulut et al. (2017) and Alwassity et al. (2022) reported no significant association between gender and dyslipidemia in T1DM. Regarding the duration of diabetes, Table 11 shows no statistically significant difference between dyslipidemic and normolipidemic groups (9.7 ± 3.6 vs. 9.4 ± 3.5 years, p = 0.640). This finding is consistent with Maahs et al. (2007), Hamad and Qureshi (2008), and Zabeen et al. (2018), who also found no relationship between lipid abnormalities and disease duration in pediatric patients with T1DM. In terms of treatment, the mean insulin dose was higher in the dyslipidemic group compared with the normolipidemic group (1.05 ± 0.24 vs. 1.01 ± 0.21 units/kg), but the difference did not reach statistical significance (p = 0.06). This result agrees with Alakkad et al. (2020).

Table 8 shows that BMI was significantly higher in the dyslipidemic group compared with the normolipidemic group (22.07 ± 4.42 vs. 20.32 ± 3.52, p = 0.002). This finding is consistent with Bulut et al. (2017) and Hassan et al. (2015). Finally, Table 11 demonstrates that mean HbA1c was higher in the dyslipidemic group compared with the normolipidemic group (10.2 ± 2.5 vs. 9.4 ± 2.4). Although both groups had poor glycemic control (mean HbA1c > 9%), the dyslipidemic group showed worse control. These findings agree with Sarfraz et al. (2016), Bulut et al. (2017), and Ladeia et al. (2006). According to the American Diabetes Association, the target HbA1c for diabetic patients is < 7%. The markedly elevated HbA1c levels observed in this study highlight the urgent need for stricter glucose control and lifestyle interventions to achieve recommended targets.

## Conclusion

This study found that dyslipidemia is significantly more frequent among children and adolescents with type 1 diabetes mellitus (T1DM) compared with non-diabetic controls. Hypertriglyceridemia was the most common abnormality, followed by hypercholesterolemia, with female patients more frequently affected. Poor glycemic control was strongly associated with dyslipidemia, highlighting its role in increasing cardiovascular risk in this population. Given the high prevalence and potential complications, routine screening for dyslipidemia in children and adolescents with T1DM is essential. In line with ADA and ISPAD guidelines, screening should begin at age 10 years or five years after diabetes onset, with earlier testing in those with a family history of hypercholesterolemia or premature cardiovascular disease. Optimizing glycemic control, encouraging healthy lifestyle behaviors, and considering lipid-lowering therapy when necessary are recommended to reduce long-term cardiovascular risk.

***Conflict of interest.*** Nil


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