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Emotional Resilience and Metacognition in Children with Type 1 Diabetes Mellitus

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Highlights

What are the main findings?

- Children with type 1 diabetes mellitus exhibited significantly higher anxiety and depression scores, poorer sleep quality, and greater emotional reactivity, potentially reflecting lower emotional resilience, compared with healthy controls.
- Metacognitive awareness was significantly lower in children with type 1 diabetes, while more frequent hospitalizations were associated with greater psychological distress and sleep disturbances.

What are the implications of the main findings?

- Psychosocial assessment in children with type 1 diabetes should include emotional resilience, metacognitive awareness, and sleep quality in addition to anxiety and depression.
- Multidisciplinary approaches addressing emotional and cognitive difficulties may support psychological well-being and diabetes self-management.

Abstract

Objectives: Type 1 diabetes mellitus (T1D) is the most common chronic endocrine disease in childhood and requires long-term, multidisciplinary management. Difficulties in treatment adherence and lifestyle changes may lead to psychosocial problems in affected children. This study aimed to evaluate emotional reactivity, metacognitive awareness, sleep quality, anxiety, and depression levels in children with T1D and to compare them with healthy peers. Methods: The study included 63 children aged 8–18 years with a T1D diagnosis for at least two years and 64 healthy controls aged 7–14 years. Children with pre-existing psychiatric disorders were excluded from the study. Age, sex, and clinical characteristics, including HbA1c levels, duration of diabetes, hospitalization frequency, and continuous glucose monitoring (CGM) use, were recorded. Participants were assessed using the Emotional Reactivity Scale (ERS), Metacognitive Awareness Inventory for Children (Jr. MAI-A), Pittsburgh Sleep Quality Index (PSQI), and Revised Child Anxiety and Depression Scales–Child Version (RCADS-CV). Results: Children with T1D had significantly higher anxiety, depression, and emotional reactivity scores, potentially reflecting lower emotional resilience, as well as poorer sleep quality compared with healthy controls. Metacognitive awareness scores were significantly lower in the diabetes group. No significant associations were found between CGM use or HbA1c levels and psychosocial scale scores. However, children hospitalized two or more times had significantly higher combined anxiety–depression scores and poorer sleep quality than those with fewer hospitalizations. Conclusions: The findings suggest that T1D is associated with poorer psychosocial well-being in children. Enhancing

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Received: 19 October 2026
Revised: 13 November 2026
Accepted: 21 November 2026
Published: 24 November 2026

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metacognitive skills, emotional resilience, and self-esteem through a multidisciplinary approach may support both psychological health and disease management.

Keywords: type 1 diabetes; diabetes management; adolescent; anxiety; depression; emotional resilience; metacognitive awareness

1. Introduction

Type 1 diabetes mellitus (T1D) results from autoimmune-mediated destruction of pancreatic beta cells, leading to insulin deficiency and persistent hyperglycemia [1]. Although advances in diabetes care have improved disease management, individuals with T1D remain susceptible to microvascular and macrovascular complications [2]. As T1D frequently begins early in life, its management demands may affect psychological well-being and developmental experiences throughout childhood and adolescence [3]. Among young people with T1D, depressive symptoms have been associated with difficulties in maintaining treatment adherence and achieving adequate glycemic control [4,5]. Metabolic disturbances, hormonal changes, and inflammatory pathways may also contribute to the relationship between diabetes and depression [6]. Resilience describes the capacity to adapt to adversity and maintain or regain psychological functioning when facing challenging circumstances. In individuals living with chronic diseases, greater resilience may contribute to better treatment engagement and psychological well-being [7]. It has also been proposed as a protective factor against anxiety and depressive symptoms [8]. Depression has been reported to occur approximately two to three times as frequently in children and adolescents with T1D as in those without diabetes [9]. Its presence may adversely affect glycemic management, treatment adherence, and quality of life [9]. Psychiatric comorbidities may also increase vulnerability to acute diabetes-related events, including severe hypoglycemia and diabetic ketoacidosis [10]. In addition to these psychological concerns, mild to moderate impairments in cognitive functioning have been described in pediatric populations with T1D [11]. Sleep represents another important dimension of psychosocial health in pediatric T1D. Compared with children without diabetes, those with T1D have been reported to experience poorer sleep quality, potentially influenced by fluctuations in glucose levels during the night [12]. In young children with T1D, sleep disturbances related to nighttime blood glucose monitoring have been associated with lower health-related quality of life [13]. These observations support the inclusion of sleep-related difficulties in comprehensive psychosocial evaluations. Metacognitive awareness involves the ability to reflect on, monitor, and regulate one's thinking and learning processes [14]. Such abilities may be relevant to T1D management, which involves ongoing acquisition of knowledge, therapeutic decision-making, and daily self-care responsibilities. Nevertheless, research focusing specifically on metacognitive awareness among children and adolescents living with T1D remains scarce.

The present study aimed to evaluate anxiety, depression, sleep disturbances, metacognitive awareness, and emotional resilience in children with T1D.

2. Material and Methods

This single-center, cross-sectional observational study included 63 children and adolescents aged 8–18 years who had been diagnosed with type 1 diabetes mellitus (T1D) at least two years before enrollment, together with their primary caregivers. T1D diagnosis was established in accordance with the International Society for Pediatric and Adolescent

Diabetes (ISPAD) guidelines. Participants were recruited from the outpatient clinic using convenience sampling based on eligibility criteria and willingness to participate.

Clinical data, including age, sex, diabetes duration, hemoglobin A1c (HbA1c) levels, hospitalization frequency, and continuous glucose monitoring (CGM) use, were obtained from medical records documented during routine three-monthly follow-up visits.

The comparison group consisted of 64 children aged 7–14 years who had normal neurological examinations and no abnormalities identified through clinical or laboratory assessment. These children had initially attended the Child and Adolescent Psychiatry Department for reasons unrelated to the study and were referred from that department. A child and adolescent psychiatrist evaluated these children and confirmed the absence of psychiatric disorders. Participants with psychiatric or neurodevelopmental disorders, concomitant chronic illnesses, or neurocognitive conditions that could interfere with study participation were excluded from both groups. Children who declined to participate were also excluded.

The study aimed to compare emotional reactivity, metacognitive awareness, sleep quality, and symptoms of anxiety and depression between children with T1D and healthy controls using standardized questionnaires.

2.1. Ethical Approval

The study was approved by the Ethics Committee of Tepecik Training and Research Hospital (Approval No: 2022/12-39; Approval Date: 11 January 2023). Written informed consent was obtained from participants and their parents or legal guardians before questionnaire administration. The study was conducted in accordance with the Declaration of Helsinki.

2.2. Questionnaires

Revised Child Anxiety and Depression Scales—Child Version (RCADS-CV): Developed by Chorpita et al. [15], the RCADS-CV is a self-report instrument assessing symptoms of anxiety disorders and depression in children. It comprises 47 items rated on a four-point Likert scale, with higher scores indicating more pronounced symptoms. Its reliability and validity have been established in community and clinical populations [16], and the Turkish adaptation has also demonstrated satisfactory psychometric properties [17].

The Metacognitive Awareness Inventory for Children (Jr. MAI-A): The Jr. MAI assesses children's awareness and regulation of their cognitive processes [14]. The instrument includes two versions, Forms A and B, intended for different age groups. Form A was administered in this study. It contains 12 items scored on a three-point Likert scale, producing total scores between 12 and 36. Higher scores indicate greater metacognitive awareness. The Turkish versions of the Jr. MAI were evaluated by Karakelle and Saraç, who reported acceptable validity and reliability [18].

Emotional Reactivity Scale (ERS): The ERS is one of the three scales developed by Prince-Embury as part of the Resiliency Scales for Children and Adolescents (RSCA). In this study, the 19-item Turkish adaptation validated by Kurtoğlu and Doğan was used [19]. Responses are recorded on a five-point Likert scale, and the instrument assesses three aspects of emotional functioning: sensitivity to emotional experiences, recovery following emotional distress, and impairment associated with emotional reactions. Higher total scores indicate greater emotional reactivity and, consequently, lower emotional resilience, whereas lower scores indicate greater emotional resilience.

Pittsburgh Sleep Quality Index (PSQI): The PSQI is a self-report measure assessing sleep quality and disturbances during the preceding month. Its 19 items contribute to seven component scores covering subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The

component scores are combined to obtain a global PSQI score. A global score above 5 indicates poor sleep quality. For this cutoff, sensitivity of 89.6%, specificity of 86.5%, and agreement of $\kappa = 0.75$ ($p < 0.001$) have been reported [20].

2.3. Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA), and R software, version 4.0.5 (R Foundation for Statistical Computing, Vienna, Austria), including the ggplot2 and Hmisc packages. Continuous variables were described using means, standard deviations, medians, and minimum–maximum values, while categorical variables were presented as frequencies and percentages. The Shapiro–Wilk test was applied to assess the normality of continuous variables. For comparisons between two independent groups, the independent-samples *t*-test or Mann–Whitney U test was selected according to data distribution. Comparisons involving more than two groups were performed using analysis of variance (ANOVA) or the Kruskal–Wallis test, as appropriate. Significant Kruskal–Wallis results were followed by Dunn's pairwise comparisons with Bonferroni-adjusted *p*-values. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test. Statistical significance was defined as $p < 0.05$. To account for the significant age difference between the T1D and control groups, additional linear regression models were constructed with adjustment for age. Total anxiety, combined anxiety–depression, ERS total, and metacognitive awareness scores were examined as separate dependent variables. Each model included age and study group (1 = T1D; 2 = healthy control) as independent variables. These analyses assessed whether between-group differences in psychological outcomes persisted after accounting for age.

3. Results

A total of 127 children were included in the study, 63 with T1D and 64 in the control group. In the T1D group 30 were boys (47.6%) and 33 were girls (52.4%), while in the control group 30 were boys (46.9%) and 34 were girls (53.1%) ($p > 0.05$). The mean age of the T1D group was 14.5 ± 2.68 years, while the mean age of the control group was 10.37 ± 1.79 years ($p < 0.001$).

In the T1D group, 21 children (33.3%) were using a CGM, and the entire group was on multiple dose insulin therapy. The mean HbA1c level was 9.62 ± 2.3%. Thirty-six (57.1%) of the T1D group had never been hospitalized, 12 (19%) had been hospitalized once, 11 (17.5%) had been hospitalized twice, and 4 (6.4%) had been hospitalized three or more times, excluding the time when newly diagnosed.

RCADS-CV data were available for 62 of the 63 children with T1D. RCADS-CV scores are presented in Tables 1 and 2. Children with T1D had significantly higher anxiety and depression scores than healthy controls ($p < 0.001$). In age-adjusted linear regression analyses, both total anxiety and combined anxiety–depression scores remained significantly higher in the T1D group compared with controls ($p < 0.001$ for both). Age was not a significant predictor in either model ($p > 0.05$).

Table 1. Comparison of Revised Child Anxiety and Depression Scales—Child Version (RCADS-CV) scores in the diabetes and control groups.

	Diabetes (n = 62)	Control (n = 64)	*p*-Value
Separation Anxiety	4.41 ± 4.03	1.84 ± 0.94	<0.001
Generalized Anxiety	6.59 ± 3.76	1.43 ± 1.48	<0.001
Panic	6.58 ± 5.60	1.12 ± 0.78	<0.001

Table 1. *Cont.*

	Diabetes (n = 62)	Control (n = 64)	*p*-Value
Social Phobia	9.32 ± 6.62	2.03 ± 2.02	<0.001
Obsessions/Compulsions	6.03 ± 4.16	3.87 ± 3.27	0.002
Depression	10.25 ± 7.33	2.06 ± 2.30	<0.001
Total Anxiety	32.95 ± 20.34	10.37 ± 5.13	<0.001
Total Anxiety and Depression	43.22 ± 26.04	12.43 ± 5.70	<0.001

Data are presented as mean ± standard deviation (SD). RCADS-CV, Revised Child Anxiety and Depression Scale—Child Version.

Table 2. Age-adjusted linear regression analyses of total anxiety and combined anxiety–depression scores.

Outcome Variable	Predictor	B (95% CI)	*p*-Value
Total Anxiety	Group	−24.70 (−31.72 to −17.69)	<0.001
	Age	−0.52 (−1.67 to 0.63)	0.373
Total Anxiety and Depression	Group	−32.10 (−41.03 to −23.17)	<0.001
	Age	−0.32 (−1.79 to 1.14)	0.665

B, unstandardized regression coefficient; CI, confidence interval. Group was coded as 1 = type 1 diabetes mellitus and 2 = healthy control. All regression models were adjusted for age.

ERS and Jr. MAI-A scores in children are shown in Table 3. The diabetes group had a statistically significant, higher ERS score compared to the control group ($p < 0.001$). However, on the Jr. MAI-A scale, the control group had a significantly higher score than the diabetes group ($p = 0.011$).

Table 3. Comparison of Emotional Reactivity Scale (ERS) and Metacognitive Awareness Inventory for Children (Jr. MAI-A) scores between the diabetes and control groups.

	Diabetes (n = 63)	Control (n = 64)	*p*-Value
Sensitivity	10.90 ± 5.66	2.85 ± 1.16	<0.001
Recovery	5.57 ± 4.07	2.78 ± 1.44	<0.001
İmpairment	11.87 ± 9.38	4.82 ± 1.99	<0.001
ERS Total	28.38 ± 17.08	10.46 ± 3.97	<0.001
Metacognitive Awareness	30.53 ± 3.68	31.96 ± 2.42	0.011

Data are presented as mean ± standard deviation (SD). ERS, Emotional Reactivity Scale; Jr. MAI-A, Metacognitive Awareness Inventory for Children. Higher ERS scores indicate lower emotional resilience, whereas higher Jr. MAI-A scores indicate greater metacognitive awareness.

In age-adjusted linear regression analysis, ERS total scores remained significantly higher in the T1D group compared with controls ($p < 0.001$), indicating greater emotional reactivity, potentially reflecting lower emotional resilience in children with T1D. Age was not a significant predictor ($p = 0.277$). In contrast, metacognitive scores were significantly higher in controls compared to the T1D group (p <0.001). Additionally, age was a significant predictor of metacognitive scores ($p = 0.014$) (Table 4).

PSQI scores were significantly higher in children with T1D than in healthy controls (5.53 ± 3.13 vs. 4.10 ± 1.62; $p = 0.002$), indicating poorer sleep quality in the diabetes group.

Table 4. Linear regression analyses of emotional resilience and metacognitive scores adjusted for age.

Outcome Variable	Predictor	B (95% CI)	*p*-Value
ERS Total	Group	−15.73 (−21.60 to −9.86)	<0.001
	Age	0.53 (−0.43 to 1.49)	0.277
Metacognitive Awareness	Group	2.66 (1.21 to 4.11)	<0.001
	Age	0.30 (0.06 to 0.53)	0.014

B, unstandardized regression coefficient; CI, confidence interval; ERS, Emotional Reactivity Scale. Group was coded as 1 = type 1 diabetes mellitus and 2 = healthy control. All regression models were adjusted for age.

Children with two or more hospitalizations had significantly higher PSQI scores (6.48 ± 3.13 vs. 4.83 ± 2.99; $p = 0.038$) and combined anxiety–depression scores (50.77 ± 24.41 vs. 37.40 ± 26.08; $p = 0.044$) than those with fewer than two hospitalizations. Hospitalizations at initial diabetes diagnosis were excluded from this analysis.

There was no statistically significant correlation between the use of continuous glucose monitoring (CGM) and scores on the PSQI, Jr. MAI-A, RCADS-CV, or ERS ($p > 0.05$).

No significant correlation was found between HbA1c levels and PSQI, Jr. MAI-A, RCADS-CV, or ERS scores ($p > 0.05$).

4. Discussion

Psychosocial well-being in children and adolescents with T1D has been widely investigated, with particular emphasis on sleep quality, anxiety, and depression. However, research addressing metacognitive awareness and emotional resilience in this population remains limited. By evaluating these less-explored dimensions, our study provides additional insight into the psychological characteristics of children with T1D, although the findings should be considered within the context of its methodological limitations.

Anxiety and depressive symptoms are frequently observed among children and adolescents living with T1D. According to a systematic review and meta-analysis, depressive symptoms affected 30.04% of this population, while anxiety symptoms were reported in 32% [5]. In our study, the mean combined anxiety–depression score was 43.22 ± 26.04 in the T1D group and 12.43 ± 5.70 in healthy controls ($p < 0.001$). The difference between groups persisted after controlling for age. Comparable findings have been reported in adolescents with chronic kidney disease and transfusion-dependent thalassemia, in whom RCADS assessments revealed higher anxiety and depression scores than in healthy peers [21,22]. These observations suggest that psychological distress is relevant not only to T1D but also to other chronic conditions affecting children and adolescents.

Diabetes has been linked to alterations in brain structure and neurocognitive performance. McIntyre et al. [23] reviewed these findings and suggested that diabetes and mood disorders may share certain underlying pathophysiological mechanisms.

A study comparing 36 preschool children with T1D and 32 healthy peers found no overall difference in cognitive performance, with scores remaining within the expected range in both groups. Nevertheless, higher HbA1c concentrations were linked to poorer general cognitive abilities within the T1D group, pointing to a possible association between glycemic control and cognitive functioning [24]. In a separate investigation, Miller et al. [25] examined metacognition in relation to diabetes self-management. Although changes in metacognition were not predictive of changes in self-management, improvements in behavioral regulation were associated with better self-management outcomes.

Children with T1D had lower metacognitive awareness scores than healthy controls ($p = 0.011$). No significant association was identified between HbA1c levels and metacogni-

tive awareness. Given the limited research addressing metacognition in pediatric T1D, our findings provide additional evidence of differences in this domain. Although metacognitive awareness may be relevant to diabetes self-management, further studies are needed to determine whether interventions targeting this ability could improve diabetes management.

Resilience refers to the ability to adapt to challenging circumstances and maintain psychological functioning despite adversity [26]. In our study, children with T1D exhibited significantly higher emotional reactivity scores than healthy controls, potentially reflecting lower emotional resilience, as higher ERS scores indicate lower resilience. Living with T1D involves ongoing challenges, making emotional resilience particularly relevant during childhood and adolescence. A systematic review involving adults with chronic diseases found that greater resilience was associated with lower levels of anxiety and depression [27]. Likewise, Lerma et al. [28] reported an inverse association between resilience and symptoms of anxiety and depression among adults receiving chronic hemodialysis. In our study, children with T1D also had higher anxiety–depression scores than healthy controls. Although these findings are consistent with the broader literature, the relationship between emotional reactivity and anxiety or depression was not directly examined in our study.

Further evidence comes from a study of 71 children with different chronic conditions, in which resilience was significantly related to health-related quality of life and explained 45% of the variance in quality-of-life scores [29]. These findings highlight the potential relevance of emotional resilience when addressing the psychosocial needs of children with T1D. Nevertheless, additional research is required to establish how emotional resilience relates to psychological outcomes and diabetes self-management in this population.

Previous research has documented alterations in sleep architecture and poorer sleep quality among children with T1D compared with healthy peers [12]. Farabi [12] also discussed the potential role of nocturnal glucose fluctuations in sleep disruption. Consistent with these observations, children with T1D in our study had significantly higher PSQI scores than healthy controls, indicating poorer subjective sleep quality. Sinisterra et al. [13] reported fewer sleep disturbances among young children with T1D using CGM than among nonusers. In contrast, our study found no significant association between CGM use and sleep quality. Furthermore, HbA1c levels were not significantly associated with sleep quality in our sample.

In our study, children with T1D who had been hospitalized two or more times had significantly higher PSQI scores than those with fewer hospitalizations, indicating poorer subjective sleep quality. These hospitalizations were related to diabetic ketoacidosis or inadequate glycemic management, suggesting that greater disease burden may be associated with sleep disturbances. Combined anxiety–depression scores were also significantly higher among children with at least two hospitalizations. Together, these findings suggest that recurrent hospitalizations may be associated with poorer sleep quality and greater psychological distress in children with T1D. However, the cross-sectional design of our study does not allow causal relationships to be established.

The main limitations of our study include the relatively small sample size and the significant age difference between the groups. Pubertal status was not assessed, which may have influenced psychological outcomes. Although age-adjusted regression analyses were performed, residual confounding related to pubertal development cannot be excluded. The use of the Emotional Reactivity Scale beyond its validated age range and the administration of the Jr. MAI-A form across different developmental stages represent additional limitations. The same assessment forms were administered to all participants to maintain consistency in data collection and facilitate between-group comparisons. However, the use of these instruments across different age groups may have affected their measurement validity and comparability, as developmental differences may influence how participants understand

and respond to the items. Therefore, the observed group differences should be interpreted with caution. Furthermore, detailed sociodemographic characteristics, such as parental education level, socioeconomic status, and family structure, were not collected. Therefore, the potential influence of these factors on psychological outcomes could not be evaluated. Additionally, the children's level of independence in diabetes self-management was not assessed, which represents a further limitation of the study.

In conclusion, our findings indicate that children with type 1 diabetes (T1D) exhibited higher levels of anxiety, depression, and sleep disturbances compared with healthy controls. The significantly higher Emotional Reactivity Scale (ERS) scores observed in the T1D group indicate potentially lower emotional resilience. Metacognitive awareness was also lower in children with T1D. Furthermore, a higher frequency of hospitalization was associated with higher combined anxiety–depression scores and poorer sleep quality. These findings should be interpreted with caution, as methodological limitations and unmeasured personal and environmental factors, including developmental characteristics, family support, and socioeconomic conditions, may have influenced the observed differences. Our findings suggest the potential importance of psychosocial assessment in children with T1D, although further studies are needed to clarify these associations.

Author Contributions: R.M. and G.E.Ö. contributed to the study conception and design. Material preparation and data collection were performed by R.M. and G.E.Ö. Statistical analysis was performed by E.E. The first draft of the manuscript was written by R.M. All authors (R.M., G.E.Ö., E.E., B.E.F. and B.N.D.) contributed to the critical review and revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Tepecik Training and Research Hospital (approval no. 2022/12-39; 11 January 2023).

Informed Consent Statement: Written informed consent was obtained from all participants and their legal guardians prior to participation in the study.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy and ethical restrictions.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

CGM	Continuous glucose monitoring
CI	Confidence interval
ERS	Emotional Reactivity Scale
HbA1c	Glycated hemoglobin
Jr. MAI-A	Metacognitive Awareness Inventory for Children
PSQI	Pittsburgh Sleep Quality Index
RCADS-CV	Revised Child Anxiety and Depression Scale—Child Version
SD	Standard deviation
T1D	Type 1 diabetes

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