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The relationship between food addiction, eating attitudes, and psychiatric symptoms with metabolic control in adolescents with Type 1 Diabetes Mellitus

Esma Kaya Özdemir[1,4*], Sarper İçen[2,3], Esra Döğer[1], Yasemin Taş Torun[2], Nihan Solmaz[1], M. Orhun Çamurdan[1] and Aysun Bideci[1]

Abstract

Background Metabolic control is of critical importance in children with Type 1 Diabetes Mellitus (T1DM) for the stabilization of blood glucose levels and long-term health outcomes. Dietary choices play an important role in glucose control and the prevention of diabetes-related complications. This study aims to investigate the relationship between food addiction, eating attitudes, and psychiatric symptoms with metabolic control in adolescents diagnosed with T1DM.

Methods Participants ($N=100$) were assessed using the Yale Food Addiction Scale (Y-FAS), Eating Attitudes Test-40 (EAT-40), and Brief Symptom Inventory (BSI) to evaluate food addiction, eating attitudes, and psychiatric symptoms. Metabolic parameters of adolescents with T1DM, such as body mass index (BMI), HbA1c levels, insulin dosage, duration of diabetes, and the incidence of ketoacidosis and hypoglycemia, were recorded.

Results The study found that 15% of adolescents had food addiction criteria, and 17% were prone to disordered eating behaviors. The presence of a history of hypoglycemia was related to a higher total symptom score on YFAS and higher total scores, depression, anxiety, somatization, and hostility subscale scores on BSI ($p<.05$ for all). BMI was positively correlated with anxiety about gaining weight on EAT-40 and higher total scores, depression, and anxiety subscale scores on BSI ($p<.05$ for all). As the BMI percentile group increased from normal to overweight/obesity, more food addiction symptoms were observed, and significant increases were found in depression, anxiety, negative self-perception, and somatization subscale scores, and the BSI total score ($p<.05$ for all).

Conclusions Findings suggest that adolescents with T1DM may have a higher susceptibility to food addiction and eating disorders compared to the rates reported in the general population. Hypoglycemia can be a metabolic risk factor for food addiction in adolescents with T1DM. Psychological problems such as depression, anxiety, and somatization in adolescents with T1DM are associated with poor metabolic control. Further studies are needed with larger and more diverse samples.

*Correspondence:
Esma Kaya Özdemir
kayaesmag@gmail.com

Full list of author information is available at the end of the article

Plain English Summary
Adolescence is a difficult period for patients with type 1 diabetes due to problems in following dietary management. Consuming certain foods may become addictive, similar to well-known substance or alcohol addictions, and complicate the treatment of diabetes. This study showed links between food addiction and diabetes-related parameters among adolescents with type 1 diabetes. On the other hand, some of the eating attitudes may be related to increased risk for eating disorders, such as anxiety about gaining weight among type 1 diabetes patients with obesity. Moreover, findings point out that there may be associations between psychological difficulties and poor glycemic control.

Keywords Food addiction, Eating disorders, Diabetes, Adolescence

Background

Type 1 Diabetes Mellitus (T1DM) is an autoimmune disease characterized by a reduction or complete cessation of insulin production. In recent years, a notable increase in the prevalence of T1DM has been observed, particularly among children and adolescents. Metabolic control is of great importance in T1DM patients to maintain stable blood glucose levels and ensure long-term health outcomes [1, 2]. Dietary choices play an important role in glucose control and the prevention of diabetes-related complications. In individuals with diabetes, excessive consumption of high-sugar and high-fat foods that trigger food addiction, such as hamburgers, chocolate, and junk food, poses significant challenges to diabetes management [3]. Food addiction refers to an uncontrollable craving for certain foods and a loss of control over consumption, with symptoms similar to those seen in psychiatric disorders due to substance use and addictive behaviors [4–6]. The necessity of adhering to strict dietary regimens, undergoing multiple daily insulin injections, regular blood glucose monitoring, and managing diabetes-related complications may cause individuals with diabetes to become excessively preoccupied with food [7]. Besides addiction-like eating, disordered eating attitudes may emerge during T1DM treatment, which may progress to eating disorders [7]. Eating disorders encompass a range of syndromes characterized by abnormal eating behaviors such as under-eating, not eating at all, overeating, and purging, often accompanied by weight changes and/or social dysfunction, significantly affecting the quality of life and social functioning [8]. During adolescence, sensitivity to rewarding stimuli increases, whereas the neural mechanisms responsible for controlling responses to such stimuli remain underdeveloped [9]. Therefore, adolescence is considered a critical period for the development of food addiction and eating disorders due to heightened biopsychosocial risk factors, intense emotional fluctuations, and inadequate inhibitory control [9]. Additionally, the physiological burden of T1DM, combined with the emotional changes inherent to adolescence, has been reported to contribute to the prevalence of psychiatric symptoms such as depression, anxiety, and stress among adolescents with T1DM [10]. This study aims to assess the relationship between food addiction, disordered eating behaviors, and psychiatric symptoms correlated with metabolic factors in adolescents with T1DM. Investigating these complex interactions is necessary to provide an understanding of metabolic health status and difficulties in dietary adjustment among adolescent patients with T1DM.

Methods

Participants and procedure

This is a cross-sectional observational study aiming to evaluate the correlations between investigated variables. We included adolescents aged 11–18 with T1DM with consecutive sampling. Inclusion criteria were being diagnosed with T1DM for at least one year and being under follow-up at Gazi University Faculty of Medicine, Department of Pediatric Endocrinology. The study was approved by the clinical research ethical committee of Gazi University with a date/approval number of 07.02.2022/97. Before inclusion, informed consent was obtained from both the adolescents and their accompanying parents regarding the study procedure and the anonymous publication of the findings. Those who did not wish to give informed consent were excluded from the study and received their treatment as usual. Five patients refused to participate and their reason for refusing to participate in the study was not having time to fill the measurement tools. In the end, we obtained and analyzed the data from one hundred participants.

We administered the adolescents' self-report measurement tools, including the Yale Food Addiction Scale (YFAS), the Eating Attitudes Test-40 (EAT-40), and the Brief Symptom Inventory (BSI) to assess food addiction, eating attitudes, and psychiatric symptoms, respectively [11–13]. In clinical evaluation, we recorded body mass index (BMI) and evaluated BMI percentiles according to national standards [14]. According to age- and sex-specific percentiles, the adolescents were classified as underweight if their BMI was below the 5th percentile, normal weight if it was between the 5th and 85th percentiles, overweight if it was between the 85th and 95th percentiles, and obese if it was above the 95th percentile [14].

Other variables included average HbA1c levels over the past year, average insulin therapy doses over the past six months, duration of diabetes, and the presence of ketoacidosis and hypoglycemic symptoms, recorded according to patient files.

A normal fasting blood glucose value is expected to range between 70 mg/dL and 100 mg/dL. A glucose value of less than 3.9 mmol/L (70 mg/dl) is used as the clinical alert or threshold for initiating treatment for hypoglycemia because of the potential for glucose to fall further [15]. However, glucose values below 3.0 mmol/L (54 mg/dl) are defined as clinically important or serious hypoglycemia, as neurogenic symptoms and cognitive dysfunction can occur below this level [15]. Accordingly, participants who had blood glucose levels below 54 mg/dL at least once a month in the past six months, with neurogenic symptoms and/or cognitive dysfunction, were categorized as having hypoglycemia symptoms in this study. In addition, those who experienced ketoacidosis at least once in the past year were categorized as having ketoacidosis symptoms.

Measurement tools

Yale food addiction scale (YFAS)

Developed by Gearhardt et al. (2009), this tool is used to assess addiction-like symptoms triggered by highly palatable foods rich in fat and sugar [16]. The Turkish adaptation was conducted by Bayraktar et al. (2012), and the internal consistency of the Turkish version was reported to be good (α = 0.93) [11]. The scale asks participants how frequently they have experienced addiction-like symptoms related to certain foods over the past year. The foods in question, as described in the scale's instructions, include sweets such as ice cream, chocolate, cookies, and cakes; starchy foods such as white bread, pasta, and rice; salty snacks like chips and crackers; fatty foods like pizza, hamburgers, and french fries; and sugary beverages such as soda and soft drinks. The final item on the scale asks participants to specify the types of foods concerning their addiction symptoms. Two types of results are obtained from the scale: the total symptom score, which is a continuous variable in the range of 0 to 7 (the number of symptoms out of 7 that are present), and a binary evaluation for the diagnosis of food addiction as present or absent (presence of 3 or more symptoms along with clinically significant impairment related to specific foods in the past year).

Eating attitudes Test-40 (EAT-40)

Developed by Garner and Garfinkel in 1979, this 40-item tool is used to assess disordered eating behaviors and the risk of developing eating disorders [17]. A Turkish adaptation study of the scale was conducted by Savaşır and Erol (1989), and it was reported that its internal consistency was acceptable (α = 0.70) [12]. In addition to a total score, the scale provides four subscale scores: anxiety about gaining weight, dieting behavior, social pressure, and thin body preoccupation. The anxiety about gaining weight subscale includes feelings of anxiety and fear about an increase in body fat, preoccupation with thoughts of gaining fat, and guilt after eating. The dieting behavior subscale reflects behaviors such as being aware of the calorie content of consumed foods, avoiding high-calorie foods, preferring diet foods, and calculating calories burned during exercise. The social pressure subscale assesses feelings of being pressured by others about eating too much/little or being too thin/overweight. The thin body preoccupation subscale includes extreme efforts to remain thin, such as keeping the stomach empty, exercising enough to balance the calories consumed, and excessive preoccupation with food. Higher scores indicate more disordered eating behaviors. The developers recommended a cut-off point of 30 for the total score, with scores above this threshold indicating a higher risk for eating disorders such as anorexia nervosa and bulimia nervosa [17].

Brief symptom inventory (BSI)

This tool is developed by Derogatis (1992) as a self-report measure to assess individuals' psychopathological symptoms [18]. The total score evaluating all 53 items from the scale adapted to Turkish by Şahin et al. (2002) to be used for adolescents (α = 0.94), 14-item depression (α = 0.88), 17-item anxiety (α = 0.84), 9-item negative self-esteem score. (α = 0.74), 7-item somatization (α = 0.70), and 4-item hostility (α = 0.73) subscale scores are obtained, and it has been reported to be a valid and reliable measurement tool [13]. Higher scores indicate that the symptoms in that subscale are experienced more frequently and intensely.

Statistical analysis

Data were analyzed using IBM SPSS Statistics Version 22.0 [19]. Descriptive analyses were presented as mean (minimum-maximum values) for numerical variables and frequency (percentage) for categorical variables. The Shapiro-Wilk and Kolmogorov-Smirnov tests were applied, and skewness and kurtosis values were examined to assess whether the numerical data followed a normal distribution. Since the data were found not to conform to a normal distribution, Spearman's correlation analysis was used to evaluate the bidirectional relationships between numerical variables. In this study, a p-value of less than 0.05 was considered statistically significant.

Table 1 Descriptive findings of the sample ($n = 100$)

Variable	Frequency (Percentage) or Mean (Min-Max)
Gender	Male 52 (52%)/ Female 48 (48%)
Age (years)	14.64 (11.00–18.00)
Age at diagnosis (years)	8.46 (1.00-15.20)
Duration of diabetes (years)	6.18 (1.00-15.60)
BMI	21.62 (14.60–34.00)
BMI percentile groups	
≥ 5th - <85th percentile	78 (78%)
≥ 85th - <95th percentile	10 (10%)
≥ 95th percentile	12 (12%)
HbA1c value (%)	8.69 (5.80–15.30)
HbA1c groups	
≤ 7 (%)	13 (13%)
> 7 - ≤9 (%)	58 (58%)
> 9 (%)	29 (29%)
Average insulin dose (IU/kg/day)	0.91 (0.19 – 1.70)
CSII usage	11 (11%)
History of hypoglycemia	41 (41%)
History of ketoacidosis	1 (1%)

(BMI; Body Mass Index, CSII; Continuous Subcutaneous Insulin Infusion)

Results

Descriptive findings and scale evaluations

Table 1 presents descriptive findings about the study sample. Accordingly, 10 adolescents were overweight, 12 adolescents had obesity, and the remaining 78 were in the normal weight range. In evaluating HbA1c values, we found a mean HbA1c level of 8.69% in our sample, ranging between 5.80% and 15.30%. In terms of glycemic control, 13% were in the good control range (HbA1c ≤ 7%), and 29% had poor glycemic control (HbA1c > 9%). Eleven adolescents (11%) were using continuous subcutaneous insulin infusion. Forty-one adolescents had a history of hypoglycemia, and a history of ketoacidosis was present in one adolescent.

The evaluation of food addiction symptoms and the food addiction diagnosis in the sample is presented in Table 2. The mean YFAS total score was 3.1, with scores ranging from 0 to 7. Key symptoms included persistent desire to quit (84%), continuing consumption despite negative consequences (51%), and needing more food for the same effect (56%). 19% experienced significant distress or impairment, and 15% met the diagnostic criteria for food addiction. Food types commonly associated with addiction were chocolate (66.7%), ice cream (60%), pizza (60%), and cookies (60%). These results highlight the prevalence and food preferences related to food addiction in this sample.

Table 3 presents findings regarding the evaluation of eating attitudes. The EAT-40 results show a total mean

Table 2 Evaluation of food addiction symptoms and diagnosis in the sample ($n = 100$)

	Frequency (percentage) or mean (min-max)
YFAS– Total symptom score	3.1 (0.00–7.00)
YFAS– Food addiction symptoms	
Consuming more and for a longer period than intended	35 (35)
Persistent desire or repeated unsuccessful attempts to quit	84 (84)
Spending a lot of time or energy to obtain, consume, or recover from the effects	26 (26)
Giving up or reducing important activities due to consumption	27 (27)
Continuing consumption despite awareness of negative consequences	51 (51)
Needing more to achieve the same effect or diminished effect with the same amount	56 (56)
Experiencing withdrawal symptoms and consuming to relieve them	27 (27)
YFAS– Clinical impairment criterion	
Symptoms cause significant distress or functional impairment	19 (19)
YFAS– Diagnostic evaluation of food addiction	
Meeting clinical impairment criterion in addition to at least three symptoms	15 (15)
YFAS– Food types associated with food addiction	
Chocolate	10 (66.7)
Ice cream	9 (60)
Pizza	9 (60)
Cookies	9 (60)
Cake	8 (53.3)
Chips	8 (53.3)
Soda/carbonated drinks	8 (53.3)

(YFAS; Yale Food Addiction Scale)

Table 3 Evaluation of eating attitudes and tendency towards disordered eating behaviors in the sample ($n = 100$)

Measure	Frequency (percentage) or Mean (min-max)
EAT-40– Total score	21.29 (5.00–62.00)
EAT-40– Subscale scores	
Anxiety about gaining weight	1.77 (0.00–11.00)
Dieting behavior	3.62 (0.00–18.00)
Social pressure	1.56 (0.00–9.00)
Thin body preoccupation	0.78 (0.00–5.00)
EAT-40– Increased risk of eating disorder	17 (17)

(EAT-40; Eating Attitude Test– 40)

Table 4 Evaluation of psychopathology symptoms in the sample ($n = 100$)

Variable	Frequency (Percentage) or Mean (Min-Max)
BSI– Total score	46.60 (0.00-176.00)
BSI– Subscale scores	
Depression	14.26 (0.00–52.00)
Anxiety	14.48 (0.00–51.00)
Negative self	5.97 (0.00–29.00)
Somatization	4.84 (0.00–26.00)
Hostility	6.02 (0.00–16.00)
BSI– Clinically significant scores	
Depression	13 (13%)
Anxiety	16 (16%)
Negative self	12 (12%)
Somatization	10 (10%)
Hostility	14 (14%)

(BSI; Brief Symptom Inventory)

score of 21.29 (range 5.00–62.00). Subscale evaluations revealed a mean score of 1.77 (range 0.00–11.00) on anxiety about gaining weight, moderate dieting behavior, a mean score of 3.62 (range 0.00–18.00) on dieting behaviors, a mean score of 1.56 on social pressure (range 0.00–9.00), and a mean score of 0.78 on thin body preoccupation (range 0.00–5.00). Additionally, 17% of participants exhibited an increased risk of eating disorders according to the cut-off point of 30.

The evaluation of psychopathological symptoms in the sample is presented in Table 4. The BSI results show varying levels of psychological distress within the sample. The total mean score was 46.60, with anxiety (mean = 14.48) and depression (mean = 14.26) being the most prominent symptoms. Lower scores were observed for negative self-perception (5.97), somatization (4.84), and hostility (6.02). Clinically significant symptoms were found in 16% of participants for anxiety, 13% for depression, 14% for hostility, 12% for negative self-perception, and 10% for somatization. These results highlight the presence of significant psychological distress in the sample.

Findings of the correlation analysis

Table 5 presents correlations between various variables, such as age, duration of diabetes, BMI, HbA1c, and history of hypoglycemia, and scores from different psychological and eating-related measures. As the BMI percentile group progressed from the normal weight range to the overweight and obese groups, a higher number of symptoms of food addiction were observed according to the YFAS total symptom score ($p < .05$). Moreover, a significant relationship was found between the history of hypoglycemia and the total symptom score of the YFAS among adolescents diagnosed with T1DM ($p < .05$). There was a significant positive correlation between BMI and the anxiety about gaining weight subscale score of the EAT-40 ($p < .05$). Additionally, as HbA1c levels increased, a significant increase was observed in the social pressure subscale score of the EAT-40 ($p < .05$). The

Table 5 Relationships between diabetes-related variables, eating behaviors, and psychopathological symptoms

Variable	Age	Duration of diabetes	BMI value	BMI percentile group	HbA1c value	HbA1c group	History of hypoglycemia	CSII treatment
YFAS Total symptom score	-0.03	-0.11	0.01	**0.23***	0.07	0.08	**0.21***	-0.01
EAT-40 Total score	-0.04	-0.14	0.05	0.03	0.01	0.10	0.04	-0.04
EAT-40 Anxiety about gaining weight	-0.00	-0.09	**0.25***	0.16	0.16	-0.01	0.01	-0.01
EAT-40 Dieting behavior	0.02	-0.06	0.02	-0.02	-0.04	0.04	0.03	-0.03
EAT-40 Social pressure	-0.13	0.05	-0.06	-0.05	0.16	**0.21***	0.03	0.01
EAT-40 Thin body preoccupation	0.08	-0.04	0.17	0.09	0.00	0.07	-0.05	0.11
BSI Total score	0.06	0.08	**0.24***	**0.24***	0.08	0.09	**0.24***	-0.05
BSI Depression	0.13	0.06	**0.28***	**0.25***	0.03	0.03	**0.25***	-0.04
BSI Anxiety	0.05	0.09	**0.22***	**0.17**	0.09	0.10	0.26	-0.06
BSI Negative self-perception	-0.06	0.00	0.18	**0.29***	0.09	0.13	0.15	-0.03
BSI Somatization	-0.01	0.10	0.18	**0.21***	**0.20***	**0.21***	**0.22***	-0.01
BSI Hostility	-0.01	0.13	0.08	0.08	0.11	0.12	**0.23***	-0.10

(YFAS; Yale Food Addiction Scale, EAT-40; Eating Attitude Test-40, BSI; Brief Symptom Inventory, BMI; Body Mass Index, CSII; Continuous Subcutaneous Insulin Infusion)

Spearman's rho correlation coefficient is statistically significant at $p < .05$. Statistically significant results are highlighted in bold

correlation of body measurements and diabetes-related variables with psychological difficulties in BSI revealed noteworthy findings. A significant positive correlation was found between BMI and the total score of the BSI, as well as the subscale scores for depression and anxiety ($p < .05$ for all). Furthermore, it was found that there were significant increases in the scores for depression, negative self-perception, and somatization subscales, as well as in the total score of the BSI, about the BMI percentile group ($p < .05$ for all). As HbA1c levels increased and progressed from good control to moderate control and poor control ranges, a significant increase was noted in the somatization subscale score of the BSI ($p < .05$). Additionally, a significant positive correlation was observed between the history of hypoglycemia and the total score of the BSI, as well as with the subscale scores for depression, anxiety, somatization, and hostility ($p < .05$ for all). While there were no cross-sectional relationships between CSII treatment and scale measurements, it is worth noting that none had food addiction, and two had a risk of eating disorders out of eleven patients using CSII.

Discussion

In this study, we investigated correlates of metabolic health parameters among adolescents with T1DM in terms of food addiction, eating attitudes, and psychological symptoms. Our findings revealed that 15% of the adolescents with T1DM had diagnostic levels of food addiction symptoms on YFAS, 17% had an increased risk of eating disorders on EAT-40, and clinically significant psychological symptoms varied between 10 and 16% for different subscales of BSI. Moreover, food addiction and psychological symptoms had important correlates in terms of metabolic health, as indicated by BMI, BMI group, HbA1c, glycemic control, and history of hypoglycemia among adolescents with T1DM. Although there were no significant correlates of CSII treatment, our study is among the first to assess the relationship between CSII and food addiction or eating attitudes.

Food addiction and eating attitudes

Previous studies investigating food addiction have reported prevalence rates of 7.2–12.1% among children and adolescents in the general population, with rates ranging from 10.1 to 14.4% in overweight/obese samples [20, 21]. In this study, the prevalence of food addiction in adolescents diagnosed with T1DM was found to be 15%, indicating that this rate is higher than in healthy adolescents without diabetes and overweight/obese adolescents. Based on this, it is proposed that T1DM may be a risk factor for food addiction symptoms in adolescents. Moreover, as the BMI groups progressed from normal weight to overweight/obese, a greater number of food addiction symptoms were observed according to the YFAS total symptom score, indicating a relationship between food addiction and obesity in adolescents with T1DM, as in adolescents without T1DM. This situation is explained by the significant clinical and neurobiological overlap between food addiction and obesity [22].

Hypoglycemia and glucose fluctuations have been documented to enhance motivation for high-intensity and high-calorie foods by modulating limbic/contextual brain regions and triggering biologically and behaviorally addictive responses [22]. Rapid fluctuations in blood glucose levels with high glycemic index foods lead to the activation of brain regions related to reward, desire, and food intake, which may be associated with developing food addiction and obesity [3, 23, 24]. In our study, a significant relationship was found between the history of hypoglycemia and the total symptom score of food addiction in adolescents diagnosed with T1DM. Therefore, based on our findings, we can suggest that insulin-dependent hypoglycemia may constitute a risk factor for food addiction and obesity in adolescents with T1DM. Additionally, the absence of a positive relationship between food addiction and HbA1c levels in patients with T1DM in this study may be explained by hypoglycemia masking high HbA1c levels. At last, it is worth noting that our findings suggest that CSII treatment is not related to food addiction, as none of the eleven adolescents using CSII had food addiction symptoms at the diagnostic level.

The most commonly reported food addiction symptom in our sample with T1DM was 'persistent desire or repeated unsuccessful attempts to quit consuming certain food,' which is similar to a previous study reporting it as the most common symptom but with a lower rate among patients with overweight/obesity in Iran [25]. Certain types of food not only optimize the magnitude of reward signaling in the brain through high doses of calorically dense components and additives but also enhance the speed at which this reward is delivered [26]. Chocolate is the most commonly reported addictive food, and it is also known that cravings for carbohydrates and salty snacks are prevalent [26–28]. In this study, similar to the literature, the most addictive foods reported in food addiction cases were chocolate (67.7%), ice cream (60%), pizza (60%), cookies (60%), cake (53.3%), chips (53%), and carbonated drinks (53.3%).

Regarding eating disorders, concerns about weight and body image, continuous glucose monitoring, subsequent insulin administration, weight gain due to excessive insulin use following overeating, dietary restrictions, and worries as part of disease management serve as risk factors in adolescents with T1DM [29, 30]. Individuals with vulnerability factors like low self-esteem and perfectionism may find it challenging to manage the uncertainties of diabetes. This situation can trigger unhealthy behaviors, such as mismanagement of insulin to support

dietary restrictions and/or weight loss, leading to wide fluctuations in plasma glucose levels. Consequently, a cycle develops characterized by uncontrolled eating and purging behaviors, along with neuroadaptive changes. In our study, the susceptibility to eating disorders among adolescents with T1DM was found to be 17% according to the EAT-40 scale, which is higher than the previously reported lower rates among adolescents from the general population [31, 32]. Adolescents with T1DM in our sample had increasing levels of anxiety about gaining weight with increasing BMI. Additionally, our study observed an increase of social pressure with worsening HbA1c levels. Environmental exposures, such as discussions about "eating too much" or "being overweight" at home and in clinical settings, can further increase concerns about weight and body shape, thereby reinforcing the risk of eating disorders. Using CSII treatment was not related to eating disorder risk, as only two out of eleven patients with T1DM who are using CSII had an increased risk of eating disorders according to the EAT-40 total score cut-off point. We interpret this as using CSII may contribute to the improvement of disordered eating attitudes by reducing overeating and insulin-omission behaviors.

Psychological symptoms

Among patients with T1DM, adolescence is described as the most challenging period of life in managing diabetes due to both physiological and psychosocial processes [33, 34]. Glycemic control worsens due to physiological insulin resistance caused by high growth hormone levels [35]. Psychological issues can manifest their effects by hindering fundamental behaviors related to treatment and/or triggering the release of glucocorticoids through the continuous activation of the hypothalamic-pituitary-adrenal axis, leading to a series of physiological events that result in elevated glycemic levels [36]. Adolescents diagnosed with T1DM are at a higher risk of developing psychiatric disorders, with depression, anxiety, and behavioral problems being two to three times more prevalent than in their non-diabetic peers [37, 38]. A recent meta-analysis involving a large number of adolescents with T1DM reported prevalence rates of 22% for depression and 17% for anxiety [39]. In our study, clinically significant depression and anxiety scores were found in 13% and 16% of T1DM adolescents, respectively. Depressive symptoms in adolescents, even if they do not meet the diagnostic criteria for major depressive disorder, may still affect self-care behaviors negatively, reduce treatment adherence, and decrease participation in physical activities. This, in turn, leads to poor glycemic control, increases the risk of future complications, and contributes to mortality [40, 41].

Previously demonstrated relationships between anxiety/depression and hypoglycemia in adults with T1DM have also been shown among adolescents with T1DM in our study [42, 43]. In this study, a significant relationship was found between depression and anxiety scores and hypoglycemia, one of the indicators of poor metabolic control in adolescents with T1DM. It is suggested that behavioral or motivational changes caused by depression and anxiety symptoms increase the risk of hypoglycemia [42]. Early psychiatric intervention is essential to reduce the risk of acute complications from T1DM and achieve better metabolic outcomes [44].

Additionally, overweight/obese children are more likely to experience low self-esteem and develop depressive symptoms during adolescence compared to their normal-weight peers, which may contribute to depression [45]. Similar to non-diabetic adolescents with obesity, we observed increased depression symptoms and negative self-perception among adolescents with T1DM. The negative emotional impact of obesity on adolescents with T1DM may result in poorer eating and exercise habits, contributing to the perpetuation of obesity and leading to worse metabolic outcomes, creating a vicious cycle. It is suggested that obesity management in adolescents with T1DM should be approached holistically, considering both its physical and mental effects.

To our knowledge, our study is among the first to report a significant link between HbA1c and somatization. Somatization refers to the experience of physical symptoms, such as headache, abdominal pain, and dizziness, resulting from unconscious or unexpressed emotional issues [18]. These bodily symptoms can be triggered by acute intense stress or chronic persistent stress. In our study, clinically significant somatization was found in 10% of adolescents with T1DM, which may be due to living with a chronic illness or acute complications. Moreover, our findings suggest that poor metabolic health status and hypoglycemia attacks may be related to somatization among adolescents with T1DM. Future studies are needed to confirm these findings.

Clinical implications, limitations, and future directions

The findings of our study implicate important points for the clinical management of adolescent patients with T1DM. Medical treatment alone would be insufficient, and regular evaluation is recommended for prevention, early detection, and treatment of mental health issues. It is essential that the two main pillars of diabetes management—adherence to insulin administration and regulation of eating behaviors—be managed either by a professional specializing in both areas or by close collaboration between specialist teams. This approach is crucial to prevent adolescents from falling into poor self-control, which can lead to long-term chronic complications that reduce their quality of life.

Given its limitations, this study's results should be viewed with care. One limitation is the small sample size. Future studies with a larger sample size would allow for more comprehensive subgroup analyses, including factors such as gender and socioeconomic status. The reliance on self-reported measures may be subject to bias due to social desirability or stigma. Moreover, our findings may not be generalizable before being replicated in different cultures and diverse samples. Longitudinal studies would be beneficial in understanding the causality of relationships, as the cross-sectional nature of our study limits the ability to draw causal inferences. Future studies should also try to control for confounding factors such as the family history of eating disorders or parental involvement in diabetes management to provide a more accurate understanding.

Conclusion

In conclusion, our study has important findings that may pave the way for future research. Our findings suggest that adolescents with T1DM may have a higher susceptibility to food addiction and eating disorders compared to the rates reported in the general population. Hypoglycemia can be a metabolic risk factor for food addiction in adolescents with T1DM. Psychological problems such as depression, anxiety, and somatization in adolescents with T1DM might be associated with poor metabolic control. Further studies are needed with larger and more diverse samples.

Abbreviations

T1DM	Type 1 Diabetes Mellitus
YFAS	Yale Food Addiction Scale
EAT-40	Eating Attitudes Test-40
BSI	Brief Symptom Inventory
BMI	Body Mass Index
CSII	Continuous Subcutaneous Insulin Infusion

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Author contributions

EKÖ, YTT, and AB designed the study; EKÖ, ED, and NS collected the data; Sİ conducted statistical analyses; EKÖ, Sİ, and YTT interpreted the data; EKÖ and Sİ drafted the work; YTT, OÇ, and AB substantively revised the work; All authors have read the final manuscript and approved the submitted version.

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Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to including patient information that was not consented to be publicly available, but they are available from the corresponding author at reasonable request.

Declarations

Ethics approval and consent to participate

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2013. All procedures involving human subjects/patients were approved by the Clinical Research Ethical Board of Gazi University with date/approval number 07.02.2022/97. Before inclusion, informed consent was obtained from both the adolescents and their accompanying parents regarding the study procedure and the anonymous publication of the findings. Those who did not wish to give informed consent were excluded from the study and received their treatment as usual.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Child Health and Diseases, Department of Pediatric Endocrinology, Gazi University Faculty of Medicine, Ankara, Türkiye
[2]Department of Child and Adolescent Mental Health and Diseases, Gazi University Faculty of Medicine, Ankara, Türkiye
[3]Department of Child and Adolescent Mental Health and Diseases, Ahi Evran University Research and Training Hospital, Kırşehir, Türkiye
[4]Gazi University Faculty of Medicine, Ankara, Çankaya, Türkiye

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