Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Food Insecurity, Sleep Quality, and Quality of Life in Adolescents with Type 1 Diabetes: A Cross-Sectional Study

Kubra Esin
dytkubraesin@gmail.com
Gazi University
Emine Yassibas
Gazi University
Neslihan Arslan
Sağlık Bilimleri Üniversitesi
Feride Ayyildiz
Gazi University
Sena Caliskan
Üsküdar University
Hande Turan
Istanbul University Cerrahpaşa
Elvan Bayramoglu
Istanbul University Cerrahpaşa
Olcay Evliyaoglu
Istanbul University Cerrahpaşa
Didem Gunes Kaya
Istanbul University Cerrahpaşa

Research Article

Keywords: Type 1 diabetes, adolescents, food security, sleep quality, life quality

Posted Date: June 15th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9813237/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

TITLE PAGE

Title: Food Insecurity, Sleep Quality, and Quality of Life in Adolescents with Type 1 Diabetes: A Cross-Sectional Study

Kübra ESİN[1] Emine YASSIBAŞ[2] Neslihan ARSLAN[3], Feride AYYILDIZ[4], Sena ÇALIŞKAN[5], Hande TURAN [6], Elvan BAYRAMOĞLU [7], Olcay EVLİYAOĞLU [8], Didem GÜNEŞ KAYA[9]

[1] Gaziosmanpaşa University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Tokat, Türkiye
e-mail: dytkubraesin@gmail.com ORCID: 0000- 0002- 2687-1811

[2] Gazi University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Ankara, Türkiye
e-mail: eyassibas@gazi.edu.tr ORCID: 0000-0002-8784-3371

[3] Sağlık Bilimleri University, Gülhane Faculty of Health Sciences, Department of Nutrition and Dietetics, Ankara, Türkiye
e-mail: akdeniz.neslihan91@gmail.com ORCID: 0000-0002-1232-8009

[4]Gazi University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Ankara, Türkiye
e-mail: feridecelebi@gazi.edu.tr ORCID: 0000-0003-2828-3850

[5] Uskudar University,Faculty of Health Sciences, Department of Nutrition and Dietetics,Istanbul, Türkiye
e-mail:senacaliskansena1@gmail.com ORCHID: 0009-0001-5686-3628

[6]Istanbul University, Cerrahpasa-Cerrahpasa Faculty of Medicine, Pediatric Endocrinology, İstanbul, Türkiye
e-mail: hande.turan@ iuc.edu.tr ORCID: 0000-0003-0121-3756

[7]Istanbul University, Cerrahpasa-Cerrahpasa Faculty of Medicine, Pediatric Endocrinology, İstanbul, Türkiye
e-mail: elvan.bayramoglu@iuc.edu.tr ORCID: 0000-0002-6732-8823

[8]Istanbul University, Cerrahpasa-Cerrahpasa Faculty of Medicine, Pediatric Endocrinology, İstanbul, Türkiye
e-mail: olcay.evliyaoglu@iuc.edu.tr ORCID: 0000-0003-4851-8637

[9] Istanbul University, Cerrahpasa-Cerrahpasa Faculty of Medicine, Pediatrics, İstanbul, Türkiye
e-mail: didemguneskaya@iuc.edu.tr ORCID: 0000-0003-0791- 916X

Kübra Esin is the corresponding author of this study.
e-mail: dytkubraesin@gmail.com

Abstract

Purpose

Household food insecurity may adversely affect well-being in adolescents with type 1 diabetes (T1D). This study examined the associations of household food insecurity with sleep quality and diabetes-specific quality of life.

Methods

This cross-sectional study, included 114 adolescents aged 13–18 years with T1D and their parents. Household food insecurity was assessed using the 18-item U.S. Household Food Security Survey Module (HFFSM), sleep quality was assessed using the Sleep Quality Scale and Sleep Variables Questionnaire (SQS-SVQ) and diabetes-specific quality of life using the Pediatric Quality of Life Inventory Diabetes Module (PedsQL™ 3.0), including adolescent self-report and parent-proxy versions. Body weight and height of adolescents were measured, and body mass index-for-age z-scores (BAZ) were calculated.

Results

Among the participants, 76.3% were classified as food secure, while 23.7% were identified as food insecure. Adolescents with food security had better sleep quality than those with food insecurity, indicated by lower SQS scores (11.9±2.37 vs. 13.3±2.82, p=0.016). Adolescent-reported total PedsQL™ scores were lower in the food-insecure group (76.9[65.5-82.2] vs. 87.3[70.5-92.1], p=0.014), as were Diabetes Symptoms subscale scores (63.6 [50.0–72.8] vs. 72.7 [59.1–84.1], p=0.012) and Worry subscale scores (83.3[62.5-91.7] vs. 91.7[66.7-100.0], p=0.031). Parent-proxy reports similarly showed lower total PedsQL™ scores (62.1±13.38 vs. 69.7±14.70, p=0.019) and lower Diabetes Symptoms scores in the food-insecure group ($p<0.05$). Food security scores were weakly correlated with adolescent-reported (r=-0.233, p=0.013) and parent-reported (r=-0.258, p=0.006) total PedsQL™ scores. Poorer sleep quality was consistently associated with lower quality of life across multiple domains.

Conclusion

Food insecurity was observed in nearly one-quarter of adolescents with T1D and was associated with poorer sleep quality and lower diabetes-specific quality of life. Sleep health and

socioeconomic vulnerability should both be considered in comprehensive pediatric diabetes care.

Keywords: Type 1 diabetes, adolescents, food security, sleep quality, life quality

INTRODUCTION

Adolescents with type 1 diabetes (T1D) must navigate complex daily self-management tasks, including insulin administration, glucose monitoring, meal planning, and lifestyle adjustments, while also undergoing rapid physical, psychological, and social development [1]. Globally, an estimated 9.5 million individuals are living with T1D, including substantial numbers of children and adolescents, and this burden is projected to increase further in the coming decades [2]. Effective management of T1D requires lifelong insulin replacement therapy, along with regular glucose monitoring, nutritional management, and lifestyle modifications, to achieve glycaemic targets and reduce the risk of acute and long-term complications [3]. Because optimal T1D care depends on both matching insulin to meals and maintaining healthy dietary patterns, consistent access to nutritious food is essential for adolescents with T1D. However, this may be particularly challenging for individuals experiencing food insecurity [4].

Food insecurity is defined as limited or uncertain access to sufficient, safe, and nutritious foods [5]. In youth with T1D, food insecurity has been associated with significantly higher odds of poorer glycaemic control, increased emergency department visits, and a greater risk of acute complications such as diabetic ketoacidosis and severe hypoglycemia [6-8]. Several mechanisms may explain the association between food insecurity and diabetes outcomes. Families experiencing food insecurity may rely on inexpensive, energy-dense foods high in refined carbohydrates and added sugars or experience irregular meal patterns due to inconsistent food availability. These dietary disruptions can complicate insulin dosing and lead to fluctuations in blood glucose levels, increasing the risk of both hyperglycemia and hypoglycemia. In addition, competing financial demands may force individuals to prioritize food over medical expenses, potentially resulting in reduced medication adherence or delayed healthcare visits. Food insecurity is also associated with chronic stress and anxiety, which may further worsen glycaemic outcomes through adverse mental health effects [4, 9]. Beyond metabolic outcomes, food insecurity has been linked to poorer psychosocial outcomes among individuals with diabetes, including lower physical and mental health-related quality of life, poorer overall health, lower life satisfaction, and higher levels of depression and diabetes-related distress [10, 11].

Sleep represents another important, but frequently overlooked, component of diabetes management. In adolescents with T1D, sleep may be disrupted by nocturnal hypoglycemia or hyperglycemia, glucose alarms, treatment demands, and diabetes-related stress [12-15]. Poor

sleep quality or insufficient sleep has been associated with impaired mood, reduced cognitive functioning, lower treatment adherence, and suboptimal glycaemic outcomes [15, 16]. Food insecurity may further exacerbate sleep disturbances through psychosocial stress, inconsistent meal timing, and lower dietary quality [12]. These overlapping biological, behavioral, and socioeconomic influences may have important implications for daily functioning and perceived well-being.

Adolescence is a particularly vulnerable developmental period for individuals with T1D. Pubertal hormonal changes, increasing autonomy, psychosocial pressures, and challenges with treatment adherence may complicate diabetes management during this stage of life [17]. Despite advances in care, many adolescents remain above recommended glycaemic targets and continue to experience a substantial psychosocial burden [16]. Although previous studies have separately examined food insecurity, sleep, and psychosocial outcomes in adolescents with T1D, evidence evaluating these interrelated factors simultaneously remains limited.

Therefore, this study aimed to determine the level of food insecurity and to investigate its relationship with sleep quality and quality of life among adolescents with T1D.

METHODS

Study Design and Sample

This cross-sectional study included 114 adolescents aged 13–18 years diagnosed with T1D and their parents. Participants were recruited from the Pediatric Endocrinology and Diabetes Clinic of Istanbul University-Cerrahpasa Faculty of Medicine between November 2025 and March 2026.

Adolescents were eligible if they were aged 13–18 years, had been diagnosed with T1D for at least six months, and were under follow-up at the study clinic. Adolescents with another chronic disease, cognitive impairment that could interfere with questionnaire completion, or incomplete study questionnaires were excluded. Participation was voluntary, and anonymity was ensured throughout the study.

A priori sample size calculation was performed using G*Power version 3.1.9.7. Because the study aimed to evaluate the associations among food insecurity, sleep quality, and quality of life, a two-tailed correlation analysis was used as the basis for sample size estimation. Assuming a medium effect size ($r=0.30$), a type I error rate of 5% ($\alpha=0.05$), and 85% statistical power

(1−β=0.85), the minimum required sample size was calculated as 96 participants. The final sample included 114 adolescents and their parents.

Data were collected face-to-face using a structured questionnaire. The questionnaire included sociodemographic and household characteristics, diabetes-related clinical information, meal patterns, sleep-related variables, food security status, and diabetes-specific quality of life. Anthropometric measurements were obtained during the study visit. HbA1c values were obtained from patients' medical records, using the most recent value available at the time of data collection. In addition to adolescent self-reports, parents completed questionnaire items regarding household characteristics, food security status, and the parent-proxy version of the PedsQL™ 3.0 Diabetes Module.

Measures

U.S. Household Food Security Survey Module (HFSSM)

Household food insecurity was assessed using the 18-item U.S. Household Food Security Survey Module (HFSSM) developed by the United States Department of Agriculture (USDA), which evaluates household food security status during the previous 12 months (USDA, 2012). Affirmative responses to the 18 items were summed to obtain a total score ranging from 0 to 18, with higher scores indicating greater severity of food insecurity. According to USDA guidelines for households with children, food security status was classified as high (0), marginal (1–2), low (3–7), or very low (8–18) [18]. For statistical analyses, high and marginal food security were combined and defined as "food secure," while low and very low food security were combined and defined as "food insecure.

The Turkish validity and reliability study of the scale was conducted by Tatlılıoğlu [19]. In the present study, Cronbach's α was 0.923, indicating very good reliability.

Sleep Quality Scale and Sleep Variables Questionnaire (SQS-SVQ)

Sleep quality and sleep-related variables were also assessed using the Sleep Quality Scale and Sleep Variables Questionnaire (SQS-SVQ) developed by Meijer and van den Wittenboer [20]. The instrument includes items assessing sleep quality, as well as sleep-related variables such as parental control, total sleep time, sleep midpoint, and sleep efficiency. Sleep quality items are rated on a three-point scale, and total scores range from 7 to 21, with higher scores indicating poorer sleep quality.

The Turkish validity and reliability study of the scale was conducted by Önder et al. [21]. In the present study, Cronbach's α coefficient for the SQS was 0.721, indicating acceptable internal consistency.

Pediatric Quality of Life Inventory Diabetes Module (PedsQL™ 3.0 Diabetes Module)

Quality of life was assessed using the Pediatric Quality of Life Inventory Diabetes Module (PedsQL™ 3.0 Diabetes Module) developed by Varni et al. [22]. The scale consists of 28 items organized into five subscales, including diabetes symptoms, treatment barriers, treatment adherence, worry, and communication. Each item is rated on a five-point Likert scale ranging from 0 (never a problem) to 4 (almost always a problem). For scoring, items are reverse-scored and linearly transformed to a 0–100 scale, with higher scores indicating better quality of life. In the present study, both the adolescent self-report version (13–18 years) and the parent-proxy version of the scale were used [22].

The Turkish validity and reliability of the scale were established by Çövener Özçelik and Aktaş [23], who reported Cronbach's alpha values of 0.92 for the child self-report and 0.88 for the parent proxy-report. In the original PedsQL™ 3.0 Diabetes Module, five subscales were identified based on exploratory factor analysis. However, in the Turkish validity and reliability study, the "treatment barriers" and "treatment adherence" subscales were combined into a single "treatment" subscale due to their conceptual similarity and overlap in item content. Therefore, the Turkish version of the instrument comprises four subscales: diabetes symptoms, treatment, worry, and communication. In the present study, Cronbach's α was 0.910 for the child self-report and 0.861 for the parent proxy-report.

Anthropometric Measurements

Anthropometric measurements were obtained from both adolescents and their parents. Body weight and height were measured, by trained staff using an ultrasonic measuring station (seca 287, seca GmbH & Co. KG, Hamburg, Germany), with participants wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m²). For adolescents, BMI-for-age z-scores were calculated using WHO AnthroPlus software for individuals aged 5–19 years [24]. Nutritional status was classified according to WHO growth reference standards as severe thinness (< −3 SD), thinness (< −2 SD), normal weight (≥ −2 SD to ≤ +1 SD), overweight (> +1 SD), and obesity (> +2 SD) [25].

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 31. Continuous variables were presented as mean ± standard deviation or median [interquartile range], depending on distribution, and categorical variables were presented as frequencies and percentages. The normality of continuous variables was evaluated using the Kolmogorov–Smirnov test. Comparisons between food-secure and food-insecure groups were performed using an independent samples t-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed continuous variables. Categorical variables were compared using the chi-square test or Fisher–Freeman–Halton exact test, as appropriate.

Adolescent- and parent-reported PedsQL™ 3.0 Diabetes Module total scores were compared using the Wilcoxon signed-rank test, as the data were not normally distributed. Agreement between adolescent and parent reports was evaluated using the intraclass correlation coefficient (ICC), based on a two-way mixed-effects model with absolute agreement. Relationships among HFSSM scores, SQS scores, PedsQL™ scores, BMI-for-age z-scores, and HbA1c were assessed using Pearson or Spearman correlation coefficients, depending on variable distribution. A two-sided p-value <0.05 was considered statistically significant.

Ethical Approval Ethical approval for the study was obtained from the Ethics Committee for Social and Human Sciences Research of Tokat Gaziosmanpaşa University (Decision No: 01-31, Date: 10.10.2025) prior to data collection. The study was conducted in accordance with the principles of the Declaration of Helsinki. All participants were informed about the study's purpose, and written informed consent was obtained from both adolescents and their parents before participation.

RESULTS

The study included 114 adolescents with T1D, 53 males (46.5%) and 61 females (53.5%), aged 13–18 years. Overall, 87 participants (76.3%) were classified as food secure and 27 (23.7%) as food insecure (Figure 1). The general characteristics, meal patterns, and diabetes-related variables of participants by food security status are presented in Table 1. The groups differed significantly in monthly household income, perceived income–expense balance, and self-reported economic status ($p<0.05$). The proportion of adolescents with at least one emergency department visit in the past six months was higher in the food-insecure group than in the food-secure group (37.0% vs. 14.9%, $p=0.012$). No significant differences were observed between

groups in other sociodemographic characteristics, meal patterns, anthropometric status, insulin delivery method, HbA1c, hospital visits, or hospitalization status ($p>0.05$).

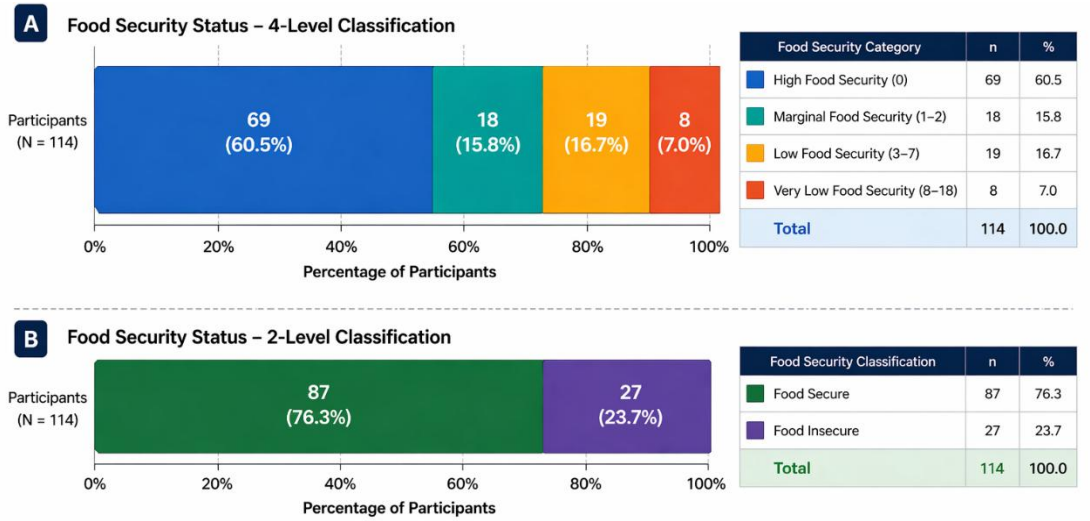


Figure 1. The distribution of food security status among adolescents with type 1 diabetes

Table 1. Sociodemographic characteristics, meal patterns, and diabetes-related variables of participants according to food security status

Variable	Food Secure (n=87)	Food Insecure (n=27)	p-value
Gender, male n(%)*	38 (43.7%)	15 (55.6%)	0.280
Age, mean ± SD (median [IQR]) ¥	15.9±1.77 (16[15-18])	15.2±2.13(14[13-17,5])	0.079
Maternal age, mean ± SD**	44.2±5.01	43.1±5.41	0.280
Paternal age, mean ± SD**	47.9±5.75	47.2±6.56	0.317
Maternal education level, n (%)*			
Illiterate	3 (3.5%)	3 (11.1%)	
Primary school	28 (32.2%)	12 (44.4%)	
Secondary school	12 (13.8%)	4 (14.8%)	0.220
High school	25 (28.7%)	7 (26.0%)	
University	13 (14.9%)	1 (3.7%)	
Postgraduate	6 (6.9%)	-	
Paternal education level, n (%)*			
Illiterate	2 (2.3%)	-	
Primary school	20 (23.3%)	10 (37.1%)	
Secondary school	15 (17.4%)	8 (29.6%)	0.162
High school	31(36.0%)	8 (29.6%)	
University	17 (19.8%)	1 (3.7%)	
Postgraduate	1 (1.2%)	-	
Household size, mean ± SD (median [IQR]) ¥	4.4±1.14(4[4-5])	4.6±1.22(4[4-5])	0.477
Number of children, mean ± SD (median [IQR]) ¥	2.5±1.00(2[2-3])	2.9±1.09(3[2-3])	0.051
Monthly household income n(%)*			
Below minimum wage (<17000 TL)	7 (8.0%)	5 (18.5%)	
Minimum wage (17000 TL)	15 (17.2%)	12 (44.4%)	**0.001**
Above minimum wage (>17000 TL)	65 (74.8%)	10 (37.1%)	
Perceived income status, n (%)*			
Income > expenses	13 (15.0%)	4 (14.8%)	
Income = expenses	53 (60.9%)	7 (25.9%)	**0.002**
Income < expenses	21 (24.1%)	16 (59.3%)	
Self-reported economic status, n (%)*			
Poor	7 (8.1%)	6 (22.2%)	
Moderate	61 (70.0%)	20 (74.1%)	**0.036**
Good	18 (20.7%)	1 (3.7%)	
Very good	1 (1.2%)	-	
Main meals, n (%)*			
2/day	15 (17.2%)	3 (11.1%)	
3/day	71 (81.6%)	24 (88.9%)	0.661
4/day	1 (1.2%)	-	
Snacks, n (%)*			
1/day	17 (19.5%)	5 (18.5%)	
2/day	36 (41.4%)	13 (48.2%)	0.934
3/day	22 (25.3%)	6 (22.2%)	
No snacks	12 (13.8%)	3 (11.1%)	
Screen time, n (%)*			
No screen time	1 (1.2%)	1 (3.7%)	
30 minutes/day	1 (1.2%)	1 (3.7%)	0.185
1-2 hours/day	18 (20.6%)	2 (7.4%)	
≥2 hours/day	67 (77.0%)	23 (85.2%)	
Daily sleep duration (hours), mean ± SD**	8.0±1.17	8.0±1.65	0.988
Daily physical activity duration, n (%)*			
No regular physical activity	35 (40.2%)	13 (48.2%)	
30 minutes/day	7 (8.0%)	1 (3.7%)	0.820
30-60 minutes/day	20 (23.0%)	6 (22.2%)	

>60 minutes/day	25 (28.8%)	7 (25.9%)	
BMI for-age z-scores classification			
Thinness	14(16.1%)	2(7.4%)	0.354
Normal weight	43(49.4%)	13(48.2%)	
Overweight	27(31.0%)	9(33.3%)	
Obesity	3(3.5%)	3(11.1%)	
Insulin delivery method, n (%)* **			
Multiple daily injections	71(81.6%)	24(88.9%)	0.556
Insulin pump	16 (18.4%)	3(11.1%)	
HbA1c (mean ± SD) **	8.0±1.73	8.3±1.69	0.567
Hospital visits in the past 6 months, mean ± SD (median [IQR]) ¥	2.1±0.84(2[2-2])	2.5±1.67(2[2-2])	0.083
Hospitalization in the past 6 months, n (%)* **			
Yes	9(10.3%)	2(7.4%)	0.491
No	78(89.7%)	25(92.6%)	
Emergency visits in the past 6 months, n (%)*	1.3±0.49	1.3±0.68	0.895
Yes	13(14.9%)	10(37.0%)	**0.012**
No	74(85.1%)	17(63.0%)	

BMI: Body Mass Index, *Pearson Chi-Square, ** Independent t test, ***Fisher-Freeman-Halton Exact Test, ¥Mann-Whitney U test

Table 2 presents SQS and PedsQL™ 3.0 Diabetes Module scores according to food security status. Adolescents with food security had significantly lower SQS scores than adolescents with food-insecurity, indicating better sleep quality (11.9±2.37 vs. 13.3±2.82, p=0.016). Adolescent-reported total PedsQL™ scores were significantly lower in the food-insecure group than in the food-secure group (76.9[65.5-82.2] vs. 87.3[70.5-92.1], p=0.014), as were Diabetes Symptoms subscale scores (63.6 [50.0–72.8] vs. 72.7 [59.1–84.1], p=0.012) and Worry subscale scores (83.3[62.5-91.7] vs. 91.7[66.7-100.0], p=0.031). Parent-proxy reports also showed significantly lower total PedsQL™ scores (62.1±13.38 vs. 69.7±14.70, p=0.019) and Diabetes Symptoms scores (59.1 [51.1–64.8] vs. 72.7 [59.1–84.1], p=0.007) in the food-insecure group.

Table 2. Scale scores of participants according to food security status

Scale scores	Food Secure (n: 87)		Food Insecure (n: 27)		p-value
	Mean ± SD	Median [IQR]	Mean ± SD	Median [IQR]	
SQS total score *	11.9±2.37		13.3±2.82		**0.016**
Subscales of PedsQL™ 3.0 Diabetes Module score (A)					
Diabetes Symptoms (A)**	70.5±17.03	72.7[59.1-84.1]	62.0±14.86	63.6[50.0-72.8]	**0.012**
Treatment (A)**	83.1±16.60	86.4[77.3-93.2]	78.4±15.50	79.6[71.6-88.6]	0.063
Worry (A)**	82.5±20.57	91.7[66.7-100.0]	74.1±21.85	83.3[62.5-91.7]	**0.031**
Communication (A)**	87.3±21.49	100.0[83.3-100.0]	85.2±14.12	91.7[75.0-100.0]	0.077
Total PedsQL™ 3.0 Diabetes Module score (A)**	80.8±15.69	87.3[70.5-92.1]	74.9±12.29	76.9[65.5-82.2]	**0.014**
Subscales of PedsQL™ 3.0 Diabetes Module score (P)					
Diabetes Symptoms (P)**	71.0±17.21	72.7[59.1-84.1]	61.3±13.73	59.1[51.1-64.8]	**0.007**
Treatment (P)**	72.4±17.57	75.0[63.6-84.1]	67.3±16.65	72.7[54.6-81.8]	0.121
Worry (P)**	74.4±28.04	83.3[62.5-100.0]	67.3±32.19	83.3[45.8-95.8]	0.359
Communication (P)**	50.4±32.65	50.0[25.0-75.0]	41.4±32.73	41.7[12.5-62.5]	0.208
Total score PedsQL™ 3.0 Diabetes Module (P)*	69.7±14.70		62.1±13.38		**0.019**

A: Adolescent, P: Parent, SQS: Sleep Quality Scale, *Independent t test, **Mann-Whitney U test

Adolescent-reported total PedsQL™ scores were significantly higher than parent-proxy scores (79.4±15.11 vs. 67.9±14.70, $p<0.01$). Agreement between adolescent and parent-proxy total PedsQL™ scores was moderate (ICC=0.670, 95% CI: 0.555–0.760).

The correlations among HFSSM, SQS, PedsQL™ scores, BMI-for-age z-scores, and HbA1c are presented in Table 3. SQS total scores were inversely correlated with adolescent-reported total PedsQL™ scores and all adolescent-reported subscales (all $p<0.05$). SQS scores were also negatively correlated with parent-reported total PedsQL™, Diabetes Symptoms, and Worry scores (all $p<0.05$). No significant correlations were observed between SQS total score and HFSSM or BMI-for-age z-scores. Higher HFSSM scores were weakly but significantly correlated with lower adolescent-reported total PedsQL™ scores ($r=-0.233$, $p=0.013$) and parent-reported total PedsQL™ scores ($r=-0.258$, $p=0.006$).

Table 3. The correlations of Household Food Security Survey Module, PedsQL™ 3.0 Diabetes Module adolescent and parent scores and body mass index-for-age z-scores

	1		2		3		4		5		6		7		8		9		10		11		12		13		14	
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
1. SQS total score	1																											
PedsQL™ 3.0 Diabetes Module																												
2. Diabetes Symptoms (A)	-0.601	**0.000**	1																									
3. Treatment (A)	-0.463	**0.000**	0.567	**0.000**	1																							
4. Worry (A)	-0.460	**0.000**	0.611	**0.000**	0.543	**0.000**	1																					
5. Communication (A)	-0.488	**0.000**	0538	**0.000**	0.510	**0.000**	0.574	**0.000**	1																			
6. PedsQL™ 3.0 Diabetes Module Total score (A)	-0.623	**0.000**	0.845	**0.000**	0.770	**0.000**	0.840	**0.000**	0.769	**0.000**	1																	
7. Diabetes Symptoms (P)	-0.431	**0.000**	0.646	**0.000**	0.576	**0.000**	0.523	**0.000**	0.511	**0.000**	0.635	**0.000**	1															
8. Treatment (P)	-0.303	0.069	0.442	**0.031**	0.643	**0.000**	0.459	**0.000**	0.461	**0.000**	0.553	**0.000**	0.542	**0.000**	1													
9. Worry (P)	-0.249	**0.008**	0.421	**0.000**	0.413	**0.000**	0.559	**0.000**	0.510	**0.000**	0.570	**0.000**	0.576	**0.000**	0.643	**0.000**	1											
10. Communication (P)	-0.004	0. 965	0.051	0.593	0.090	-0.090	0.132	0.163	-0.54	0.571	0.082	0.386	0.060	0.523	0.029	0.760	-0.090	0.340	1									
11. PedsQL™ 3.0 Diabetes Module Total score (P)	-0.396*	**0.000**	0.608	**0.000**	0.498	**0.000**	0.575	**0.000**	0.542	**0.000**	0.674	**0.000**	0. 853	**0.000**	0.826	**0.000**	0.749	**0.000**	0.231	**0.013**	1							
12. HFSSM score	0.176	0.061	-0.217	**0.021**	-0.217	**0.021**	-0.165	0.079	-0.177	0.060	-0.233	**0.013**	-0.210	0.025	-0.187	0.046	-0.090	0.341	-0.135	0.152	-0.258	**0.006**	1					
13. BAZ	0.066*	0.483	-0.029	0.757	-0.037	0.693	0.074	0.432	-0.041	0.666	0.020	0.834	-0.054	0.570	0.024	0.797	0.093	0.326	-0.074	0.436	-0.025	0.788	0.143	0.130	1			
14. HbA1c	-0.039	0.680	-0.145	0.124	-0.020	0.833	0.004	0.971	-0.020	0.835	-0.057	0.546	-0.104	0.273	0.040	0.677	0.013	0.890	0.027	0.772	-0.035	0.714	0.136	**0.031**	0.152	**0.031**	1	

A: Adolescent, BAZ: Body Mass Index-for-age z-scores, HFSSM: Household Food Security Survey Module, P: Parent, PedsQL™: Pediatric Quality of Life, SQS: Sleep Quality Scale, *Pearson correlation (the others Spearman's rho)

DISCUSSION

This study examined the associations among household food insecurity, sleep quality, and diabetes-specific quality of life in adolescents with T1D, using both adolescent self-reported and parent-proxy measures. Three main findings emerged. First, adolescents from food insecure households had poor sleep quality and lower diabetes-specific quality of life than their food-secure peers, as consistently reflected in both self-reported and parent-proxy assessments. Second, sleep quality was consistently associated with quality of life across multiple adolescent- and parent-reported domains, whereas food insecurity showed weaker but significant associations with total quality of life scores. Third, adolescent-reported quality of life scores were higher than parent-proxy scores, with only moderate agreement between the two perspectives.

The differences observed between food-secure and food-insecure groups are in line with previous research showing that food insecurity is associated with adverse health and psychosocial outcomes in children and adolescents [26]. Adolescents experiencing food insecurity may be exposed to psychosocial stress, irregular dietary patterns, and household instability, all of which can negatively affect sleep and perceived well-being [27]. In the present study, adolescents with food insecurity had higher SQS scores, indicating poorer sleep quality, as well as lower PedsQL™ total scores, particularly in the Diabetes Symptoms and Worry domains. These findings suggest that food insecurity may add an additional burden to an already demanding chronic disease management process.

Despite these group-level differences, correlation analyses revealed that sleep quality was more strongly associated with quality of life than food security. The consistent inverse relationship between SQS scores and both adolescent- and parent-proxy PedsQL™ scores suggests that sleep quality is an important determinant of well-being in adolescents with T1D. These findings are in line with research in Japanese adults with T1D, which demonstrated significant associations between overall quality of life and both subjective sleep quality and daytime dysfunction [28]. On the other hand, previous studies have reported that sleep quality is associated with poorer glycemic control [16, 29]. However, in the present study, no significant association was observed between sleep quality scores and last HbA1c levels. This finding suggests that the relationship between sleep quality and HbA1c in adolescents with T1D is likely complex, multifactorial, and potentially nonlinear. The lack of association may reflect

the long-term nature of HbA1c, which may not capture short-term fluctuations in sleep, as well as the influence of confounding factors such as treatment adherence and psychosocial stress.

The association between food insecurity and quality of life also deserves attention. Previous studies in adults with diabetes have shown that food insecurity is linked to lower quality of life [10, 11, 30]. Evidence in adolescents with T1D is more limited, but the present findings suggest a similar pattern. HFSSM scores were weakly but significantly associated with both adolescent-reported and parent-proxy total PedsQL™ scores. Although the effect sizes were modest, the direction of the associations was consistent across both informants. This supports the idea that food insecurity may represent an important socioeconomic vulnerability in adolescents with T1D, even when its direct associations with clinical indicators such as HbA1c are not apparent.

Another relevant finding was the discrepancy between adolescent and parent-proxy reports of quality of life. Adolescents reported significantly higher PedsQL™ scores than their parents, while the ICC indicated only moderate agreement between the two perspectives. This pattern is consistent with existing literature suggesting that parents may perceive the burden of diabetes differently. Parents may be more aware of treatment responsibilities, potential complications, or family-level stressors, whereas adolescents may evaluate their quality of life based more on daily functioning, peer relationships, and perceived autonomy [31-33]. These discrepancies highlight the importance of incorporating both self- and parent-reported measures in clinical and research settings to obtain a more comprehensive assessment of patient well-being.

This study has several strengths. It addresses a relatively underexplored area by evaluating household food insecurity, sleep quality, and diabetes-specific quality of life together in adolescents with T1D. The use of validated instruments and the inclusion of both adolescent self-report and parent-proxy quality of life measures strengthen the assessment of patient well-being. In addition, the study provides clinically relevant information from a pediatric diabetes population in which social and behavioural factors may substantially influence daily disease management. Several limitations should also be acknowledged. The cross-sectional design prevents causal inference, and the direction of the observed associations cannot be determined. Sleep quality was assessed using self-reported measures, which may be affected by recall and reporting bias. We were not able to comprehensively evaluate several factors that may influence sleep, such as meal timing, caffeine intake, bedtime screen exposure, nocturnal hypoglycaemia, glucose alarm burden, or diabetes-related distress. The relatively small number of adolescents with food insecurity may also have limited the ability to detect weaker associations. Finally,

this was a single-centre study, which may limit the generalizability of the findings to adolescents with T1D in other healthcare systems or socioeconomic settings

In conclusion, food insecurity was observed in nearly one-quarter of adolescents with T1D and was associated with poorer sleep quality and lower diabetes-specific quality of life. Sleep quality showed particularly consistent associations with quality of life outcomes, whereas food insecurity demonstrated weaker but significant relationships with total quality of life scores. These findings suggest that assessment of sleep health and socioeconomic vulnerability may be useful components of comprehensive pediatric diabetes care. Longitudinal studies are needed to clarify the directionality and mechanisms linking food insecurity, sleep quality, and quality of life in adolescents with T1D.

Declarations

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare no conflict of interest.

References

1. Gregory, J. W., et al., ISPAD clinical practice consensus guidelines 2022: diabetes in adolescence. Pediatric Diabetes, 2022. 23(7), 857.
2. Ogle, G.D., et al., Global type 1 diabetes prevalence, incidence, and mortality estimates 2025: Results from the International diabetes Federation Atlas, and the T1D Index Version 3.0. Diabetes Research and Clinical Practice, 2025. 225: p. 112277.
3. Lucier J, Mathias PM. Type 1 Diabetes. 2024 Oct 5. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan–. PMID: 29939535.
4. Gucciardi, E., et al., The intersection between food insecurity and diabetes: a review. Current nutrition reports, 2014. 3(4): p. 324-332.
5. FAO, 2002. Food security: concepts and measurement. Trade reforms and food security: Conceptualising the linkages, 2002. 25-34.
6. Mendoza, J.A., et al., Food insecurity is associated with high risk glycemic control and higher health care utilization among youth and young adults with type 1 diabetes. Diabetes research and clinical practice, 2018. 138: p. 128-137.
7. Wagner, J.A., A. Bermúdez-Millán, and R.S. Feinn, Prevalence and Predictors of Food Insecurity among Adults with Type 1 Diabetes: Observational Findings from the 2022 Behavioral Risk Factor Surveillance System. Nutrients, 2024. 16(15): p. 2406.
8. Brown, A.D., et al., Household Food Insecurity and Cognition in Youth and Young Adults with Youth-Onset Diabetes. Pediatric Diabetes, 2023. 2023(1): p. 6382663.

9. Levi, R., S.N. Bleich, and H.K. Seligman, Food insecurity and diabetes: overview of intersections and potential dual solutions. Diabetes care, 2023. 46(9): p. 1599-1608.
10. Walker, R.J., et al., The burden of food insecurity on quality of life in adults with diabetes. Nutrients, 2024. 16(21): p. 3602.
11. Mosley-Johnson, E., et al., Relationship between food insecurity and housing instability on quality of care and quality of life in adults with diabetes. Plos one, 2022. 17(12): p. e0278650.
12. Howard, Q. and S. Griggs, Socioeconomic Risk and Sleep Health Among Young Adults With Type 1 Diabetes. Western journal of nursing research, 2025. 47(12): p. 1137-1146.
13. Khalil, M., et al., The association between sleep and diabetes outcomes–A systematic review. Diabetes research and clinical practice, 2020. 161: p. 108035.
14. Farabi, S.S., Type 1 diabetes and sleep. Diabetes spectrum: a publication of the American Diabetes Association, 2016. 29(1): p. 10.
15. Angelino, S., et al., Sleep quality and glucose control in adults with type 1 diabetes during the seasonal daylight saving time shifts. Diabetes Research and Clinical Practice, 2024. 217: p. 111859.
16. Ji, X., Y. Wang, and J. Saylor, Sleep and type 1 diabetes mellitus management among children, adolescents, and emerging young adults: a systematic review. Journal of Pediatric Nursing, 2021. 61: p. 245-253.
17. Bombaci, B., et al., Psychological and clinical challenges in the management of type 1 diabetes during adolescence: a narrative review. Children, 2024. 11(9): p. 1085.17.
18. USDA Economic Research Service. (2012). U.S. Household Food Security Survey Module: Three-Stage Design, with Screeners. United States Department of Agriculture. https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/survey-tools#household.
19. Tatlılıoğlu, M.E., Hanehalkı Besin Güvencesi ve Adölesanlarda Besin Güvencesi Anketlerinin Türkçeye Uyarlanması: Geçerlik ve Güvenilirlik Çalışması (Yüksek lisans tezi). Gazi Üniversitesi, Sağlık Bilimleri Enstitüsü, Ankara, Türkiye. 2025.
20. Meijer, A.M. and G.L. van den Wittenboer, The joint contribution of sleep, intelligence and motivation to school performance. Personality and Individual Differences, 2004. 37(1): p. 95-106.
21. Önder, İ., et al., Psychometric properties of sleep quality scale and sleep variables questionnaire in Turkish student sample. International Journal of Psychology and Educational Studies, 2016. 3(3): p. 9-21.
22. Varni, J.W., et al., The PedsQL™ in type 1 and type 2 diabetes: reliability and validity of the Pediatric Quality of Life Inventory™ generic core scales and type 1 diabetes module. Diabetes care, 2003. 26(3): p. 631-637.
23. Çövener Özçelik, Ç. and E. Aktaş, The reliability and validity of the pediatrics quality of life inventoryTM (PedsQL) diabetes module 3.0 for Turkish adolescents with type 1 diabetes. International Journal of Diabetes in Developing Countries, 2015. 35(Suppl 2): p. 109-116.
24. World Health Organization. (2009). WHO AnthroPlus for personal computers: Software for assessing growth of the world's children and adolescents. Geneva: World Health Organization.
25. World Health Organization. WHO child growth standards: length/heightforage, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. World Health Organization. 2006. .
26. Abraham, S., et al., Household food insecurity and its impact on child and adolescent health outcomes in Western High-Income Countries: a rapid review of mechanisms and associations. Public Health Nutrition, 2025: p. 1-74.

27. Clark, E.C., et al., Health outcomes following childhood or adolescent exposure to household food insecurity: a rapid systematic review. Public Health Nutrition, 2025: p. 1-69.
28. Ichikawa, M., et al., A cross-sectional study of the relationship between quality of life and sleep quality in Japanese patients with type 1 diabetes mellitus. Endocrine Journal, 2022. 69(4): p. 399-406.
29. Perfect, M.M., The relations of sleep and quality of life to school performance in youth with type 1 diabetes. Journal of Applied School Psychology, 2014. 30(1): p. 7-28.
30. Gholami, A., et al., Household food insecurity is associated with health-related quality of life in rural type 2 diabetic patients. Archives of Iranian medicine, 2017. 20(6): p. 350-355.
31. Özçelik, Ç.Ç. and N.Ş. Celasin, Tip 1 diyabetli çocuk/ergenlerin beslenme alışkanlıkları ve yaşam kalitesi. Turkish Journal of Diabetes and Obesity, 2021. 5(3): p. 302-311.
32. Lukács, A., B. Varga, and S. Barótfi, Health-related quality of life of youths with type 1 diabetes: reliability and validity of the Hungarian version of the Pedsql 3.0 diabetes module. Journal of Diabetes & Metabolism, 2012. 3(04).
33. Sand, P., et al., The reliability of the health related quality of life questionnaire PedsQL 3.0 Diabetes Module™ for Swedish children with type 1 diabetes. Acta Paediatrica, 2012. 101(8): p. e344-e349.