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The Relationship Between Smartphone Addiction and Diabetes Self-Management In Adolescents With Type 1 Diabetes

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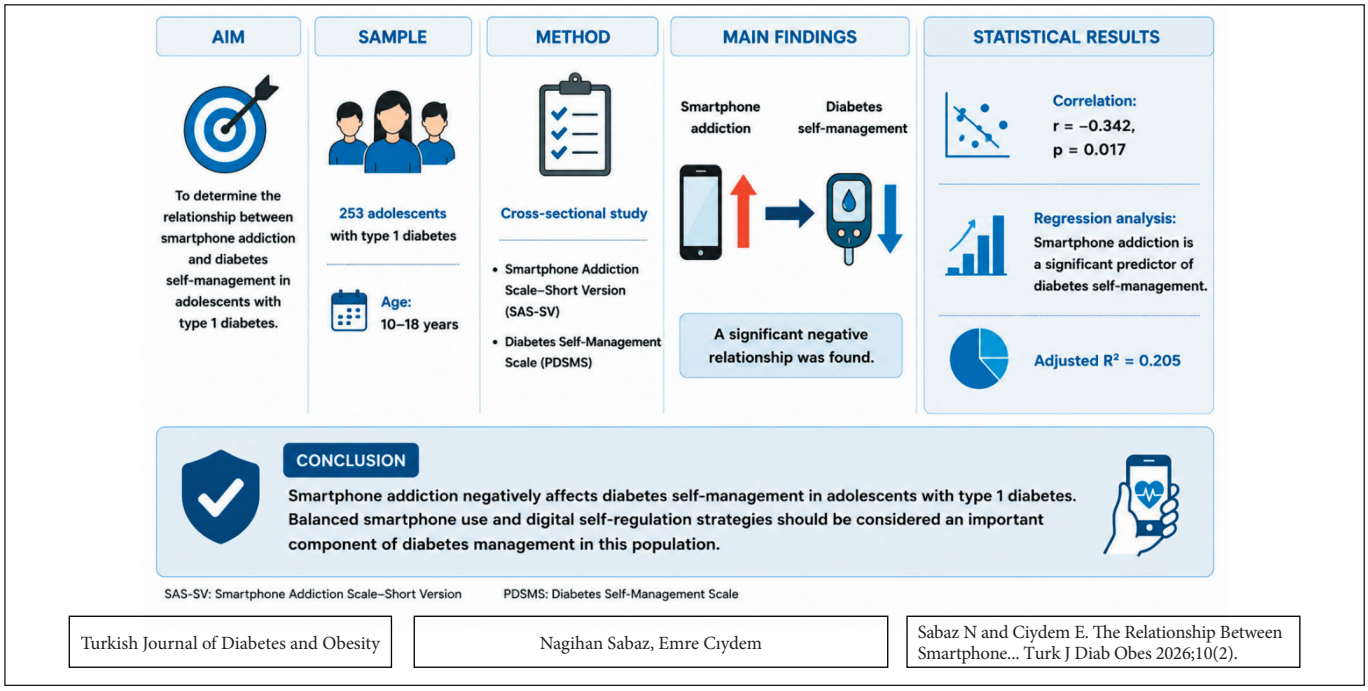
GRAPHICAL ABSTRACT



ABSTRACT

Aim: This study aimed to examine the relationship between smartphone addiction and diabetes self-management in adolescents with type 1 diabetes.

Material and Methods: This study was conducted using a cross-sectional descriptive and correlational design. The sample consisted of 253 children and adolescents aged 6–18 years diagnosed with type 1 diabetes in Türkiye. Participants were recruited through online diabetes education groups and social media platforms. Multiple linear regression analysis (backward elimination method) was used to analyze the data.

Results: An increase of 1 unit in the smartphone addiction scale total score is associated with a decrease of 3.550 units in the participant's perceived diabetes self-management level ($p < 0.001$). An increase of 1 unit in HbA1c level is associated with a decrease of 0.165 units in

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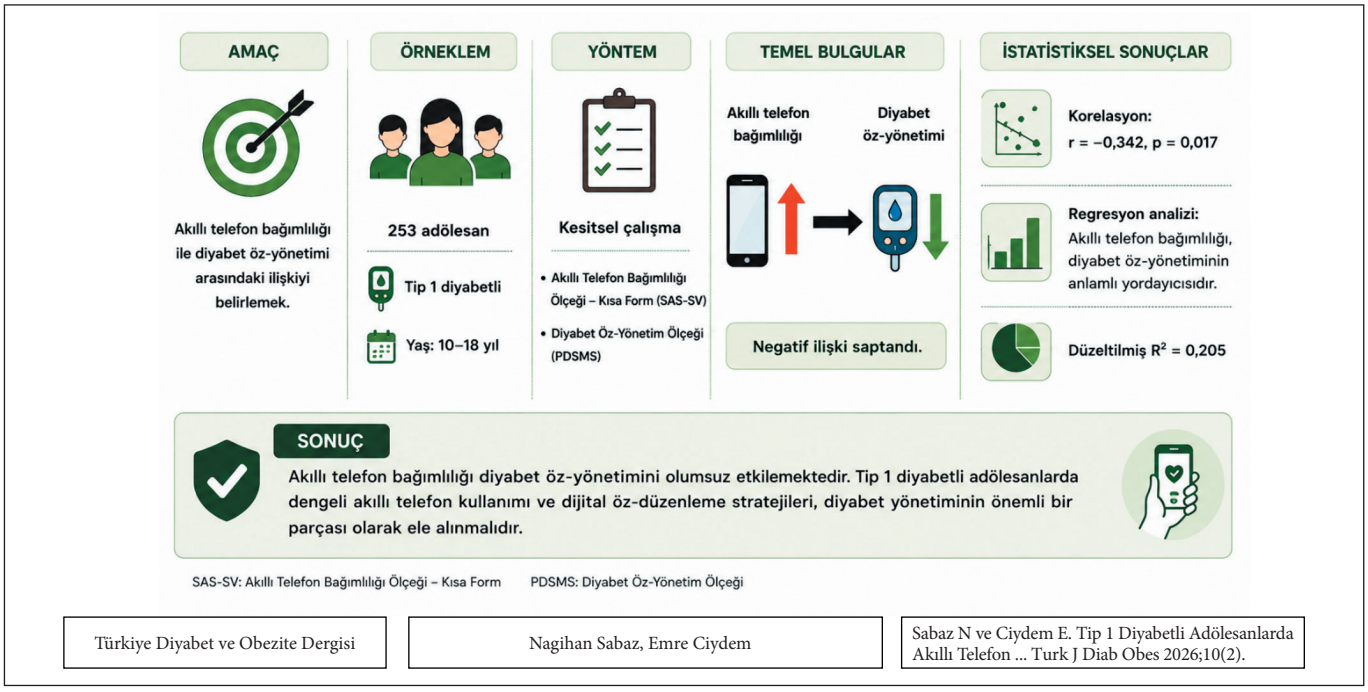
the participant's perceived diabetes self-management level (p = 0.031). An increase of 1 unit in the number of hypoglycemic episodes in the last month is associated with a decrease of 0.970 units in the perceived diabetes self-management level (p = 0.049). An increase of 1 unit in the number of hyperglycemic episodes in the last month is associated with a decrease of 0.168 units in the participant's perceived diabetes self-management level (p < 0.001).

Conclusion: Smartphone addiction was negatively associated with perceived diabetes self-management. Higher HbA1c levels and more frequent hypo- and hyperglycemic episodes were also significantly related to poorer self-management. Healthcare professionals should routinely assess smartphone addiction and glycemic control indicators in adolescents with type 1 diabetes to support effective self-management interventions.

Keywords: *Type 1 diabetes, Smartphone addiction, Diabetes self-management, Adolescents, Glycemic control*

Tip 1 Diyabetli Adölesanlarda Akıllı Telefon Bağımlılığı İle Diyabet Öz-Yönetimi Arasındaki İlişki

GRAFİKSEL ÖZET



ÖZ

Amaç: Bu çalışma, tip 1 diyabetli ergenlerde akıllı telefon bağımlılığı ile diyabet öz-yönetimi arasındaki ilişkiyi incelemeyi amaçlamıştır.

Gereç ve Yöntemler: Bu araştırma kesitsel, tanımlayıcı ve korelasyonel bir tasarım kullanılarak gerçekleştirilmiştir. Araştırmanın örneklemini Türkiye'de tip 1 diyabet tanısı almış 6–18 yaş aralığındaki 253 adölesan oluşturmuştur. Katılımcılar çevrim içi diyabet eğitim grupları ve sosyal medya platformları aracılığıyla araştırmaya dahil edilmiştir. Verilerin analizinde çoklu doğrusal regresyon analizi (geriye doğru eleme yöntemi) kullanılmıştır.

Bulgular: Akıllı telefon bağımlılığı ölçeği toplam puanındaki 1 birimlik artışın, algılanan diyabet öz-yönetimi düzeyinde 3,550 birimlik azalış ile ilişkili olduğu bulunmuştur (p < 0.001). HbA1c düzeyindeki 1 birimlik artışın algılanan diyabet öz-yönetiminde 0,165 birimlik azalışla ilişkili olduğu saptanmıştır (p = 0.031). Son bir ayda yaşanan hipoglisemi sayısındaki 1 birimlik artışın algılanan diyabet öz-yönetimi düzeyinde 0,970 birimlik azalışa yol açtığı belirlenmiştir (p = 0.040). Benzer şekilde, son bir ayda yaşanan hiperglisemi sayısındaki 1 birimlik artışın algılanan diyabet öz-yönetimi düzeyinde 0,168 birimlik azalışla ilişkili olduğu bulunmuştur (p < 0.001).

Sonuç: Akıllı telefon bağımlılığı ile algılanan diyabet öz-yönetimi arasında negatif yönlü bir ilişki saptanmıştır. HbA1c düzeyi, hipoglisemi ve hiperglisemi epizodlarının sıklığındaki artışın algılanan diyabet öz-yönetim düzeyindeki azalmayla anlamlı olarak ilişkili olduğu bulunmuştur. Sağlık profesyonellerinin, tip 1 diyabetli adölesanlarda etkili öz-yönetim müdahalelerini desteklemek amacıyla akıllı telefon bağımlılığını ve glisemik kontrol göstergelerini rutin olarak değerlendirmeleri önerilmektedir.

Anahtar Sözcükler: *Tip 1 diyabet, Akıllı telefon bağımlılığı, Diyabet öz-yönetimi, Adölesan, Glisemik kontrol*

INTRODUCTION

Type 1 diabetes is one of the most common chronic diseases in childhood and adolescence and requires effective self-management (1). Adolescence is a developmental period characterized by intense biopsychosocial changes, increasing autonomy, and still-maturing self-regulation skills (2-4). During this stage, diabetes management involves multidimensional responsibilities such as regular blood glucose monitoring, insulin administration, dietary planning, and physical activity, making adolescents' self-management skills critically important (5,6). Adolescents' diabetes self-management abilities are influenced by various individual, familial, and environmental factors (6,7). Elements such as self-regulation capacity, self-efficacy perception, emotional status, peer relationships, family support, and parental supervision can determine the extent to which adolescents fulfill diabetes-related responsibilities (6,8,9). In addition, sleep patterns, academic workload, and the intensity of social life play significant roles in treatment adherence. Within this multidimensional framework, digital media use has increasingly become a determining factor (6,10,11).

Today, smartphone use has become an integral part of adolescents' daily lives. Intensive engagement with digital content such as social media, gaming, and messaging applications may lead to distraction, poor time management, and postponement of responsibilities (12,13). This situation may constitute a potential risk factor for adolescents with type 1 diabetes who require continuous chronic disease management (14). A review of the literature reveals no study that directly examines the relationship between smartphone addiction and perceived diabetes self-management among adolescents with type 1 diabetes. However, there is evidence indicating that digital media use is associated with glycemic control and diabetes management indicators. A study conducted in Türkiye reported a negative association between social media addiction and HbA1c as well as fasting blood glucose levels (14). Research carried out in Taiwan demonstrated that intensive internet and social media use led to disruptions in treatment routines and deterioration in glycemic control (15). Similarly, a study in the United States suggested that the distracting and addictive characteristics of social media applications may contribute to interruptions in diabetes-related responsibilities (16). In addition, some studies have reported a potential association between internet use and glycemic control (17). Overall, the literature suggests that digital media use may influence glycemic control and diabetes management among adolescents with type 1 diabetes. However, there remains an important gap regarding the nature of the relationship between smartphone addiction and perceived diabetes self-management. Accordingly, this study aimed to examine the relationship between smartphone addiction and diabetes self-management in adolescents with type 1 diabetes. The findings of this research are expected to contribute to a better understanding of how smartphone addiction affects diabetes management. Furthermore, the results may guide healthcare professionals in incorporating adolescents' smartphone use levels into clinical assessments. The study findings are also expected to assist families and educators in promoting balanced technology use and to provide a foundation for developing intervention programs aimed at strengthening diabetes self-management. In this way, the development of holistic diabetes management approaches that take smartphone addiction into account may be supported.

MATERIALS and METHODS

Study Design

The study was conducted using a correlational design to examine the relationship between participants' smartphone addiction and difficulties in perceived diabetes self-management among children and adolescents aged 6–18 years with type 1 diabetes.

Research Questions

- Is there a relationship between smartphone addiction and perceived diabetes self-management difficulties among children and adolescents aged 6–18 years with type 1 diabetes?
- What factors influence the perceived diabetes self-management levels of children and adolescents aged 6–18 years with type 1 diabetes?

Population and Sample

The population of the study consisted of all adolescents aged 6–18 years with type 1 diabetes who were members of diabetes education WhatsApp groups in Türkiye or who followed other related online platforms. Announcements about the study were shared with both parents and adolescents through online platforms (WhatsApp, Telegram, Instagram, Facebook, and X). In addition, the data collection tools were distributed via online platforms where both parents and adolescents were actively engaged. The minimum required sample size was calculated as 262 using the G*Power 3.1.9.7 program, based on a 95% confidence level (1–α), 95% test power (1–β), and an effect size of 0.20. The study was completed with 253 children and adolescents diagnosed with type 1 diabetes. A post-hoc power analysis indicated that, with an effect size of 0.26, a 95% confidence level (1–α), and a sample of 253 participants, the statistical power of the study was 99%. Convenience sampling was

used for recruitment. Five participants were excluded from the sample because they had been diagnosed with type 1 diabetes for less than one year. The study included children and adolescents aged 6–18 years who had been diagnosed with type 1 diabetes for more than one year, were not hospitalized during the data collection period, and did not have any chronic diseases accompanying diabetes. Participants were required to reside in Türkiye, have access to online platforms, and complete the data collection tools. Both parental written informed consent and the child/adolescent's written assent were mandatory for participation. Participants were excluded if they had been diagnosed with type 1 diabetes for less than one year, were hospitalized at the time of data collection, or had an additional chronic medical condition unrelated to diabetes. Individuals who were unable to complete the data collection tools due to cognitive, neurological, or communication limitations, as well as those who did not provide both the required parental written informed consent and the child/adolescent written assent, were excluded. Additionally, nine participants were excluded from the analysis because their questionnaires contained incomplete or inconsistent responses. No imputation procedure was performed, and only complete datasets were included in the final analyses.

Instruments

Information Form

The information form, developed by the researchers based on the relevant literature, consisted of 14 questions. This form was designed to gather detailed information about the participants' demographic characteristics as well as diabetes-related clinical features (14,16).

The Perceived Diabetes Self-Management Scale (PDSMS)

Wallston et al. Developed the PDSMS to measure how capable adults with type 1 or type 2 diabetes perceive themselves to be in managing their condition (18). Yapar and Aksakal subsequently conducted the Turkish adaptation and psychometric evaluation of the instrument in individuals with both types of diabetes (19). The PDSMS focuses on perceived competence in carrying out diabetes self-care activities and can therefore be regarded as an indicator of diabetes-related self-efficacy. It comprises eight statements rated from 1 (strongly disagree) to 5 (strongly agree). Four statements (items 1, 2, 6, and 7) are negatively keyed and require reverse coding before the overall score is computed. After appropriate recoding, item scores are summed to obtain a total between 8 and 40. Higher values represent a stronger perception of one's ability to effectively manage diabetes-related demands. The Turkish validation study supported a unidimensional structure of the PDSMS in participants with both type 1 and type 2 diabetes based on exploratory and confirmatory factor analyses. Among participants with type 1 diabetes, item factor loadings varied from 0.397 to 0.794, and the internal consistency coefficient was 0.784. The stability of the instrument over time was also high, with intraclass correlation coefficients exceeding 0.97 (19). In the present study, the PDSMS demonstrated high internal consistency, with a Cronbach's α of 0.94.

The Smartphone Addiction Scale–Short Version (SAS-SV)

Kwon, et al. developed the SAS-SV to evaluate symptoms associated with excessive smartphone use among adolescents (20). Şata and Karip later adapted the instrument for Turkish adolescents and evaluated its psychometric performance, providing evidence supporting its use in this population (21). The SAS-SV includes 10 self-reported statements addressing behaviors and tendencies associated with problematic smartphone use. Responses to each statement are given on a six-point response format, with options extending from 1 (strongly disagree) to 6 (strongly agree). Summing the item responses yields an overall score of 10–60, where increasing scores reflect greater severity of smartphone addiction tendencies. Psychometric evaluation of the Turkish form supported a single-factor model. Its reliability was also satisfactory, as indicated by coefficients of $\alpha = 0.90$ and $\omega = 0.94$ (21). In the present study, the SAS-SV showed high internal consistency, with a Cronbach's α of 0.93.

Procedure

The data were collected online using Google Forms between January 1 and February 5, 2026. Announcements about the study were shared on online platforms followed by parents and adolescents with type 1 diabetes, including WhatsApp, Telegram, Instagram, Facebook, and X. Adolescents aged 6–18 years who met the inclusion criteria were informed about the purpose and procedures of the study. Both parental written informed consent and the child/adolescent's written assent were obtained electronically before participation. After providing consent, participants were asked to complete the demographic information form, the PDSMS, and SAS-SV.

Ethical Issues

The study was conducted in accordance with the principles of the Helsinki Declaration. Ethical approval for the research was obtained from the Marmara University Faculty of Health Sciences Non-Interventional Clinical Research Ethics Committee (Date: 25.12.2025, Protocol No: 192) as documented in the official ethics approval letter. Because the data were collected digitally through online platforms, no additional institutional permission was required. Prior

to participation, parents and adolescents were informed about the objectives and procedures of the study. Participation was entirely voluntary, and both written informed consent from parents and written assent from adolescents were obtained electronically. Participants were assured that they could discontinue their involvement at any stage without providing any justification. All data were collected anonymously, stored in an encrypted digital folder on the researcher's computer, and will be permanently deleted two years after the completion of the study to ensure confidentiality and data protection.

Statistical Analysis

All statistical procedures were performed with IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA). Participant characteristics and diabetes-related variables were described using appropriate descriptive measures and frequency distributions. The distributional properties of continuous data were checked with the Kolmogorov–Smirnov test. Associations between continuous measures were investigated using Pearson's correlation coefficient. Perceived diabetes self-management was subsequently examined as the dependent variable in a multiple linear regression model. Sociodemographic characteristics, clinical factors, and smartphone addiction were considered as potential predictors, and backward elimination was applied for variable selection. Before interpreting the model, regression diagnostics were performed to verify that the relevant assumptions were satisfied. Residual distribution was inspected using histograms and normal P–P plots, whereas plots of standardized residuals against standardized predicted values were used to evaluate linearity and constant error variance. The Durbin–Watson statistic was considered when assessing residual independence. Possible collinearity among predictors was investigated on the basis of tolerance and variance inflation factor (VIF) values. Standardized residuals, Cook's distance, and Mahalanobis distance were additionally inspected to identify potentially unusual or influential observations. The diagnostic findings supported the assumptions of residual normality, linearity, homoscedasticity, and independence and did not indicate problematic multicollinearity or influential outliers. Therefore, the final regression model was estimated using the backward elimination procedure to identify variables independently associated with perceived diabetes self-management.

RESULTS

Of the participants, 49.8% were male and 63.6% were high school students. A total of 86.2% did not have a sibling with type 1 diabetes. The rate of hospitalization due to diabetes within the last year was 27.3%. Additionally, 92.1% of the participants reported receiving diabetes management education, and 52.2% had attended a diabetes camp (Table 1). The mean age of the participants was 14.92 ± 1.93 years (minimum–maximum: 10–17 years). The mean most recently measured HbA1c level was 8.55 ± 1.81% (minimum–maximum: 6.5–11%). The mean number of hypoglycemic episodes in the last month was 2.67 ± 1.35 episodes (minimum–maximum: 1–10 episodes), while the mean number of hyperglycemic episodes was 2.68 ± 1.32 episodes (minimum–maximum: 1–10 episodes). The mean duration of type 1 diabetes was 6.90 ± 3.94 years (minimum–maximum: 1–10 years). The mean frequency of blood glucose measurement was 6.11 ± 2.60 times/day (minimum–maximum: 1–6 times/day). The mean number of diabetes-related hospitalizations in the last year was 1.28 ± 0.59 times (minimum–maximum: 1–4 times), and the mean duration of diabetes-related hospitalization in the last year was 10.25 ± 12.84 days (minimum–maximum: 1–30 days) (Table 1).

As presented in Table 2, participants scored 29.21 ± 3.37 on the SAS-SV (range: 10–50 scores) and 25.79 ± 6.63 on the PDSMS (range: 8–36 scores) (Table 2).

A significant negative correlation was observed between SAS-SV and PDSMS total scores ($r = -0.342$, $p = 0.017$) (Table 3).

The regression model examining the factors associated with participants' perceived diabetes self-management levels was statistically significant ($F = 12.656$, $p < 0.001$) and explained 20.5% of the variance (adjusted $R^2 = 0.205$). A one-point increase in the Smartphone Addiction Scale total score was associated with a 3.550-point decrease in perceived diabetes self-management ($B = -3.550$, $p < 0.001$). Similarly, a one-percentage-point increase in HbA1c was associated with a 0.165-point decrease in perceived diabetes self-management ($B = -0.165$, $p = 0.031$). Each additional hypoglycemic episode in the last month was associated with a 0.970-point decrease in perceived diabetes self-management ($B = -0.970$, $p = 0.049$). Likewise, each additional hyperglycemic episode in the last month was associated with a 0.168-point decrease in perceived diabetes self-management ($B = -0.168$, $p < 0.001$) (Table 4).

DISCUSSION

When the findings of the present study are examined, it is observed that higher levels of smartphone addiction are associated with significantly lower levels of perceived diabetes self-management. This suggests that increased smartphone use may cause adolescents to feel less competent in managing their diabetes and to experience greater difficulty in carrying out daily diabetes-related tasks. Although the association between smartphone addiction and perceived diabe-

Table 1: Individuals' and disease-related characteristics of the participants (n=253).

Individuals' and disease-related characteristics*	Findings (n=253)		
Gender, n (%)			
Male	126 (49.8)	—	—
Female	127 (50.2)	—	—
Education status, n (%)			
Secondary school	92 (36.4)	—	—
High school	161 (63.6)	—	—
Presence of a sibling with type 1 diabetes, n (%)			
Yes	13 (5.1)	—	—
No	218 (86.2)	—	—
No siblings	22 (8.7)	—	—
Hospitalization due to diabetes in the last year, n (%)			
Yes	69 (27.3)	—	—
No	184 (72.7)	—	—
Received diabetes management education, n (%)			
Yes	233 (92.1)	—	—
No	20 (7.9)	—	—
Attended a diabetes camp, n (%)			
Yes	132 (52.2)	—	—
No	121 (47.8)	—	—
Age (years± SD) (min.-max.))	—	14.92 ± 1.93	10–17
Most recently measured HbA1c (%± SD) (min.-max.)	—	8.55 ± 1.81	6.5–11
Hypoglycemic episodes in the last month (episodes± SD) (min.-max.))	—	2.67 ± 1.35	1–10
Hyperglycemic episodes in the last month (episodes± SD) (min.-max.))	—	2.68 ± 1.32	1–10
Duration of type 1 diabetes (years± SD) (min.-max.))	—	6.90 ± 3.94	1–10
Blood glucose measurement frequency (times/day± SD) (min.-max.))	—	6.11 ± 2.60	1–6
Diabetes-related hospitalizations in the last year (times± SD) (min.-max.))	—	1.28 ± 0.59	1–4
Duration of diabetes-related hospitalization in the last year (days± SD) (min.-max.))	—	10.25 ± 12.84	1–30

*Categorical data are presented as number and percentage, n (%); continuous data are presented as mean ± standard deviation (SD) and minimum–maximum values.

Table 2: Participants' mean scores on the smartphone addiction scale and perceived diabetes self-management scale (n=253).

Scales and Scores*	Findings (n=253)	
Smartphone Addiction Scale total scores	29.21 ± 3.37	10–50
Perceived Diabetes Self-Management Scale total scores	25.79 ± 6.63	8–36

*Data are presented as mean ± standard deviation (SD) and minimum–maximum values.

Table 3: Relationship between smartphone addiction and perceived diabetes self-management scores (n=253).

Variables		Perceived diabetes self-management scale total
Smartphone addiction scale total	r	-0.342
	p	0.017

Note: **r:** Pearson correlation coefficient.

tes self-management was statistically significant, the magnitude of the relationship was weak to moderate (r = -0.342). Therefore, smartphone addiction should be considered as one of several factors potentially associated with diabetes self-management rather than a sole or dominant determinant. The finding that perceived self-management decreases as HbA1c levels rise further supports this interpretation.

Table 4: Factors affecting participant' perceived diabetes self-management levels (n=253).

Variables	Non-standardized coefficient		Standardized coefficient	t	p	95% CI			
	B	SE	Beta			Lower	Upper	VIF	Tolerance
(Constant)	25.309	1.700		14.888	0.000	21.782	28.838		
Smartphone addiction scale total	-3.550	0.84	-0.245	-4.226	0.000	-5.264	-1.967	5.56	0.18
HbA1c (%)	-0.165	0.079	-0.111	-2.167	0.031	-0.296	-0.024	7.14	0.14
Hypoglycemic episodes in the last month (episodes)	-0.970	0.532	-0.094	-1.823	0.049	-2.024	-0.059	5.26	0.19
Hyperglycemic episodes in the last month (episodes)	-0.168	0.017	-0.223	-9.882	0.000	-0.202	-0.135	7.69	0.13

F=12.656, p<0.001; R^2=0.271, Adj. R^2=0.205. Durbin-Watson: 2.114 Variables entered to regression model: Age, gender, education status, presence of a sibling with type 1 diabetes, duration of type 1 diabetes (years), frequency of blood glucose measurement (per day), smartphone addiction scale total, HbA1c, number of hypoglycemic episodes in the last 1 month, number of hyperglycemic episodes in the last 1 month, hospitalization status due to diabetes in the last 1 year, status of receiving diabetes management education, status of attending a diabetes camp.

Indeed, adolescents with poorer glycemic control appear to struggle more with diabetes management and report lower self-efficacy. Another finding that reinforces this result is the relationship between the number of hypoglycemic and hyperglycemic episodes experienced in the past month and perceived diabetes self-management. The results indicate that as the frequency of these metabolic episodes increases, perceived self-management decreases. Frequent glucose fluctuations may lead adolescents to feel a loss of control over their diabetes and make it harder for them to adhere to treatment routines. Taken together, these findings suggest that intensive smartphone use may contribute to behavioral disruptions such as poor time management, delays in glucose monitoring and insulin administration, and irregular meal patterns, which in turn may negatively affect adolescents' perceptions of their diabetes self-management.

A review of the literature revealed no study that directly examined the relationship between smartphone addiction and perceived diabetes self-management among adolescents with type 1 diabetes. However, a study conducted in Türkiye by Avan and Barna (14) reported a negative association between social media addiction and both HbA1c and fasting blood glucose levels in adolescents with type 1 diabetes. This finding supports the results of the present study by indicating that digital addiction may adversely affect glycemic control indicators.

Similarly, Hung et al. (15) reported that adolescents with type 1 diabetes in Taiwan frequently stayed up late browsing the internet, playing video games, and using social media. As a result, their sleep patterns were disrupted, insulin injections were delayed, and long-acting insulin doses were often missed. The researchers noted that these problems were particularly evident during holiday periods, when adolescents tended to stay up late and wake up later, leading to greater deviations from their treatment routines and contributing to poorer glycemic control. These findings closely align with the present study, in which increased smartphone use was associated with lower perceived diabetes self-management. Both studies clearly demonstrate that digital media use can negatively affect self-management processes in adolescents with type 1 diabetes.

In a study conducted in the United States, Rechenberg et al. (16) reported that nearly all adolescents with type 1 diabetes actively used social media applications and perceived these platforms as enjoyable yet distracting and potentially addictive. Participants stated that they primarily used social media to communicate with friends, share photos, and engage in leisure activities; however, this intensive use was noted to contribute to excessive engagement with technology, particularly during out-of-school hours. The study also found that only two adolescents followed diabetes-related social media accounts. The characterization of social media applications as "distracting" and "addictive" supports the findings of the present study, suggesting that such platforms may contribute to disruptions in diabetes-related tasks and responsibilities.

In another study conducted in Türkiye, Büyükyılmaz et al. (22) reported a weak negative relationship between the duration of diabetes and internet addiction. In the same study, no significant association was found between internet addiction and HbA1c levels. These results differ partially from the findings of the present study, which identified a significant negative relationship between smartphone addiction and HbA1c. This discrepancy may be explained by differences in the nature and purpose of technology use, as internet addiction and smartphone addiction do not nec-

essarily reflect the same behavioral patterns. Variations in age groups and the ways adolescents engage with digital technologies may also contribute to these differing results. Nevertheless, both studies indicate that digital behaviors interact with diabetes management indicators and highlight the importance of considering digital habits within the context of self-management processes.

In a study conducted in Greece by Daniilidou et al. (17), a positive association approaching statistical significance was reported between internet use and glycemic control ($r = 0.315$, $p = .065$). This finding suggests that increased internet use may contribute to higher HbA1c levels. Although the study indicated that adolescents with type 1 diabetes had lower internet addiction scores compared with their healthy peers, the observation that longer internet use was associated with poorer glycemic control is partially consistent with the present study's findings on smartphone addiction. Taken together, the evidence from previous research shows substantial alignment with the results of the current study and suggests that digital media use, whether manifested as social media addiction, internet addiction, or smartphone addiction, may negatively influence glycemic control and self-management processes among adolescents with type 1 diabetes.

These results can be explained through several mechanisms. Adolescence is a developmental period in which attention management, self-regulation skills, and time management abilities are still maturing (2,3). For this reason, intensive smartphone use may disrupt diabetes management behaviors such as regular blood glucose monitoring, insulin administration, meal tracking, and physical activity. Digital content that provides immediate rewards, including social media, gaming, and messaging, may pull adolescents' attention away from diabetes-related responsibilities and weaken their self-management skills (15,16). Emotional regulation offers another explanation. Excessive use of digital devices may be a strategy for coping with stress, loneliness, or anxiety, which can lead to behavioral avoidance and postponement of responsibilities (23,24). Frequent hypoglycemic and hyperglycemic episodes can also decrease perceptions of self-management and reinforce this behavioral pattern. As glucose fluctuations become more common, adolescents may lose confidence in their ability to manage diabetes, which in turn may increase their tendency to use smartphones as an escape (14). This pattern may create a cycle in which high technology use and low levels of perceived self-management reinforce each other. Another contributing factor is reduced parental supervision. Late-night smartphone use and irregular sleep routines may negatively affect diabetes management (25,26). Delayed sleep can result in postponed morning glucose measurements, irregular insulin administration, and impaired glycemic control during the day. These disruptions may elevate HbA1c levels and strengthen adolescents' perceptions of inadequate self-management (25,26). Finally, the type of digital content consumed also plays an important role. Social media and game-based content may drain adolescents' mental energy, alter their perception of time, and cause delays in completing tasks that require attention (15,16). In contrast, the limited engagement with diabetes education content suggests that the potential benefits of technology are not being fully utilized (15). Therefore, how and for what purpose technology is used appears to be a key factor influencing diabetes management.

One of the strengths of this study is its relatively large sample size, which increases the reliability of the findings regarding smartphone addiction and perceived diabetes self-management among adolescents with type 1 diabetes. The use of standardized, validated measurement tools enhanced the accuracy and validity of the data collected. Another strength is the inclusion of a wide age range (6–18 years), allowing for a comprehensive evaluation of diabetes self-management across different developmental stages.

Despite its strengths, the study also has several limitations. First, the cross-sectional design prevents establishing a causal relationship between smartphone addiction and perceived diabetes self-management; the associations identified can only be interpreted as correlational. Second, the use of self-report measures may have introduced recall bias or social desirability bias, particularly in reporting smartphone use habits and diabetes management behaviors. Another limitation is that data were collected exclusively through online platforms, which may have excluded adolescents from lower socioeconomic backgrounds or those with limited internet access. The absence of clinical verification of HbA1c values and hypoglycemia/hyperglycemia episodes is another constraint, as these variables were based on participant self-report. Additionally, potential confounding factors such as mental health status, family dynamics, and parental supervision were not assessed, which may influence both smartphone use and diabetes self-management. An additional limitation of this study is the use of convenience sampling and online recruitment through social media platforms and diabetes-related online groups. Adolescents who actively participate in such online communities may differ from the general population of adolescents with type 1 diabetes in terms of health literacy, engagement with diabetes care, access to technology, and motivation for self-management. Consequently, selection bias may have occurred, and the study sample may not fully represent all adolescents with

type 1 diabetes in Türkiye. Therefore, the findings should be interpreted with caution, and the generalizability of the results to the broader population of adolescents with type 1 diabetes may be limited. Another limitation is the broad age range of the sample (6–18 years). Participants at different developmental stages may differ substantially in cognitive abilities, diabetes self-management skills, and smartphone use behaviors. Although age was included as a covariate in the regression analysis, developmental differences across age groups may have influenced the findings and should be considered when interpreting the results. Finally, because the study was conducted within a specific cultural context, the findings may not be fully generalizable to adolescents with type 1 diabetes in other countries.

This study demonstrated that higher levels of smartphone addiction are associated with lower perceived diabetes self-management among adolescents with type 1 diabetes. Elevated HbA1c values and more frequent hypoglycemic and hyperglycemic episodes were also linked to poorer self-management perceptions, highlighting the importance of both behavioral and metabolic factors in diabetes care. These findings suggest that excessive or uncontrolled smartphone use may interfere with essential diabetes management tasks, potentially undermining adolescents' confidence and ability to maintain optimal glycemic control.

The findings of this study highlight the importance of addressing smartphone use as part of routine diabetes management in adolescents with type 1 diabetes. Healthcare professionals, particularly diabetes nurses and educators, should assess adolescents' digital media habits during clinical visits and incorporate discussions on healthy technology use into diabetes education. Providing guidance on balancing smartphone use with daily diabetes tasks such as glucose monitoring, insulin administration, and meal planning may help prevent disruptions in self-management routines. This is particularly important because type 1 diabetes management requires continuous education, self-monitoring, insulin management, healthy nutrition, physical activity, and close follow-up, while diabetes technologies can facilitate glycemic management when supported by appropriate education and guidance (27). Family involvement is also crucial. Parents should be educated about the potential impact of excessive smartphone use on diabetes management and encouraged to establish structured routines, including limits on nighttime screen use and monitoring of digital activities. Supporting adolescents in developing time-management and self-regulation strategies can further strengthen their self-management skills. Maintaining effective self-management and glycemic control is particularly important during childhood and adolescence, as previous research has shown that long-term glycemic control may remain suboptimal in young people with type 1 diabetes and that HbA1c trajectories can provide important information for identifying opportunities to intensify diabetes management (28). Schools and community programs may also play a role by integrating digital literacy and responsible technology use into health education curricula. Creating peer-support environments, both online and offline, may help adolescents use digital platforms more constructively, for example, by engaging with credible diabetes-related content rather than distractive or non-beneficial media. Previous literature indicates that professionally supported social networks and internet-based technologies can facilitate diabetes education, blood glucose monitoring, treatment-related communication, and self-management among adolescents with type 1 diabetes (29). Moreover, evidence from individuals with type 2 diabetes suggests that e-health literacy is positively associated with obtaining and verifying health information from digital media, highlighting the broader importance of developing skills to critically access and evaluate digital health information (30). Overall, the results suggest that promoting balanced smartphone use and enhancing self-regulation skills could contribute to improved diabetes management and glycemic outcomes in adolescents with type 1 diabetes. Practical interventions that combine behavioral guidance, family engagement, structured diabetes education, and digital health literacy may be useful in mitigating the potential negative effects of excessive smartphone use.

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Author's Contributions
Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Visualization, Writing - original draft, Writing - review & editing: **Nagihan Sabaz**, Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Visualization, Writing - original draft, Writing - review & editing: **Emre Ciydem.**

Conflict of interest
None.

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Ethics Committee Approval
The study was conducted in accordance with the principles of the Helsinki Declaration. Ethical approval for the research was obtained from the Marmara University Faculty of Health Sciences Non-Interventional Clinical Research Ethics Committee (Date: 25.12.2025, Protocol No: 192) as documented in the official ethics approval letter. Because the data were collected digitally

through online platforms, no additional institutional permission was required. Prior to participation, parents and adolescents were informed about the objectives and procedures of the study. Participation was entirely voluntary, and both written informed consent from parents and written assent from adolescents were obtained electronically. Participants were assured that they could discontinue their involvement at any stage without providing any justification. All data were collected anonymously, stored in an encrypted digital folder on the researcher's computer, and will be permanently deleted two years after the completion of the study to ensure confidentiality and data protection. Written assent was obtained electronically from all adolescent participants after they were informed about the purpose and procedures of the study.
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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