Trends in Pediatrics 2026;Early View:109-117
DOI: 10.59213/TP.2026.318

Research Article

Association of nutritional literacy and healthy lifestyle beliefs with metabolic control in adolescents with type 1 diabetes

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Cite this article as: Yılmaz M, Dikilitaş S, Atik Altınok Y, Gökşen D. Association of nutritional literacy and healthy lifestyle beliefs with metabolic control in adolescents with type 1 diabetes. Trends in Pediatrics 2026;Early View:109-117.

ABSTRACT

Objective: The study aims to evaluate the nutrition literacy and healthy lifestyle beliefs among adolescents with Type 1 Diabetes Mellitus (T1D) and identify their relationship to metabolic control.

Methods: This cross-sectional study included 153 adolescents aged 10-19 years who were being followed in the outpatient clinic of a tertiary hospital with a diagnosis of T1D for more than one year and had no comorbidities requiring dietary treatment. All participants completed the Adolescent Nutrition Literacy Scale (ANLS) and Healthy Lifestyle Belief Scale for Adolescents (HLBS) during a regularly scheduled medical visit. Hospital records yielded the last three months' HbA1c levels to assess metabolic control. Targeted metabolic control was defined as ≤7% HbA1c.

Results: The median age of the participants was 14.66 (4.42) years (45.8% were female), 58.2% had a normal BMI z-score, and 26.8% were achieving target HbA1c (≤7%). There was a positive correlation between the HLBS total score and the ANLS total score (r=0.39, p=0.001). The 'interactive' subfactor of ANLS, which evaluates the capacity to manage the process of nutrition in cooperation with nutrition and health professionals, was correlated with healthy lifestyle beliefs (r= 0.28, p= 0.001). Another ANLS subfactor, the 'critical' subfactor, which assesses the capacity to make critical judgments about nutrition-related information and to take actions to raise awareness in this area, was also correlated with healthy lifestyle beliefs (r = 0.37, p = 0.001). There was no difference between HLBS and ANLS total and subfactor scores between those who achieved (≤7%) and failed to achieve (>7%) the HbA1c target (p>0.05).

Conclusions: The findings of this study suggest that nutrition literacy is a notable determinant of the adoption of healthy lifestyle beliefs among adolescents with T1D. Further research with a larger sample is needed to investigate indirect effects on diabetes self-management and long-term metabolic outcomes.

Keywords: adolescents, type 1 diabetes mellitus, nutrition literacy, healthy lifestyle beliefs

INTRODUCTION

T1D is characterized by autoimmune destruction of pancreatic β-cells, leading to loss of endogenous insulin secretion.[1] Nutritional management is an essential component of diabetes education and care. For children and adolescents with T1D, the primary goals of nutritional management are to promote normal growth and development, healthy dietary habits that can sustain lifelong macro- and micronutrient needs, and achieve optimal glycemic control. It also aims to implement nutritional interventions to prevent or delay diabetes complications.[2]

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Received: 30.07.2025 **Accepted:** 30.12.2025

Adolescence is characterized by peak physical development, psychological and cognitive maturation, autonomy, and social independence. Rapid physical and sexual maturation creates a period of physiological and behavioral vulnerability. Hormonal changes that occur in adolescents are important for managing chronic diseases such as diabetes because they directly affect the physiology of glycemic control. Despite recent advances in diabetes technologies, achieving optimal glycemic control during adolescence remains a challenge. Adolescents with T1D are often more independent in their food choices and have more freedom over when and how much they eat. This can negatively impact their glycemic control and food choices.[3] Alterations in food consumption and eating disturbances—e.g., skipping meals, insufficient carbohydrates, consuming low-carbohydrate diets, or exercise performed without taking carbohydrate intake before, during, or after exercise—are risk factors for hypoglycemia, which is one of the most severe acute T1D complications. Postprandial hypoglycemia may also occur due to a mismatch between bolus insulin dose and carbohydrate intake-e.g., when insulin to carbohydrate ratio (ICR) is higher than the actual requirement, or when the ICR is accurate but carbohydrate intake is underestimated.[4] Therefore, providing continuous diabetes education to adolescents with T1D is essential in achieving glycemic targets, preventing complications, and promoting a healthy lifestyle. During this stage, healthy lifestyle habits may develop in adolescents following their exposure to nutrition information.[5-7] Physical activity levels, sociodemographic characteristics, nutritional status, and emotional and psychosocial well-being influence the attitudes and beliefs of adolescents toward healthy living. In this regard, building health-promoting behaviors might contribute to overall health. Adolescents with a higher level of nutrition literacy are more likely to possess greater food knowledge and the ability to make informed food choices, maintain adequate nutrition, and promote health preservation.[5,8-10] Nutrition literacy, defined as the capacity to obtain, process, and understand basic nutrition information for making appropriate dietary decisions, plays a crucial role in shaping adolescents' eating behaviors and overall diet quality.[9] Evidence indicates that higher nutrition literacy levels are associated with healthier food choices, better adherence to dietary guidelines, and improved heart health attitudes among adolescents.[11] In addition to cognitive skills, behavioral and motivational factors, such as healthy lifestyle beliefs and self-efficacy, also strongly influence adherence to diabetes self-care practices. Adolescents who possess greater confidence in their ability to maintain healthy routines are more likely to follow dietary recommendations and perform consistent self-management behaviors, contributing to optimal metabolic outcomes.[12] Despite these associations, few studies have simultaneously examined the interplay between nutrition literacy, healthy lifestyle beliefs, and metabolic control among adolescents with T1D. Exploring these relationships may enhance the development of a comprehensive intervention framework. For this purpose, the present study aimed to assess the nutrition literacy level in adolescents with T1D, identify their attitudes and motivations towards healthy lifestyle beliefs, and examine the relationship among these factors and metabolic control. We hypothesized that adolescents with higher nutrition literacy and stronger healthy lifestyle beliefs would exhibit more favorable metabolic outcomes.

MATERIALS and METHODS

This descriptive, cross-sectional study was conducted in the Department of Pediatrics, Division of Pediatric Endocrinology and Diabetes, Faculty of Medicine, Ege University, from November 2023 to May 2024, with 167 adolescents with T1D aged 10-19 years. All participants answered an ANLS and HLBS during regularly scheduled medical visits. The purpose of the study was explained to each participant, and written informed consent was obtained from all participants and their parents. Patients' records were reviewed for the following criteria: duration of T1D≥ 1 year, no major medical problems requiring dietary treatment (e.g., celiac disease), and no psychiatric disorders or communication difficulties. Finally, the data of 153 participants who met the eligibility criteria and responded to all items of the ANLS and HLBS were included in the analysis. The sample size was calculated using a power analysis (G*Power 3.1) based on previous literature. An expected small effect size of 0.2, a desired statistical power of 80%, and a Type I error rate of 0.05 were set. This analysis indicated a minimum required sample size of 146 participants. To account for a predicted 15% attrition rate, we aimed to enroll a total of 167 participants. The study was conducted in accordance with the Helsinki Declaration and was approved by the İzmir Tınaztepe University Non-Intervention Research Ethics Committee (Prot. no. 2023/19).

Anthropometric evaluation

Height was measured to the nearest millimeter using a Seca 264® stadiometer. Weight was measured unclothed using an electronic scale to the nearest 100 g (Desis Model

KW®). Body mass index (BMI) was calculated by the weight (kg)/ height (m^2) equation. Standard deviation scores (SDS) for weight, height, and BMI were calculated according to gender and age using reference values for Turkish children and adolescents by using Child Metrics.[13] The participants were categorized into four groups: underweight (BMI-SDS <-1), normal weight (BMI-SDS≥-1 - <+1), overweight (BMI-SDS ≥+1 to <+2), and obese (BMI-SDS ≥+2).[14]

Glycemic control

HbA1c was measured by turbidimetric inhibition immunoassay (Roche Cobas c513 analyzer using the Tina quant® HbA1c Gen. 3 assay, Germany). Participants were categorized into two groups based on their HbA1c levels, as either achieved or non-achieved HbA1c targets, according to the HbA1c target (≤7%) recommendations of the American Diabetes Association (ADA) and the International Society of Pediatric and Adolescent Diabetes (ISPAD).[15,16]

Adolescent nutrition literacy scale

The 'Adolescent Nutrition Literacy Scale (ANLS)' was utilized to measure participants' nutrition literacy. ANLS was developed by Bari in 2012[17], and the Turkish reliability and validity were established by Türkmen et al.[18] in 2017. ANLS, a five-point Likert-type scale, consists of 22 items with three subfactors: 'functional nutrition literacy', 'interactive nutrition literacy', and 'critical nutrition literacy'. 'Functional nutrition literacy' evaluates an individual's ability to read, comprehend, and write basic nutrition information, 'interactive nutrition literacy' measures the capacity to manage the process of nutrition in cooperation with nutrition and health professionals, and 'critical nutrition literacy' assesses the capacity to make critical judgments about nutrition-related information and to take action leading to awareness in this domain. The total score on the scale is 22-110, and greater scores indicate increased levels of nutrition literacy. The Turkish version of ANLS has been shown to have good internal consistency (Cronbach's alpha = 0.80).[17,18]

Healthy lifestyle belief scale for adolescents

The Healthy Lifestyle Belief Scale for Adolescents (HLBS) was developed by Kelly et al.[19], and a Turkish validity and reliability study was conducted by Kudubeş and Bektaş.[20] This scale is used to assess adolescents' beliefs towards various aspects of having a healthy lifestyle. HLBS on a five-point Likert-type scale contains 16 items with three subscales: 'health beliefs', 'physical activity', and 'nutrition'. 'Health beliefs' subfactor assesses general attitudes and beliefs related to a healthy way of life, e.g., self-efficacy in making choices on health-related issues and believing one can set up and achieve health goals, 'physical activity' subfactor identifies physical activity-related beliefs and attitudes, including perceived benefits of regular exercise, emotional and physical restoration effects of active living and 'nutrition' subfactor assesses healthy eating behaviors beliefs, where it tracks the selection of healthy snacks, consumption of nutrient-dense foods regularly, and identification of favorable health effects of eating habits. Total score ranges from 16 to 80, where higher scores indicate greater beliefs in adherence to a healthy lifestyle. The original HLBS and Turkish versions have shown good internal consistency (respectively, Cronbach's alpha=0.89, Cronbach's alpha=0.90).[19,20]

Statistical analysis

Normal distribution was tested for quantitative variables by the Shapiro-Wilk test. Quantitative variables with normal or skewed distribution were presented as mean±SD or median (IQR). Qualitative data were presented as frequencies (n) and percentages (%). Group differences were investigated using the Mann–Whitney U and Kruskal–Wallis tests. Post-hoc pairwise comparisons were tested using the Bonferroni correction. The chi-square test was used to investigate the association between categorical variables. Correlation analyses were used to explore relationships between HLBS total score, and other constructs hypothesized to covary with HLBS score such as ANLS total score, ANLS subfactor scores, diabetes duration and HbA1c, in line with Cohen, correlations of 0.10–0.29 were interpreted as small, 0.30–0.49 as a medium, and 0.50–1.0 as large.[21] All results were verified on a confidence level of 95%, and the significance level was defined as $p < 0.05$. Statistical analyses were conducted using Statistical Package for the Social Sciences version 25.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

The mean age of the participants was 14.66 ± 4.42 years (45.8% were female), 58.2% had a normal BMI z-score, and 26.8% were achieving target HbA1c (≤7%). The median HbA1c levels in MDI users and IIPT users were 8.3% (2.1) and 7.5% (1.6), respectively ($p = 0.04$). The characteristics of the participants are detailed in Table 1.

Table 1. Characteristics of participants

Variables	All (n=153)	Female (n=70)	Male (n=83)
Age (years)*	14.66 (4.42)	14.43 (4.17)	14.43 (4.17)
Diabetes duration (years)*	5 (6.3)	6.35 (6)	5.50 (6)
BMI z-score*	0.15 (1.67)	0.11 (1.48)	0.50 (1.61)
HbA1c (%)*	8.05 (2.2)	8.27 (2)	8.48 (2.5)
Insulin (U/kg/day)**	0.86±0.29	0.88±0.27	0.85±0.31
Basal insulin%*	40.5 (15)	39.16 (15)	43.16 (16.3)
Bolus insulin%*	59 (15)	59.46 (16)	56.76 (16)
Treatment model* **			
IIPT	53 (34.6)	24 (34.3)	29 (34.9)
MDI	100 (65.4)	46 (65.7)	54 (65.1)
BMI* **			
Underweight	24 (15.7)	14 (20)	10 (12)
Normal weight	89 (58.2)	46 (65.7)	43 (51.8)
Overweight	26 (17)	8 (11.4)	18 (21.7)
Obese	14 (9.2)	2 (2.9)	12 (14.5)
Metabolic Control* **			
HbA1c ≤7%	41 (36.6)	20 (28.6)	21 (25.3)
HbA1c >7%	112 (63.4)	50 (71.4)	62 (74.7)
HLBS total score*	71.0 (14.0)	69.79 (9)	62.24 (15.3)
Belief subfactor	31.0 (6.0)	30.56 (4)	30.32 (7.3)
Physical Activity subfactor	23.0 (6.8)	22.07 (4.3)	20.07 (9)
Nutrition subfactor	17.0 (6.0)	16.87 (5)	15.84 (7)
ANLS total score *	68.0 (15.0)	66.13 (14)	66.96 (16.5)
Functional subfactor	15.0 (9.8)	16.34 (10)	14.43 (9.5)
Interactive subfactor	18.0 (8.0)	18.37 (6)	19.05 (8.3)
Critical subfactor	33.0 (10.0)	31.41(8)	33.47(12.3)

*Data presented as median (IQR) **Data presented mean ± SD ***Data presented n (%), IIPT: Insulin infusion pump therapy, MDI: Multiple dose injection. BMI: Body Mass Index, HLBS: Healthy Lifestyle Belief Scale, ANLS: Adolescent Nutrition Literacy Scale.

The median scores obtained with the ANLS for the total sample, females, and males were 68.0 (15.0), 68.0 (14.0), and 68.0 (17.0), respectively, and there was no difference between females and males (p>0.05). It was observed that females had a higher ANLS functional subfactor score, and males had a higher critical subfactor score (p<0.05).

The median scores obtained with HLBS for the total sample, females, and males were 71.0 (14.0), 72.0 (10.0), and 70.0 (16.0), respectively, and there was no difference between genders (p>0.05); however, females had a higher physical activity subfactor score than males (p<0.05).

There were no differences between the HLBS total score, ANLS total score, and their subfactor scores between those who achieved the HbA1c target and those who did not (p>0.05).

While there were no differences in median ANLS total scores and subfactor scores according to treatment models, both the HLBS median total score and the ‘nutrition’ subfactor median score were higher in those on multiple dose insulin therapy (MDI) (p=0.02, p=0.01, respectively).

Obese participants had lower total and subfactor scores on the HLBS (p<0.05) (Table 2).

There was a small-sized correlation between age and both ANLS (r=-0.24, p<0.01) and HLBS (r=-0.21, p<0.01) total scores, while diabetes duration was small-sized correlated only with ANLS total score (r=-0.21, p<0.01).

Table 2. Comparison of ANLS and HLBS scores and subfactors by group characteristics

	ANLS	p	Functional	p	Interactive	p	Critical	p	HLBS	p	Health beliefs	p	Physical Activity	p	Nutrition	p
Gender																
Female	68 (14)	0.74	16 (10)	0.01*	18 (6)	0.59	31 (8)	0.02*	72 (10)	0.18	31 (5)	0.86	24 (4)	0,03*	18 (5)	0.23
Male	68 (17)		13 (10)		19 (8)		36 (11)		70 (16)		32 (8)		22 (9)		17 (7)	
BMI																
Underweight	68 (15)	0.24	13 (10)	0.82	18 (11)	0.62	31 (5)	0.70	72 (13)	0.02 **	31 (5)	0.03**	22 (6)	0.001**	18 (5)	0.001**
Normal	68 (16)		15 (9)		19 (8)		36 (9)		72 (12)		32 (5)		24 (4)		18 (5)	
Overweight	67 (12)		16 (11)		18 (4)		31 (10)		69 (15)		30 (5)		22 (7)		16 (7)	
Obese	66 (27)		13 (8)		15 (8)		31 (15)		50 (24)		26 (8)		13 (10)		12 (7)	
HbA1c (%)																
≤7	65 (15)	0.71	13 (10)	0.46	20 (7)	0.75	32 (9)	0.46	67 (13)	0.27	30 (6)	0.14	21 (6)	0.45	17 (5)	0.19
> 7	68 (14)		15 (10)		18 (8)		33 (10)		72 (14)		32 (6)		23 (6)		18 (6)	
Treatment model																
IIPT	67 (15)	0.30	14 (8)	0.38	18 (7)	0.65	33 (9)	0.56	68 (16)	0.02*	30 (9)	0.09	21 (6)	0.17	16 (7)	0.01*
MDI	69 (15)		14 (10)		18 (7)		34 (10)		72 (12)		32 (5)		23 (6)		18 (5)	

Data presented median (IQR) BMI: Body Mass Index, HLBS: Healthy Lifestyle Belief Scale, ANLS: Adolescent Nutrition Literacy Scale, IIPT: Insulin infusion pump therapy, MDI: Multiple dose injection
*Mann-Whitney U test, **Kruskal-Wallis test.

Table 3. Correlations between HLBS, ANLS, and subfactors

	1	2	3	4	5	6	7	8
1- HLBS	1							
2- Health beliefs	0.82*	1						
3- Physical Activity	0.80*	0.49*	1					
4- Nutrition	0.82*	0.61*	0.53*	1				
5- ANLS	0.39*	0.33*	0.30*	0.42*	1			
6- Functional	-	-	-	-	-	1		
7- Interactive	0.28*	0.18**	0.23**	0.33**	0.65*	-	1	
8- Critical	0.37*	0.37*	0.33*	0.32*	0.75*	-	0.50*	1

Spearman correlation, *p <0.05, **p <0.01, HLBS: Healthy Lifestyle Belief Scale, ANLS: Adolescent Nutrition Literacy Scale.

Medium-sized correlation existed between the HLBS and the ANLS (r=0.39, p=0.001). HLBS and ANLS scores have different degrees of relationship for all the subfactors except for the functional subfactor of the ANLS (Table 3).

DISCUSSION

To our knowledge, this is the first study to evaluate nutrition literacy, healthy lifestyle beliefs, and their relationship with metabolic control in adolescents with T1D. In adolescents with T1D, interactive and critical nutrition literacy, in particular, is associated with healthier lifestyle beliefs. However, these beliefs or literacy levels were not directly associated with HbA1c. This suggests that literacy is linked to an individual's ability to access, evaluate, and use information in daily decisions, rather than metabolic control. The current study's median ANLS total score was consistent with previous studies conducted with healthy populations.[11,22-24]

Although previous research has reported higher ANLS scores in adolescent girls, in our sample of adolescents with T1D, unlike previous studies, the median ANLS score did not differ by gender. The authors speculated that this may be related to children and adolescents with T1D receiving structured nutrition education appropriate for their age, and that non-T1D adolescents are less interested in nutrition-related issues than girls. The study demonstrated that higher levels of nutrition literacy among adolescents with T1D were associated with stronger healthy lifestyle beliefs. Notably, the 'interactive' and 'critical' subfactors of nutrition literacy—which encompass communication with healthcare professionals, nutritional self-management skills, critical evaluation of nutrition-related information, and awareness—were observed to result in increased healthy lifestyle beliefs. This suggests that these competencies may contribute to more effective diabetes management. Although the research indicates a lack of consensus regarding the factors influencing adolescents' healthy lifestyle behaviors, evidence from a randomized controlled trial has shown that improving health literacy in this population enhances nutritional behaviors.[25-27] A study conducted with 810 adolescents in Turkey demonstrated a moderate association between healthy eating and exercise behaviors and health literacy.[28] Another study investigating the nutrition literacy levels of young adults with T1D and its relationship with disease-related emotional burden found that, although nutritional knowledge was generally adequate, the emotional burden associated with the disease may negatively impact nutritional behaviors and social interactions.[29] Lindbloom et al.[30] reported that nutrition literacy was associated with motivation for healthy eating, which was reflected in actual eating behaviors in the general population. This study found no significant relationship between metabolic control in adolescents with T1D and nutrition literacy and healthy lifestyle beliefs. This finding suggests that metabolic control cannot be explained solely by an individual's level of nutrition literacy and beliefs about a healthy lifestyle, and suggests that more complex psychosocial processes underlie behaviors. The literature defines this phenomenon as the "intention-behavior gap". It is associated with environmental and psychosocial factors that prevent individuals' positive intentions for healthy living from being translated into behavior.[30]

Especially during adolescence, peer influence, the need for social acceptance, and group affiliation may play a stronger role than cognitive beliefs in guiding individuals' self-care behaviors.[31,32] Adolescents with T1D may neglect self-care behaviors necessary for diabetes management (e.g., insulin administration, glucose monitoring, or adherence to a nutritional management plan) due to reasons such as fear of social exclusion, a desire to fit in with their peer group, or an effort to "not look different"[33,34] These findings suggest that interventions by health professionals to support metabolic control should focus on information transfer, peer relationships, social support systems, and psychosocial empowerment approaches. In this context, peer support groups, cognitive-behavioral-based education programs, and self-efficacy-enhancing psychosocial interventions for adolescents with T1D are thought to be effective in strengthening metabolic control and self-care behaviors[35] Sociodemographic factors, such as age and gender, are known to affect the dietary habits of adolescents.[11] In our study, age was inversely associated with nutrition literacy and healthy lifestyle beliefs. Contrary to our findings, studies show that age has a positive or no effect at all. It has been discussed that age and other influencing factors (gender, physical activity, BMI) should be evaluated together. [10,26,32,33] The literature indicates that female adolescents tend to score higher than males in terms of nutrition literacy.[9,17] Unlike the previous studies, in this study, females had a higher median score on the 'functional' subfactor of the ANLS, which provides information about the ability to process basic nutrition information, while males had a higher median score on the 'critical' subfactor, which provides information about the ability to evaluate nutrition-related content critically and take action to increase awareness in this area ($p<0.05$). In our study, MDI users had higher ANLS 'nutrition' subfactor scores than insulin infusion pump therapy (IIPT) users. This subfactor includes items assessing healthy dietary choices, regular consumption of nutrient-dense foods, and the positive health effects of dietary habits. Despite receiving the same structured nutrition education, the difference between these two treatment groups was interpreted as follows: Individuals with T1D who use both MDI and insulin infusion pumps achieve better metabolic control through the practice of accurate carbohydrate counting.[36] Insulin infusion pumps, bolus types (such as extended bolus, square bolus), and/or algorithms (such as low glucose suspend, automatic bolus, and safe meal bolus) have the potential to compensate for errors in carbohydrate counting or to cover the postprandial glycemic response caused by high-fat and protein foods. However, MDI users should pay more attention to healthy food choices and carbohydrate counting to maintain an optimal postprandial glycemic response. This attention may have led to an increase in interest in these subjects and an increase in nutrition literacy.

Obesity during childhood and adolescence is a multifactorial condition arising from the interplay of genetic predisposition, unhealthy dietary habits, insufficient physical activity, and psychosocial factors. Therefore, education programs focusing on physical activity, nutrition, and lifestyle modification in adolescents are crucial for promoting comprehensive health improvements.[37,38] For young people with T1D, other possible causes of obesity include over-insulinization, excess energy intake to avoid or treat hypoglycemia, and additional carbohydrate consumed for exercise. In addition to these, consumption of low-carbohydrate, high-fat diets to reduce postprandial glucose excursions and chronic exposure of peripheral tissue to non-physiologic hyperinsulinemia via subcutaneous insulin injections or insulin infusion pump therapy may lead to increased adipose tissue in the periphery.[39,40]

Consistent with our findings, several studies conducted with adolescents have reported no relationship between nutrition literacy and BMI.[41,42] Although there was no relationship between nutrition literacy and BMI, in our study, it is noteworthy that obese adolescents with T1D had the lowest HLBS scores compared to those with underweight, normal, or overweight ones. It may be a sign that beliefs and habits related to healthy living, physical activity, and nutrition tend to be lower among individuals with obesity. However, in our sample, overweight/obese participants the low ratio may have contributed to this result and should be interpreted with caution. Furthermore, the association between physical activity levels and dietary habits reported in a study involving healthy adolescents from 89 countries supports the relationships observed between the HLBS subfactors in our study.[43] Therefore, comparisons can be drawn with research investigating the relationship between health literacy and metabolic parameters in adolescents with T1D. Existing literature suggests a positive association between health literacy and metabolic control, and an indirect relationship with insulin dose optimization, although a direct link has not been established.[44,45]

The limitation of this study is that it was conducted as a single-center study in a tertiary hospital outpatient clinic. This limits the generalizability of the findings, as the sample came from a specific geography and had similar follow-up standards. Furthermore, data on participants' socioeconomic status were not collected, which is another factor that may affect sample homogeneity. Additionally, food and physical activity diaries were not assessed in this study, limiting the practical interpretation of healthy lifestyle beliefs and nutrition literacy. It is recommended that future studies address these limitations to increase generalizability. Another limitation of this study is that metabolic control was assessed using only HbA1c. The inclusion of additional metabolic parameters, such as hypoglycemia frequency and continuous glucose monitoring metrics (time in range, time above range, time below range, glycemic variability, etc.) in future research may provide more comprehensive information on the association of nutrition literacy and healthy lifestyle beliefs with metabolic control in adolescents with T1D.

In conclusion, further studies are needed to evaluate nutrition literacy and/or healthy lifestyle beliefs among adolescents with T1D. Research in this area will help address existing gaps in the literature and provide valuable insights to guide the education of self-care strategies and nutritional management.

Acknowledgements

The authors would like to sincerely thank all participants of this study.

Author contributions

Conception and design: M.Y., Y.A.A., S.D., D.G.; Data acquisition: S.D., Y.A.A.; Data analysis: M.Y.; Data interpretation: M.Y.; Drafting of the manuscript: M.Y., Y.A.A., D.G. All authors reviewed the results, approved the final version of the manuscript, and agreed to be accountable for all aspects of this study.

Ethical approval

This study was approved by the Izmir Tınaztepe University Non-Intervention Research Ethics Committee (Decision/ Protocol No: 2023/19). Informed consent was obtained from all participants involved in this study.

Conflict of interest

The authors declare that this study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Funding

The authors declare that this study received no funding.

Generative AI statement

The authors declare that no generative AI or AI-assisted technologies were used in the writing or preparation of this study.

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