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"A Cross-sectional study of dyslipidemia among underweight, normal weight and overweight type 1 diabetic paediatric & adolescent patients coming to a tertiary care referral hospital, Mysuru, Karnataka".

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ABSTRACT

Introduction

The prevalence and impact of dyslipidemia in relation to body mass index (BMI) categories in T1DM patients remains a critical area of research. This study aims to evaluate the prevalence of dyslipidemia among underweight, normal weight, and overweight pediatric and adolescent T1DM patients and explore the effect of BMI on the prevalence of dyslipidemia.

Materials and Methods

This cross-sectional observational study included 58 pediatric and adolescent patients diagnosed with T1DM. The patients were classified into three BMI categories: underweight, normal weight, and overweight. Data were analyzed to assess the association between BMI categories and the prevalence of dyslipidemia.

Results

Dyslipidemia was observed in 82.76% of the participants, with the majority being classified as overweight (68.75%). A smaller proportion had a normal BMI (27.08%), while 4.17% were underweight. No significant association was found between BMI categories and dyslipidemia ($p = 0.4735$). The study also noted that the mean age of participants was 10.19 ± 4.96 years.

Conclusion

The study highlights the high prevalence of dyslipidemia among pediatric and adolescent T1DM patients, particularly those who are overweight. While no significant association between BMI categories and dyslipidemia was found, these findings suggest the importance of monitoring lipid profiles in T1DM patients, especially those with higher BMI, to mitigate the risk of cardiovascular complications.

Recommendations

Given the rising prevalence of overweight and obesity among pediatric and adolescent T1DM patients, understanding the impact of BMI on dyslipidemia is of critical importance. Identifying BMI-related lipid abnormalities can facilitate early intervention strategies, including lifestyle modifications, dietary interventions, and tailored insulin regimens to mitigate cardiovascular risk. Furthermore, the findings of this study could contribute to the development of targeted screening guidelines for dyslipidemia in pediatric T1DM populations, optimizing long-term metabolic health outcomes.

Keywords: *Dyslipidemia, Diabetes Mellitus, Body Mass Index, Cardiovascular disease*
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INTRODUCTION

Type 1 diabetes mellitus (T1DM) is a chronic autoimmune disorder resulting from the destruction of insulin-producing pancreatic beta cells, leading to absolute insulin deficiency and persistent hyperglycemia. (1) Despite advances in insulin therapy and glycemic management, children with

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T1DM are more vulnerable and at an increased risk of both early subclinical and clinical cardiovascular disease (CVD), a major cause of morbidity and premature mortality in this population. (2) Obesity in T1DM presents additional challenges in achieving optimal glycemic control and is linked to a higher risk of metabolic syndrome, cardiovascular disease, and renal complications, ultimately leading to increased morbidity and reduced life expectancy. (3)

In 2016, more than 340 million children and adolescents between the ages of 5 and 19 were overweight or obese, and in 2020, 39 million more children under the age of five were also considered overweight or obese, according to the World Health Organization (WHO). These increasing trends highlight the need to assess the metabolic consequences of excess weight in children and adolescents with T1DM, particularly its impact on lipid metabolism and cardiovascular risk. (3,4) Around 40–60% of individuals with T1DM are diagnosed before the age of 20, making diabetes one of the most common severe chronic diseases of childhood. The global prevalence of T1DM ranges from 0.1% to 0.3%, with an estimated 78,000 new cases diagnosed annually, particularly among children under five years of age. (1)

Dyslipidemia, characterized by an imbalance in lipid levels, is an important risk factor for atherosclerosis and cardiovascular complications in individuals with T1DM.(2,5). The pathophysiology of dyslipidemia in T1DM is complex and influenced by various factors, including glycemic control, insulin therapy, dietary habits, genetic predisposition, and body mass index (BMI). (6,7) Overweight and obese children with T1DM are more likely to exhibit a lipid pattern linked to cardiovascular risk characterized by high triglyceride levels, increased LDL cholesterol, and reduced HDL cholesterol, thereby raising their likelihood of developing early cardiovascular complications. (8)

The prevalence of dyslipidemia has been reported to vary across BMI categories, with studies indicating that 14% of children with normal weight, 22% of overweight children, and 43% of children with obesity exhibit lipid abnormalities. (9,10) Given these associations, early detection and timely management are crucial in mitigating long-term cardiovascular risk. In recognition of this, the National Heart, Lung, and Blood Institute (NHLBI) released guidelines in 2011 recommending universal lipid screening for children between the ages of 9 and 11 years, with a second screening between 17 and 21 years. (11)

Identifying BMI-related lipid abnormalities can facilitate early intervention strategies, including lifestyle modifications, dietary interventions, and tailored insulin regimens to mitigate cardiovascular risk. Therefore, this study aimed to estimate the prevalence of dyslipidemia among underweight, normal-weight, and overweight T1DM pediatric and adolescent patients. Additionally, it seeks to evaluate the influence of BMI on lipid abnormalities, providing insights for individualized therapeutic approaches. By addressing these knowledge gaps, this research will enhance clinical understanding and inform future management strategies for dyslipidemia in T1DM patients.

Aims & objectives

To estimate the prevalence of dyslipidemia among underweight, normal weight, and overweight type 1 diabetic paediatric and adolescent patients. To know the effect of BMI on dyslipidemia in type 1 diabetic paediatric and adolescent patients.

Materials and Methods

Study design

It was a cross-sectional observational study.

Study setting

The study was conducted in the Department of Paediatrics, JSS Medical College, Mysuru, Karnataka, from March 2023 to November 2024.

Study participants

Paediatric and adolescent type 1 diabetes patients who were being followed up in the Department of Paediatrics, JSS Medical College, Mysuru, Karnataka, for 18 months.

Inclusion criteria

1. Children and adolescents with type 1 DM of any age and either sex.

Exclusion criteria

1. Patients with other forms of diabetes (syndromic diabetes, maturity-onset diabetes of the young (MODY), type 2 diabetes mellitus),
2. Patients on lipid-lowering drugs,

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3. Patients with other associated endocrinological conditions such as hypothyroidism and Cushing's disease.
4. Children and/or their legal guardians who refused to participate in the study.

Study procedure

58 paediatric and adolescent patients with type 1 diabetes who were being followed up were initially screened for the study, and their legal guardians were personally approached and explained the study procedure in their indigenous language. One child refused to participate. Children, adolescents, and/or legal guardians who were ready to participate and signed the informed consent document were enrolled in the study (ANNEXURE III).

After enrollment, information on age, gender, BMI, and insulin regimen type was obtained. Parents' reports of medical history were cross-checked from hospital case records. Standing height with a portable stadiometer (Leicester Height Meter, Child Growth Foundation, UK) was recorded to the millimeter, and weight was recorded with an electronic scale to 100 g. Body mass index (BMI) was calculated by dividing weight in kg by height in meters squared. The height, weight, and BMI were then converted into Z scores based on Indian references (57), and the patients were divided into obese, normal, and underweight.

Glycaemic control was assessed by estimating glycosylated haemoglobin (HbA1c). HbA1c was estimated by high-performance liquid chromatography (HPLC, BIO-RAD, Germany). Thyroid-stimulating hormone (TSH) levels were estimated by Chemiluminiscent Microparticle Immuno Assay (CMIA). The fasting blood samples were then analyzed for lipid profile (total cholesterol, triglycerides, and HDL-C), and low-density lipoprotein-cholesterol (LDL-C) levels were estimated by the Friedewald formula. (58)

Data collection

On enrollment, the following parameters were recorded in all patients.

Demographic characteristics

Age, sex, height, weight, BMI

Clinical characteristics

Insulin regimen and HbA1c control.

Laboratory characteristics

HbA1c and lipid profile.

Ethical consideration

The protocol of the study was approved by the Institutional Ethics Committee (IEC) of JSS Medical College on 22/6/2023 with IEC no JSS/MC/PG/2044/67/2023-24, and written informed consent was taken from the children and/or their legal guardian before study commencement.

Sample size calculation

58 children and adolescents were included in the study; their data were analyzed and reported in the Results section.

Sampling technique

A convenient sampling technique was employed.

Observations & results

Table 1. Distribution of patients according to age

Age groups (years)	n (= 58)	%
1 – 5	11	18.97
6 – 10	15	25.86
11 – 13	13	22.41
14 – 18	19	32.76

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Figure 1. Distribution of patients according to age

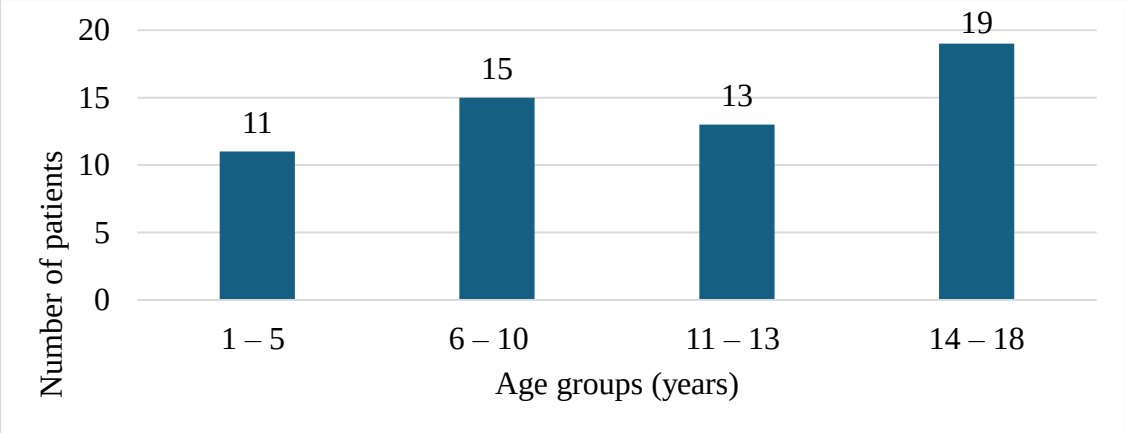

Table 1 and Figure 1 depict the distribution of patients according to age. The majority of patients were in the age group 14–18 years (32.76%), followed by those in the 6–10 years age group (25.86%). 22.41% were in the 11–13 years group, and 18.97% belonged to the 1–5 years age group. The ages ranged from 1.6 to 18 years, with a mean of 10.19 ± 4.96 years.

Table 2. Distribution of patients according to gender

Gender	n (= 58)	%
Female	34	58.62
Male	24	41.37

Figure 2. Distribution of patients according to gender

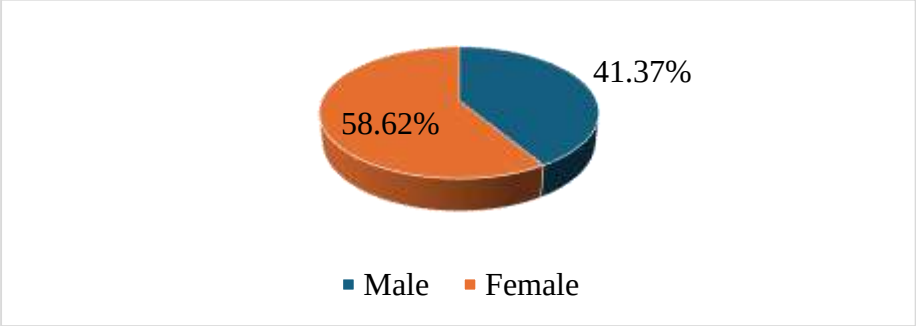

Table 2 and Figure 2 depict the distribution of patients according to gender. The majority of patients were female (58.62%), while the remaining were male (41.37%). The male-to-female ratio was 0.71.

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Table 3. Distribution of regimen among patients

Regimen	n (= 58)	%
Basal bolus	53	91.38
Split mix regimen	5	8.62

Figure 3. Distribution of regimen among patients

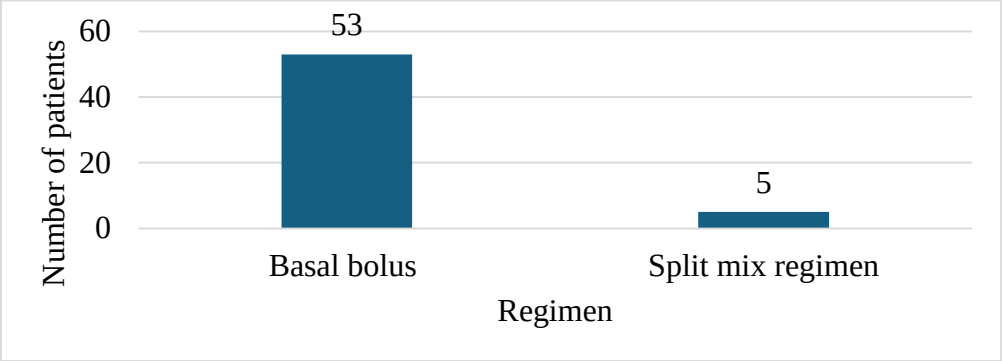

Table 3 and Figure 3 depict the distribution of regimen among patients. The majority were using the basal bolus regimen (91.38%), while the remaining were on the split mix regimen (8.62%).

Table 4. Frequency distribution of patients according to HbA1c control

HbA1c	n (= 58)	%
Poorly controlled	54	93.10
Well controlled	4	6.90

Figure 4. Frequency distribution of patients according to HbA1c control

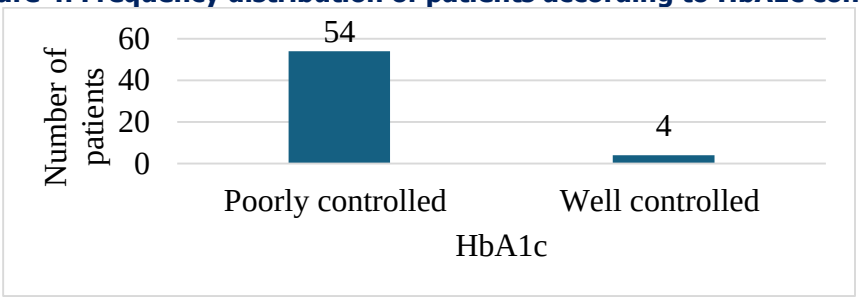

Table 4 and Figure 4 depict the frequency distribution of patients according to HbA1c control. The majority of patients had poorly controlled HbA1c (93.10%), while only 6.90% had well-controlled HbA1c.

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Table 5. Distribution of patients according to BMI categories

BMI categories	n (= 58)	%
Underweight	3	5.17
Normal	16	27.59
Overweight	39	67.24

Figure 5. Distribution of patients according to BMI categories

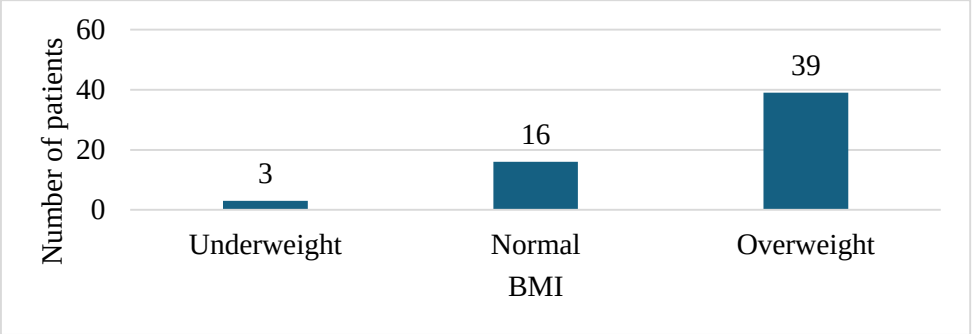

Table 5 and Figure 5 depict the distribution of patients according to BMI categories. The majority of patients were overweight (67.24%), while the remaining patients had normal BMI (27.59%), followed by 5.17% were underweight.

Table 6. Association between dyslipidemia and HbA1c

Dyslipidaemia	HbA1c		p
	Well controlled (n=4)	Poorly controlled (n=54)	
Present	4 (100.00%)	44 (81.48%)	0.3441
Absent	0 (0.00%)	10 (18.52%)	

Table 6. Association between dyslipidemia and HbA1c

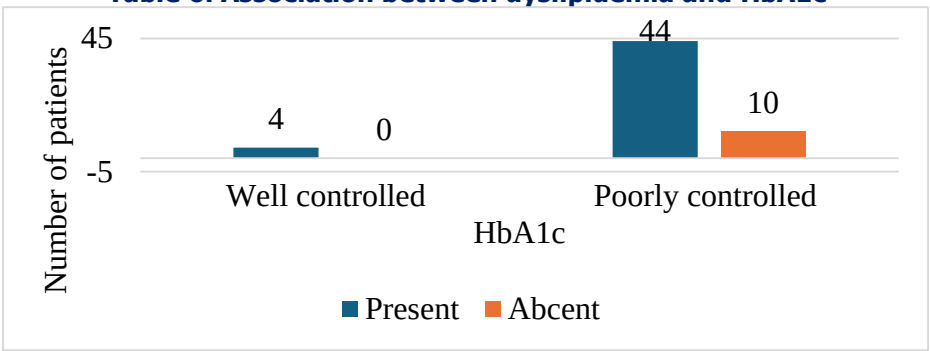

Table 6 and Figure 6 depict the association between dyslipidemia and HbA1c control. Among patients with well-controlled HbA1c, 100% had dyslipidemia, whereas among those with poorly controlled HbA1c, 81.48% had

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dyslipidemia and 18.52% did not. Statistical analysis using the Chi-square test showed no significant association between HbA1c levels and dyslipidemia (p = 0.3441).

Table 7. Association between BMI categories and HbA1c

BMI	HbA1c		p
	Well controlled (n=4)	Poorly controlled (n=54)	
Underweight	1 (25.00%)	2 (3.70%)	0.1768
Normal	1 (25.00%)	15 (27.78%)	
Overweight	2 (50.00%)	37 (68.52%)	

Figure 7. Association between BMI categories and HbA1c

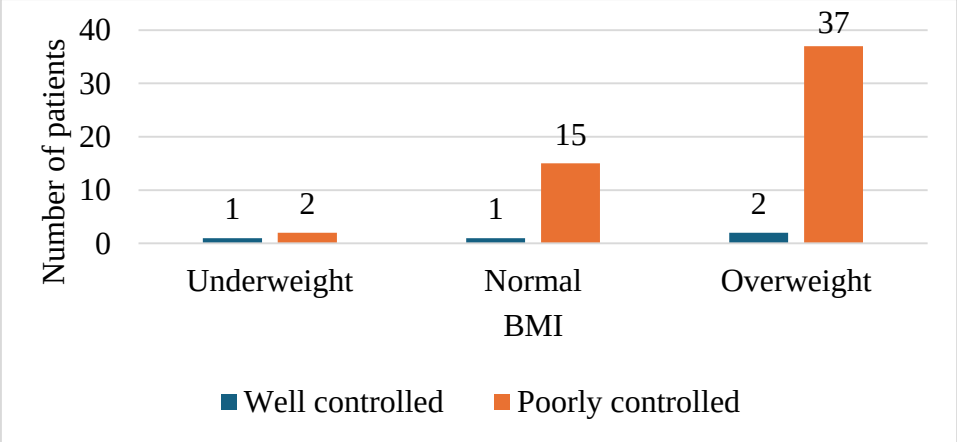

Table 7 and Figure 7 depict the association between BMI categories and HbA1c control. Among patients with well-controlled HbA1c, 25.00% were underweight, 25.00% had normal BMI, and 50.00% were overweight. In contrast, among patients with poorly controlled HbA1c, 3.70% were underweight, 27.78% had normal BMI, and the majority (68.52%) were overweight. BMI and HbA1c control had no significant association (p = 0.1768).

Table 8. Association between BMI categories and dyslipidemia

BMI	Dyslipidemia		P-value
	Present (n=48)	Absent (n=10)	
Underweight	2 (4.17%)	1 (10.00%)	0.4735
Normal	13 (27.08%)	3 (30.00%)	
Overweight	33 (68.75%)	6 (60.00%)	

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Figure 8. Association between BMI categories and dyslipidemia

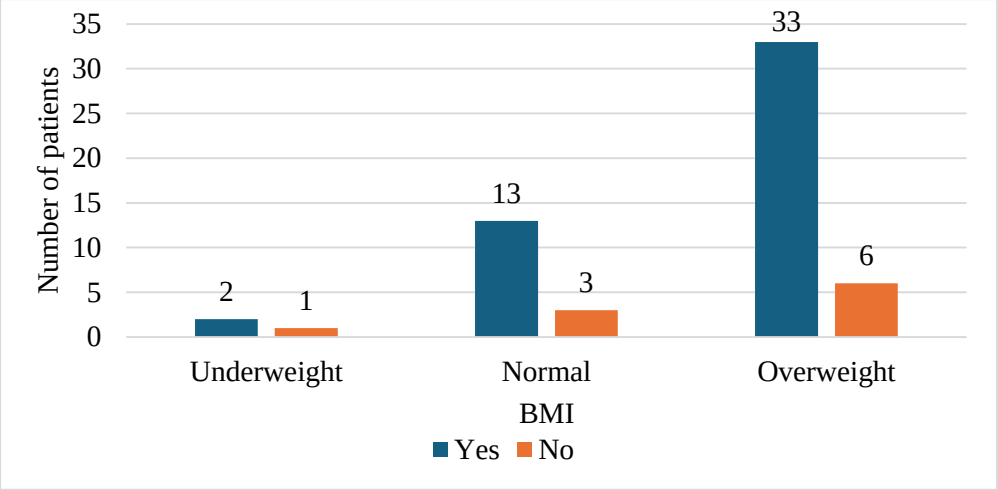

Table 8 and Figure 8 depict the association between BMI categories and dyslipidemia. Of 48 patients with dyslipidemia, 4.17% were underweight, 27.08% were normal, while 68.75% patients with dyslipidemia were overweight. BMI and dyslipidemia had no significant association (p=0.4735).

Discussion

T1DM, an autoimmune disorder primarily affecting children and adolescents, is associated with a heightened risk of long-term complications due to the early onset and extended duration of the disease. As of 2021, approximately 8.4 million people worldwide were living with T1DM, with around 18% being under the age of 20. (25) One of the critical complications associated with T1DM is dyslipidemia. (66) Although lipid derangements may not always be clinically apparent in early childhood, they often begin during this stage and can persist into adulthood, contributing to long-term cardiovascular complications. (66) Dyslipidemia plays an important role in the initiation and progression of this accelerated atherosclerosis, which in turn is responsible for premature cardiovascular disease and early mortality in patients with T1DM.(8)

This study aimed to investigate how common dyslipidemia is among children and adolescents with type 1 diabetes, and whether their body weight (BMI category: underweight, normal, or overweight) has an influence on the presence of dyslipidemia.

The findings of the present study are discussed under the following headings:

1. Age

In the present study, the largest proportion of patients (32.76%) belonged to the 14–18 years age group. Followed by those aged 6–10 years (25.86%). 22.41% patients were in the 11–13 years group, while 18.97% belonged to the 1–5 years age group. The mean age of the patient was 10.19 ± 4.96 years. Similarly, a study by Akhter et al. observed that the mean age of participants with T1DM was 11.23 ± 1.76 years. In terms of age distribution, 45% of participants were younger than 10 years, while 55% were older than 10 years. (67) Additionally, a study by Soliman et al. recorded an age range of 1 to 18 years in the patients with T1DM, with a mean age of 11.71 ± 3.6 years. (52) Another study by Shah et al. reported that in patients with T1DM, the mean age was 12.5 ± 3.9 years, with an age range of 3 to 18 years. In terms of age distribution, 26.8% were under 10 years of age, while 73.2% were above 10 years. (8) These study findings indicate that the majority of pediatric and adolescent patients with T1D fall within the school-age to early teenage years, suggesting that T1D is most commonly diagnosed during late childhood and early adolescence.

2. Gender

In the present study, most of the patients were female (58.62%), while the remaining were male (41.37%).

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Similarly, a study by Bulut et al. reported that the study population with T1DM consisted predominantly of females (56.40%), with males making up 43.60%. (56) Another study's findings by Dange et al. demonstrated that 53.30% of the participants with T1DM were females, compared to 46.70% who were males. (68) Furthermore, a study by Zabeen et al. observed that 53.08% of the participants with T1DM in their study population were female. (35) These findings indicate that females constitute a slightly higher proportion of the study populations in children and adolescents with T1DM, suggesting a modest female predominance in such cohorts.

3. Regimen

In the present study, the majority of patients were using the basal bolus regimen (91.38%), while the remaining were on the split mix regimen (8.62%). Similarly, a study by Shah et al. observed that 72% of children were on a basal-bolus regimen, while the remaining 28% were on a split-mix or modified split-mix regimen. (8) In a separate study by Soliman et al., all children and adolescents with T1DM were treated with a basal–bolus insulin regimen. (52) These findings indicate a clear preference for the basal-bolus regimen in diabetes management, likely due to its flexibility and effectiveness in achieving better glycemic control.

4. HbA1c CONTROL

Dyslipidemia in patients with T1DM can develop through various mechanisms, with poor glycemic control being the most recognized contributing factor. Studies have shown that the prevalence of dyslipidemia is significantly higher among T1DM patients with poor glycemic control compared to those who maintain adequate glycemic control. (13) In the present study, the majority of patients had poorly controlled HbA1c (93.10%), while only 6.90% had well-controlled HbA1c. Similarly, a study by Pa et al. documented that 88.0% of participants had HbA1c levels between 7% to 9.9%, while 12.0% had HbA1c levels greater than 10%. (69) Furthermore, in a study by Soliman et al., 73.45% of patients had poor glycemic control, defined as HbA1c >7.5%. (52) In contrast, a study by Carneiro et al. reported that approximately 39.2% of the participants had poorly controlled HbA1c levels. (70) Additionally, a separate study by Costa et al. recorded that 49.2% of patients had adequate HbA1c control. (71) These findings indicate that poor glycemic control is common among patients with diabetes, highlighting the need for better management and monitoring strategies to achieve target HbA1c levels.

5. BMI

Overweight and obesity have emerged as common complications in young adults, significantly increasing the risk of CVD. Obesity predisposes individuals to CVD, likely through both direct mechanisms, such as insulin resistance, and indirect effects mediated by other components of the metabolic syndrome. (72) In the present study, the majority of patients were overweight (67.24%), while 27.59% had a normal BMI, and 5.17% were underweight. Similarly, a study by El Bakry et al. reported that among children with dyslipidemia, 25.00% were overweight, 12.50% were obese, 25.00% had central obesity, and 12.50% had short stature, while 62.50% had normal height. In the normolipidemic group, 77.78% had normal BMI, 16.67% were overweight, 5.56% were obese, 16.67% had central obesity, and 16.67% had short stature. (73) In another study by Kim et al. on dyslipidemia in adolescents and young adults with T1DM, 60.80% of participants had a normal BMI, while 22.70% were overweight and 16.50% were obese. (26) Furthermore, da Costa et al. observed the following distribution in nutritional status: 1.0% of participants were underweight, 59% were eutrophic (normal weight), 30.3% were overweight, and 9.7% were obese, resulting in a total of 40% having excess weight. (71) These findings indicate that a significant proportion of pediatric and adolescent patients with T1DM fall into overweight and obese categories, highlighting the growing burden of excess weight in this population

6. ASSOCIATION BETWEEN DYSLIPIDEMIA AND HbA1c

In the present study, all patients (100%) with well-controlled HbA1c had dyslipidemia. Among those with poorly controlled HbA1c, 81.48% had dyslipidemia, while 18.52% did not. However, statistical analysis revealed no significant association between HbA1c levels and dyslipidemia ($p = 0.3441$). Similarly, in a study by Soliman et al., 74.8% of patients with dyslipidemia had poor glycemic control, while 70.2% of normolipidemic patients had poor control. Conversely, good glycemic control was seen in 25.2% of patients with dyslipidemia and 29.8% of normolipidemic patients. However, the association between glycemic control and lipid status was not statistically significant ($p = 0.17$). (52) In contrast, a study by Abed et al. reported fingerstick

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HbA1c values with a mean ± SD of 9.73 ± 1.88 for all participants. Among those with dyslipidemia, the mean HbA1c was significantly higher at 9.99 ± 2.00 compared to 9.29 ± 1.55 in participants without dyslipidemia, indicating a significant association between higher HbA1c levels and the presence of dyslipidemia (p = 0.0430). (54) Another study by Shah et al. reported that patients with dyslipidemia had significantly higher HbA1c levels (11.0 ± 2.1%, equivalent to 97.0 ± 23.0 mmol/mol) compared to those without dyslipidemia (10.4 ± 1.7%, 90.2 ± 19.0 mmol/mol), with the difference being statistically significant (p = 0.015). (8) Overall, findings suggest that poor glycemic control may be associated with dyslipidemia.

7. ASSOCIATION BETWEEN BMI CATEGORIES AND HbA1c

In the present study, among patients with well-controlled HbA1c, 25.00% were underweight, 25.00% had a normal BMI, and 50.00% were overweight. In contrast, among those with poorly controlled HbA1c, 3.70% were underweight, 27.78% had a normal BMI, and the majority (68.52%) were overweight. However, statistical analysis showed no significant association between BMI and HbA1c control (p = 0.1768). A study by Soliman et al. observed that the mean BMI SDS was −0.6 ± 1.4 in patients with poor glycemic control and −0.8 ± 1.3 in those with good glycemic control. Although the BMI SDS was slightly higher in the poorly controlled group, the difference was not statistically significant (p = 0.06). (52) In another study, Flokas et al. reported mean HbA1c levels of 6.98% in normal-weight individuals, 7.04% in overweight, and 6.99% in obese individuals, with no statistically significant difference (p = 0.077). (74)

8. Association between BMI categories and dyslipidemia

In the present study, the majority of patients with dyslipidemia were classified as overweight (68.75%), while 27.08% had a normal BMI, and 4.17% were underweight. However, there was no significant association between BMI categories and dyslipidemia (p = 0.4735). Similarly, a study by El Bakry et al. found that among children with dyslipidemia, 25.00% were overweight, 12.50% were obese, 25.00% had central obesity, and 12.50% had short stature, while 62.50% had normal height. In the normolipidemic group, 77.78% had normal BMI, 16.67% were overweight, 5.56% were obese, 16.67% had central obesity, and 16.67% had short stature. (73) Additionally, a study by Stankute et al. recorded the prevalence of dyslipidemia across different BMI categories. Dyslipidemia was present in 68.8% of obese individuals, 66.7% of those who were overweight, 61.4% of normal-weight individuals, and 60% of underweight individuals. (75) In contrast, another study by Kim et al. on dyslipidemia in adolescents and young adults with T1DM, 60.80% of participants had a normal BMI, while 22.70% were overweight and 16.50% were obese. (26) These findings indicate that dyslipidemia is more common in overweight individuals.

Conclusion

This study highlights the significant prevalence of dyslipidemia among pediatric and adolescent patients with T1DM, with 82.76% of participants affected. The results highlight the significance of taking into account variables like height, weight, age, and gender when analyzing these patients' clinical presentations. A notable proportion of patients were classified as overweight (68.75%), with a smaller percentage falling within the normal BMI (27.08%) and underweight categories (4.17%). However, analysis did not reveal a statistically significant relationship between BMI categories and dyslipidemia (p = 0.4735). These findings underline the need for comprehensive monitoring of lipid profiles in T1DM patients, especially those with a higher BMI, to help mitigate cardiovascular risks and improve long-term health outcomes.

Limitations of the study

- The relatively small sample size may reduce the statistical power and limit the robustness of the conclusions.
- The absence of a control group limits the ability to compare the findings with those of a healthy population, which could help contextualize the results.
- Potential confounding factors, such as genetics, lifestyle, and medication use, were not fully controlled for, which could have influenced the results.

Abbreviations

ADA – American Diabetes Association

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ASCVD	–	Atherosclerotic Cardiovascular Disease
BMI	-	Body mass index
CVD	-	cardiovascular disease
DM	–	Diabetes Mellitus
HbA1c	-	Hemoglobin A1c (Glycated Hemoglobin)
HDL-C	–	High-Density Lipoprotein Cholesterol
IDF	–	International Diabetes Federation
ISPAD	–	International Society of Pediatric and Adolescent Diabetes
LDL-C	–	Low-Density Lipoprotein Cholesterol
NHLBI	–	National Heart, Lung, and Blood Institute
T1DM	-	Type 1 Diabetes Mellitus
TSH	-	Thyroid-stimulating hormone
TG	–	Triglycerides
TC	–	Total Cholesterol
VLDL	–	Very Low-Density Lipoprotein

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Conflict of interest
No conflicts of interest in this study

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