Diabetic Dyslipidemia in Georgian Children with Type 1 Diabetes

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Abstract

Background: Diabetes mellitus in children and adolescents increases the risk of developing dyslipidemia. The aim of our study is to determine the relationship between HbA1c and lipid profile indicators in a Georgian population of children with type 1 diabetes.

Methods: The study was based on biochemical data obtained from 230 children and adolescents with type 1 diabetes and 383 age-comparable controls from the Megalab clinic population. The participants were 9 to 18 years old; the mean age in the T1D group was 13.22±2.82 years. Biochemical assessment was performed after a 12-hour overnight fast. We studied: Serum total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), glycated hemoglobin (HbA1c). The following lipid indices were assessed: non-HDL-C, TG/HDL-C, log10(TG/HDL-C), HDL-C/LDL-C, TC/HDL-C, LDL-C/HDL-C, and non-HDL-C/HDL-C. Statistical analysis was performed using SPSS - 23.

Results: A statistically significant positive correlation was observed between HbA1c and the following indicators: Total cholesterol (TC): r=0.527; LDL-C: r=0.441; triglycerides (TG): r=0.446; non-HDL-C: r=0.522**; HbA1c also showed a low-significant positive correlation with atherogenic indices -TC/HDL-C: r=0.321, LDL-C/HDL-C: r=0.256, non-HDL-C/HDL-C: r=0.321, TG/HDL-C: r=0.369, log(TG/HDL-C): r=0.328, LDL-C–HDL-C: r=0.385**. (p<0.001)This indicates that an increase in HbA1c in children with type 1 diabetes is associated with a worsening of the atherogenic profile. In the case of HDL-C: r=−0.009; p=0.895 - a statistically significant relationship was not observed. In the T1DM group, significantly increased compared to controls - TC: 153.15 vs 175.92 mg/dL, LDL-C: 89.83 vs106.99 mg/dL; TG: 71.15 mg/dL vs 119.28 mg/dL HDL was reduced in the T1D group by 45.07 mg/dL vs: 49.09 mg/dL. Non–HDL-C -104.06 vs 130.84 mg/dL reflects an increase in atherogenic fractions. In all cases (p<0.001). All indices were significantly higher in the T1D group: TC/HDL-C: 3.16 vs 4.14; LDL/HDL-C: 1.87 vs 2.55; Non-HDL/HDL-C: 2.16 vs 3.14; TG/HDL-C: 1.47 vs 2.95; log(TG/HDL): 0.16 vs 0.38, indicating a markedly atherogenic profile, LDL-C–HDL-C: 40.75 vs 61.92 mg/dL increase reflects a strengthening of the atherogenic imbalance.

Conclusions: Glycemic control in children with type 1 diabetes mellitus has a significant impact on lipid metabolism and determines the formation of an atherogenic lipid profile. In Georgian children with type 1 diabetes, the lipid profile is significantly more atherogenic than in healthy controls and is characterized by higher total cholesterol, LDL-C, triglycerides, and non-HDL-C, lower HDL-C, and increased atherogenic indices. The TC/HDL-C, LDL-C/HDL-C, non-HDL-C/HDL-C, and TG/HDL-C indices are all significantly higher in the diabetes group. Changes in the lipid spectrum indicate early cardiovascular risk formation and justify active prevention and monitoring already in childhood. These data indicate the early formation of cardiovascular risk and emphasize the importance of preventive measures in childhood. **TCM-GMJ June 2026; 11 (2): P41-P45)**

Keywords: Type 1 Diabetes, Children, Lipid Spectrum, Cardiovascular Risk, Lipid Indices, Atherogenic Profile .

Introduction

The global prevalence of type 1 diabetes mellitus (T1DM) is increasing. Inadequate glycemic control in children and adolescents leads to both acute and chronic complications, decreased health-related quality of life (HRQoL), and increased health care utilization[1].

It is known that diabetes mellitus in children and adolescents increases the risk of developing dyslipidemia, which is associated with the early development of atherosclerotic disease in children and adolescents with type 1 diabetes [2]. Diabetic dyslipidemia is characterized by lower high-density lipoprotein cholesterol (HDL-C) and higher low-density lipoprotein cholesterol (LDL-C) and triglyceride (TG) levels, a pattern that materially increases cardiovascular risk [3].

In cases of poor glycemic control, type 1 diabetes is associated with quantitative lipoprotein abnormalities, such as increased triglycerides and low-density lipoprotein cholesterol [4]. In contrast, compared with the general population, people with type 1 diabetes with optimal glycemic control have normal or slightly reduced triglyceride and low-density lipoprotein cholesterol levels, while high-density lipoprotein (HDL) cholesterol levels are normal or slightly increased [5]. Consequently, poor glycemic control can lead to lipid abnormalities and atherogenic changes in

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lipoprotein composition [6].

The aim of our study is to determine the relationship between HbA1c and lipid profile indicators in a Georgian population of children with type 1 diabetes.

Methods

The study was based on biochemical data obtained from 230 children and adolescents with type 1 diabetes and 383 age-comparable controls from the Megalab clinic population. The participants were 9 to 18 years old; the mean age in the T1D group was 13.22 ± 2.82 years.

A cross-sectional, analytical study was conducted. Inclusion criteria: children and adolescents with a confirmed diagnosis of type 1 diabetes mellitus, informed consent of the parent/guardian. Exclusion criteria: other metabolic or endocrine diseases, taking medications that affect the lipid profile, incomplete data.

Dyslipidemia was defined as the presence of one or more abnormal lipid or lipoprotein values. In line with the American Diabetes Association (ADA), dyslipidemia was considered present when LDL-C was ≥100 mg/dL, HDL-C was <40 mg/dL in boys and <50 mg/dL in girls, total cholesterol (TC) was ≥200 mg/dL, or triglycerides were ≥130 mg/dL [7-9].

Biochemical assessment was performed after a 12-hour overnight fast. Serum total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), fasting glucose, and glycated hemoglobin (HbA1c) were analyzed on the Atellica® CH Analyzer (Siemens Healthcare Diagnostics Inc., USA) using manufacturer-recommended methods.

The following lipid indices were assessed: non-HDL-C, TG/HDL-C, the atherogenic index of plasma (AIP) calculated as log10(TG/HDL-C), HDL-C/LDL-C, Castelli index I (TC/HDL-C), Castelli index II (LDL-C/HDL-C), and non-HDL-C/HDL-C.

The study protocol was approved by the ethics committee of David Aghmashenebeli University of Georgia.

Statistical analysis

For quantitative variables, means and standard deviations were calculated; Between-group differences for continuous variables were assessed with Student's t test for independent samples. Equality of variances was evaluated using Levene's test, and the appropriate version of the t test was selected accordingly. To assess the relationship between HbA1c and lipid parameters, the following were used: Pearson's correlation coefficient (r),. A p value <0.05 was considered statistically significant. Statistical analysis was performed using SPSS - 23.

Results and discussion

The association of HbA1c with lipid profile parameters was assessed in a Georgian pediatric population with type 1 diabetes (Table 1).

Correlation analysis showed that HbA1c is significantly associated with almost all parameters of the lipid profile.

According to the results, a statistically significant positive correlation was observed between HbA1c and the following indicators:

Total cholesterol (TC): r =0.527; p<0.001, LDL-C: r = 0.441; p<0.001, triglycerides (TG): r = 0.446; p<0.001, non-HDL-C: r = 0.522**; p<0.001, indicating that atherogenic lipid fractions increase with increasing HbA1c.

HbA1c also showed a low-significant positive correlation with atherogenic indices

TC/HDL-C: r = 0.321, LDL-C/HDL-C: r = 0.256, non -HDL-C/HDL-C: r = 0.321, TG/HDL-C: r = 0.369, log (TG/HDL-C): r = 0.328, LDL-C – HDL-C: r = 0.385**. (p<0.001)This indicates that an increase in HbA1c in children with type 1 diabetes is associated with a worsening of the atherogenic profile.

In the case of HDL-cholesterol HDL-C: r = −0.009; p=0.895 - a statistically significant relationship was not observed, which means that: HbA1c does not directly affect the level of HDL, or the relationship is weak and depends on other factors

Table 2 presents the comparison of the lipid profile between the control group (n=383) and children with type 1 diabetes (n=230).

As shown in Table 2, all lipid-related variables indicated a significantly more atherogenic profile in the diabetes group than in controls.

The control group was older than the T1D group (14.24 ± 2.76 vs 13.22 ± 2.82 years; p<0.001). In the T1DM group, significantly increased compared to controls - TC: 153.15 vs 175.92 mg/dL, LDL-C: 89.83 vs106.99 mg/dL; TG: 71.15 mg/dL vs 119.28 mg/dL HDL was reduced in the T1D group by 45.07 mg/dL vs: 49.09 mg/dL. Non–HDL-C -104.06 vs 130.84 mg/dL reflects an increase in atherogenic fractions. In all cases (p<0.001).

All indices were significantly higher in the T1D group: TC/HDL-C: 3.16 vs 4.14; LDL/HDL-C: 1.87 vs 2.55; Non-HDL/HDL-C: 2.16 vs 3.14; TG/HDL-C: 1.47 vs 2.95; log(TG/HDL): 0.16 vs 0.38, indicating a markedly atherogenic profile, LDL-C–HDL-C: 40.75 vs 61.92 mg/dL increase reflects a strengthening of the atherogenic imbalance.

Nevertheless, the results show a clear pattern: all mean values in the control group remained within the expected range, whereas in the T1D group TC, TG, and non-HDL-C were elevated, LDL-C was borderline high, HDL-C was reduced, and all calculated indices were atherogenic.

The lipid profile of children with type 1 diabetes in our cohort deviated significantly from normal values and was characterized by an atherogenic pattern of dyslipidemia. The most prominent findings were higher triglycerides and non-HDL-C, lower HDL-C, and consistently increased atherogenic indices. Together, these changes point to early cardiovascular risk formation and support the need for active monitoring and management already in childhood.

The results obtained show that a deterioration in glycemic control (an increase in HbA1c) leads to: an increase in LDL, triglycerides, non-HDL, an increase in atherogenic indices, while HDL decreases insignificantly.

Compared with controls, children with T1D had clearly less favorable lipid values: total cholesterol, LDL-C, triglycerides, non-HDL-C, and all major atherogenic ratios were higher, whereas HDL-C was lower. From a clinical standpoint, the control group averages mostly fell within acceptable pediatric ranges. In the T1D group, TC of

75.92 mg/dL was already in the borderline-high range, TG of 119.28 mg/dL exceeded the accepted threshold for ages 10-19 years, non-HDL-C of 130.84 mg/dL was unfavorable, and LDL-C of 106.99 mg/dL approached the upper acceptable limit. According to the latest ADA recommendations, the LDL-C target in children and adolescents with diabetes should be <100 mg/dL, and statin therapy may be considered if LDL-C remains >130 mg/dL [10].

These findings suggest that dyslipidemia in our T1D group was not limited to a single abnormal parameter but reflected a broader atherogenic phenotype. The increases in TC/HDL-C, LDL-C/HDL-C, non-HDL-C/HDL-C, TG/HDL-C, and log10(TG/HDL-C) are particularly important because such ratios often predict future cardiovascular risk better than isolated lipid fractions. In our data, TG/HDL-C = 2.96 and AIP = 0.38 already indicated a clearly more adverse profile than in controls. This fits with current evidence showing that overt vascular events are rare in adolescents with T1D, but risk factors and early subclinical vascular injury begin much earlier [11].

Our findings are also in agreement with the Italian study by Catamo et al. published in 2023. In a cohort of 324 children and adolescents with T1D, the authors showed that dyslipidemia may be present in both children and adolescents and that HbA1c was the strongest determinant of lipid abnormalities, being associated with total cholesterol, LDL-C, and HDL-C. They also noted that triglyceride levels were higher in children younger than 11 years, suggesting that screening should not depend on age alone. This corresponds well to our results, where elevated TG and non-HDL-C were prominent features and may indicate early atherogenic risk formation [12].

A Turkish study by Vurallı et al. in 2024 reported that cardiovascular risk factors were more common in adolescents with T1D, especially among those who were overweight or obese, and that the combination of high LDL-C, high TG, and low HDL-C was the most unfavorable. Their data also suggested that girls more often had two or more cardiovascular risk factors. Although our table did not include sex-stratified analysis, the overall lipid pattern in our cohort moved in the same direction as that reported in the Turkish population: LDL-C and TG were elevated, HDL-C was lower, and the lipid ratios were substantially worse [13].

Recent reviews continue to confirm that in young people with T1D, higher HbA1c, increasing age, overweight, and dyslipidemia are among the main predictors of vascular complications. These reviews also stress that diagnosis of T1D in childhood implies longer exposure to hyperglycemia and other cardiometabolic insults, which ultimately increases the risk of subclinical atherosclerosis [14]. Our data fit this view well: even though our T1D group was younger than the controls, their lipid profile was still significantly worse, suggesting that the difference cannot be explained by age alone and likely reflects the effect of diabetes itself and the quality of metabolic control.

The HDL-C findings also deserve attention. HDL-C averaged 49.09 mg/dL in controls and 44.99 mg/dL in the T1D group. This places the control group clearly within the acceptable range, while the diabetes group sits close to the lower boundary [14]. Current literature indicates that in T1D, quantitative HDL-C assessment may not always be sufficient because HDL function can be impaired even when the absolute concentration is not profoundly reduced. For that reason, the relatively moderate decline in HDL-C in our study does not lessen the significance of the results, especially because all major atherogenic fractions and ratios were simultaneously increased.

Non-HDL-C includes all atherogenic apoB-containing lipoproteins and is increasingly regarded as a practical and informative marker, particularly when triglycerides are elevated. Recent reviews emphasize that LDL-C remains the principal therapeutic target in pediatric T1D, but non-HDL-C and triglycerides are especially useful when the aim is to characterize overall atherogenic burden more broadly [6]. In our data, non-HDL-C of 130.84 mg/dL and a non-HDL-C/HDL-C ratio of 3.16 point to exactly such an unfavorable profile.

Recent reviews have also highlighted that cardiovascular risk in children with T1D begins early and is closely linked to dyslipidemia, especially elevated triglycerides and reduced HDL-C. These publications further note the tight association between glycemic control, reflected by HbA1c, and the lipid profile [15], which again supports our results.

In children with diabetes, hypertriglyceridemia accompanied by lower HDL-C is one of the most frequent lipid abnormalities, and this was exactly the dominant risk combination in our decision-tree model [16].

Overall, our results confirm that in children with type 1 diabetes, serum lipids are significantly more atherogenic than in healthy peers. This tendency is showing that T1D in childhood is accompanied by increases in triglycerides, LDL-C, non-HDL-C, and atherogenic indices, thereby laying the groundwork for early cardiovascular risk.

According to ADA recommendations, initial testing should be performed immediately after diagnosis. If initial testing results are normal, follow-up testing may be performed at 9–11 years of age [17]. Non-HDL cholesterol levels have been shown to be a strong predictor of atherosclerosis—as strong as any other measure of lipoprotein cholesterol in children and adolescents. . Even if results are normal, screening should be repeated in 3 years because A1C levels and other cardiovascular risk factors can change dramatically during adolescence.

Our study indicates that in children with type 1 diabetes, it is necessary not only to control HbA1c, but also to regularly monitor the lipid profile. The assessment of triglycerides and non-HDL-cholesterol is especially important, as they can be used as early markers of cardiovascular risk. The results support current recommendations that emphasize the need for screening and management of dyslipidemia even in childhood.

Conclusion

1. Glycemic control in children with type 1 diabetes mellitus has a significant impact on lipid metabolism and determines the formation of an atherogenic lipid pro-

file.

2. In Georgian children with type 1 diabetes, the lipid profile is significantly more atherogenic than in healthy controls and is characterized by higher total cholesterol, LDL-C, triglycerides, and non-HDL-C, lower HDL-C, and increased atherogenic indices. The TC/HDL-C, LDL-C/HDL-C, non-HDL-C/HDL-C, and TG/HDL-C indices are all significantly higher in the diabetes group.
3. Changes in the lipid spectrum indicate early cardiovascular risk formation and justify active prevention and monitoring already in childhood.
4. These data indicate the early formation of cardiovascular risk and emphasize the importance of preventive measures in childhood.

Table 1. Correlations between HbA1c and lipid spectrum characteristics (n=230)

Factors	r	p
T-c	0.527**	<0.001
LDL-C	0.441**	<0.001
HDL-c	-0.009	0.895
TG	0.446**	<0.001
Non–HDL_C	0.522**	<0.001
TC / HDL-C	0.321**	<0.001
LDL_C / HDL-C	0.256**	<0.001
non–HDL_C / HDL_C	0.321**	<0.001
TG / HDL-C	0.369**	<0.001
log10(TG / HDL-C)	0.328**	<0.001
LDL_c-HDL_C	0.385**	<0.001

Table 2. Comparative analysis of the lipid profile in the control group and children with type 1 diabetes

Factors	Control group n=383		TD1 n=230		t	p
	Mean	**SD**	**Mean**	**SD**		
Age (year)	14.24	2.76	13.22	2.82	4.35	<0.001
TC (mg/dL)	153.15	22.58	175.92	37.08	-9.41	<0.001
LDL-C (mg/dL)	89.83	21.34	106.99	29.54	-8.32	<0.001
HDL-C (mg/dL)	49.09	6.87	45.07	12.31	5.19	<0.001
TG (mg/dL)	71.15	16.24	119.28	67.52	-13.33	<0.001
Non-HDL-C (mg/dL)	104.06	21.67	130.84	36.23	-11.45	<0.001
TC/HDL-C	3.16	0.55	4.14	1.27	-13.21	<0.001
LDL-C/HDL-C	1.87	0.52	2.55	0.99	-11.13	<0.001
Non-HDL-C/HDL-C	2.16	0.55	3.14	1.27	-13.21	<0.001
TG/HDL-C	1.47	0.38	2.95	2.09	-13.54	<0.001
log10(TG/HDL-C)	0.16	0.10	0.38	0.27	-14.98	<0.001
LDL-C - HDL-C(mg/dL)	40.75	22.67	61.92	32.19	-9.52	<0.001

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