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The Effect of Mobile Application Use on Metabolic Control in Type 2 Diabetic Patients: The Case of a University Hospital

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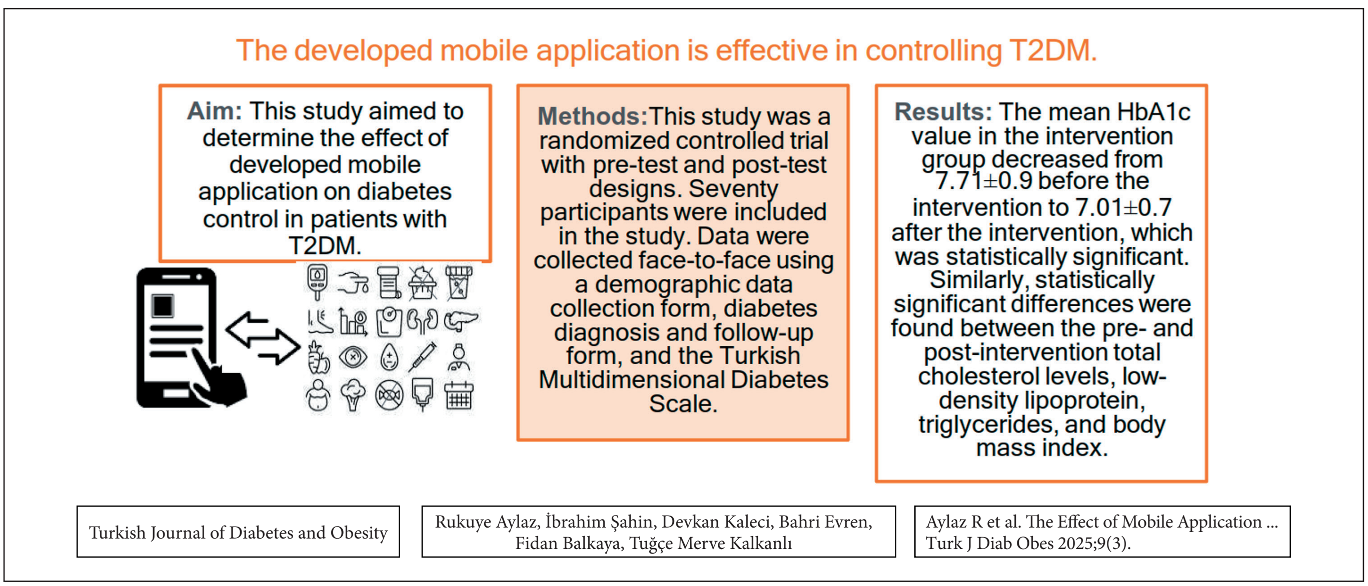
GRAPHICAL ABSTRACT



ABSTRACT

Aim: This study aimed to investigate the effect of the developed mobile application on disease control in patients with T2DM.

Material and Methods: This study was a randomized controlled trial with pre-test and post-test designs. The study population consisted of patients with T2DM. Seventy participants were included in the study. Data were collected face-to-face using a demographic data collection form, diabetes diagnosis and follow-up form, and the Turkish Multidimensional Diabetes Scale. The normality of data was confirmed with the Kolmogorov-Smirnov test. Statistical analyses included descriptive statistics, chi-square, independent samples t-tests, and paired samples t-tests.

Results: It was found that the majority of participants were individuals aged 51 and over, female, married, high school graduates, with an mean income level, and from nuclear family structures. The mean HbA1c value in the intervention group decreased from 7.71±0.9 before the intervention to 7.01±0.7 after the intervention, which was statistically significant. Similarly, statistically significant differences

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were found between the pre- and post-intervention total cholesterol levels, low-density lipoprotein, triglycerides, and body mass index. In the experimental group, a statistically significant difference was found among all subscales of the Turkish Multidimensional Diabetes Scale in both the pre- and post-intervention comparisons.

Conclusion: The statistically significant reduction in the metabolic parameters was observed with the use of this mobile application. This study demonstrates that diabetes management can be improved using a mobile application. However, to elucidate the impact of mobile apps on diabetes control, their effectiveness should be tested in different populations and with larger sample sizes. Such mobile health applications have the potential to contribute to national welfare by reducing health inequalities and healthcare expenditures.

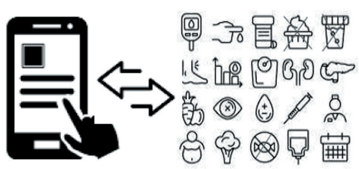
Keywords: *Diabetes mellitus, Disease management, Mobile applications, Patients*

Tip 2 Diyabetik Hastalarda Mobil Uygulama Kullanımının Diyabet Kontrolüne Etkisi: Bir Üniversite Hastanesi Örneği

GRAFİKSEL ÖZET

Geliştirilen mobil uygulama, T2DM kontrolünde etkilidir.

Amaç: Bu çalışma, geliştirilen mobil uygulamanın tip 2 diyabetik hastalarda diyabet kontrolü üzerindeki etkisini belirlemeyi amaçlamıştır.



Gereç ve Yöntem: Bu çalışma, ön test ve son test desenli bir randomize kontrollü çalışmadır. Çalışmaya yetmiş katılımcı dahil edilmiştir. Veriler, yüz yüze görüşme yoluyla bir demografik veri toplama formu, diyabet tanı ve takip formu ve Türkçe Çok Boyutlu Diyabet Ölçeği kullanılarak toplanmıştır.

Sonuç: Müdahale grubundaki ortalama HbA1c değeri, müdahale öncesinde 7,71±0,9 iken, müdahale sonrasında istatistiksel olarak anlamlı bir şekilde 7,01±0,7'ye düşmüştür. Benzer şekilde, müdahale öncesi ve sonrası total kolesterol düzeyleri, düşük yoğunluklu lipoprotein, trigliseritler ve vücut kitle indeksi arasında da istatistiksel olarak anlamlı farklar bulunmuştur.

Türkiye Diyabet ve Obezite Dergisi

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Aylaz R ve ark. Tip 2 Diyabetik Hastalarda Mobil ... Turk J Diab Obes 2025;9(3).

ÖZ

Amaç: Bu çalışmada, geliştirilen mobil uygulamanın tip 2 diyabetik hastalarda, hastalık kontrolü üzerindeki etkisinin incelenmesi amaçlanmıştır.

Gereç ve Yöntemler: Bu çalışma, ön test ve son test desenlerine sahip randomize kontrollü bir çalışmadır. Çalışmanın evrenini tip 2 diyabetik hastalar oluşturmuştur. Çalışmaya 70 katılımcı dâhil edilmiştir. Veriler, demografik veri toplama formu, diyabet tanı ve takip formu ve Türkçe Çok Boyutlu Diyabet Ölçeği kullanılarak yüz yüze görüşme yöntemiyle toplanmıştır.Normalliğin değerlendirilmesinde Kolmogorov-Smirnov testi kullanılmıştır. Veriler, tanımlayıcı istatistikler, ki-kare testleri, bağımsız örneklem t-testleri ve eşleştirilmiş örneklem t-testleri kullanılarak analiz edilmiştir.

Bulgular: Katılımcıların çoğunluğunun 51 yaş ve üzeri, kadın, evli, lise mezunu, orta gelir düzeyine sahip ve çekirdek aile yapısındaki bireylerden oluştuğu bulunmuştur. Müdahale grubunda ortalama HbA1c değeri müdahale öncesi 7,71±0,9'dan müdahale sonrası 7,01±0,7'ye düşmüş olup istatistiksel olarak anlamlı bulunmuştur. Benzer şekilde, müdahale öncesi ve sonrası toplam kolesterol düzeyleri, düşük yoğunluklu lipoprotein, trigliseritler ve vücut kütle indeksi arasında istatistiksel olarak anlamlı farklılıklar bulunmuştur. Deney grubunda, hem müdahale öncesi hem de sonrası karşılaştırmalarda, Türkçe Çok Boyutlu Diyabet Ölçeği'nin tüm alt ölçekleri arasında istatistiksel olarak anlamlı bir fark bulunmuştur.

Sonuç: Bu mobil uygulamanın kullanımıyla metabolik parametrelerde istatistiksel olarak anlamlı bir azalma gözlenmiştir. Bu çalışma, diyabet yönetiminin bir mobil uygulama kullanılarak iyileştirilebileceğini göstermektedir. Ancak, mobil uygulamaların diyabet kontrolü üzerindeki etkisini açıklamak için, etkinliklerinin farklı popülasyonlarda ve daha büyük örneklem büyüklükleriyle test edilmesi gerekmektedir. Bu türden mobil sağlık uygulamalarının, sağlık eşitsizliklerini ve sağlık harcamalarını azaltarak ülke refahına katkıda bulunma potansiyeli bulunmaktadır.

Anahtar Sözcükler: *Diyabet, Hastalık yönetimi, Hastalar, Mobil uygulamalar*

INTRODUCTION

Diabetes represents one of the most significant health challenges of the contemporary era, and its increasing prevalence both globally and within our nation has elevated it to a societal concern (1). Controlling the HbA1c level is of paramount importance for the management of the disease. To achieve this, patients need to regularly monitor their blood glucose levels, adhere to diabetes-appropriate diets, engage in regular physical activity, maintain medication adherence, abstain from smoking and alcohol consumption, and develop an increased awareness of such lifestyle modifications (2).

Effective diabetes management and control by health care professionals can enhance the motivation of patients and their families to manage the disease (3,4). Recent studies have demonstrated that mobile applications can assist patients in managing their diabetes. Various evidence-based studies have reported that mobile applications yield positive outcomes in controlling HbA1c levels and, in the long term, reduce diabetes-related complications (4-7). If the HbA1c value is not maintained within the recommended range, it can lead to progressive complications and potentially result in mortality. These complications negatively impact individuals' quality of life, emotional and overall health status, nutritional status, sexual function, and sleep quality, and potentially adversely affect their social and occupational functioning (7,8). The relationship between strict glucose control and well-coordinated disease management in preventing complications has been established through research (7,9). According to the most recent publication of the International Diabetes Federation in 2021, approximately 537 million individuals worldwide have diabetes, with projections indicating this number will reach 643 million by 2030 and 783 million by 2045 (10). Consequently, it is estimated that 10.6% of the global population aged 20-79 has diabetes, and 6.2% has Impaired Glucose Tolerance (IGT). As of 2021, the approximate prevalence of diabetes in the adult (20-79 years old) population of Turkey is 15.9%, with a standardized comparative prevalence of 14.5% according to the world population. The number of individuals with diabetes exceeds 9 million (11). The data demonstrate that the prevalence of diabetes in Turkey has been increasing significantly, aligning with global trends. Diabetes ranks fifth among the most fatal diseases globally and is considered by experts to be one of the most critical and severe diseases of our era (12).

This study was conducted in the region with the highest prevalence of diabetes in the 2012 diabetes survey in Turkey and was designed to examine the efficacy of a mobile application developed for patients with T2DM in managing their condition.

MATERIAL and METHODS

This study employed a single- center, pre-test, post-test, and randomized controlled experimental design. The study population comprised individuals with T2DM who attended an endocrinology hospital clinic. The study sample consisted of patients who visited an Endocrinology Clinic during the study period and fulfilled the inclusion criteria. A power analysis was conducted to determine the sample size with a 5% margin of error, and effect size 0.28 and 95% confidence interval at a two-sided significance level, and 80% power to represent the population. The calculated sample size was 50 individuals with diabetes in each group (50 experimental and 50 control). However, the study was completed by 38 participants in the experimental group and 32 in the control group. A post-hoc power analysis was conducted to evaluate the validity of the study. The analysis, based on an alpha level of 0.05 and an observed effect size of 0.86 (Cohen's d), revealed a statistical power of 0.97, indicating that the study possessed a high level of statistical power.

The inclusion criteria for the study were as follows: individuals aged 40-65 years who had been diagnosed with T2DM for a minimum of six months; received oral antidiabetic therapy; had an HbA1c level between 7% and 10%; had a mobile phone with video messaging and playback capabilities; and did not have sensory impairments such as hearing, speech loss, or psychiatric issues that would impede communication. This study was registered at ClinicalTrials.gov (ID NCT06620094). The exclusion criteria for the study encompassed individuals who were unable to use mobile applications, had a documented psychological diagnosis, were using insulin, had an HbA1c level above 10%, or had an infection requiring medication.

Randomization: All variables were considered to ensure homogeneity between the two groups. Patients with diabetes were randomly assigned to the experimental and control groups to avoid bias. For randomization, the "Random Integer Generator" method under the Numbers section on the random.org website was used to create columns of five groups with numbers ranging from 1 to 100. Based on the Number 1 and Number 2 in the column, patients visiting the Endocrinology Clinic were randomly assigned one or two. A draw at the beginning of the study determined which number represented the experimental or control group. For data collection, a diabetes identification and follow-up form and the Turkish Multidimensional Diabetes Questionnaire were used as data collection tools. The consort table for the study is given below (Figure 1).

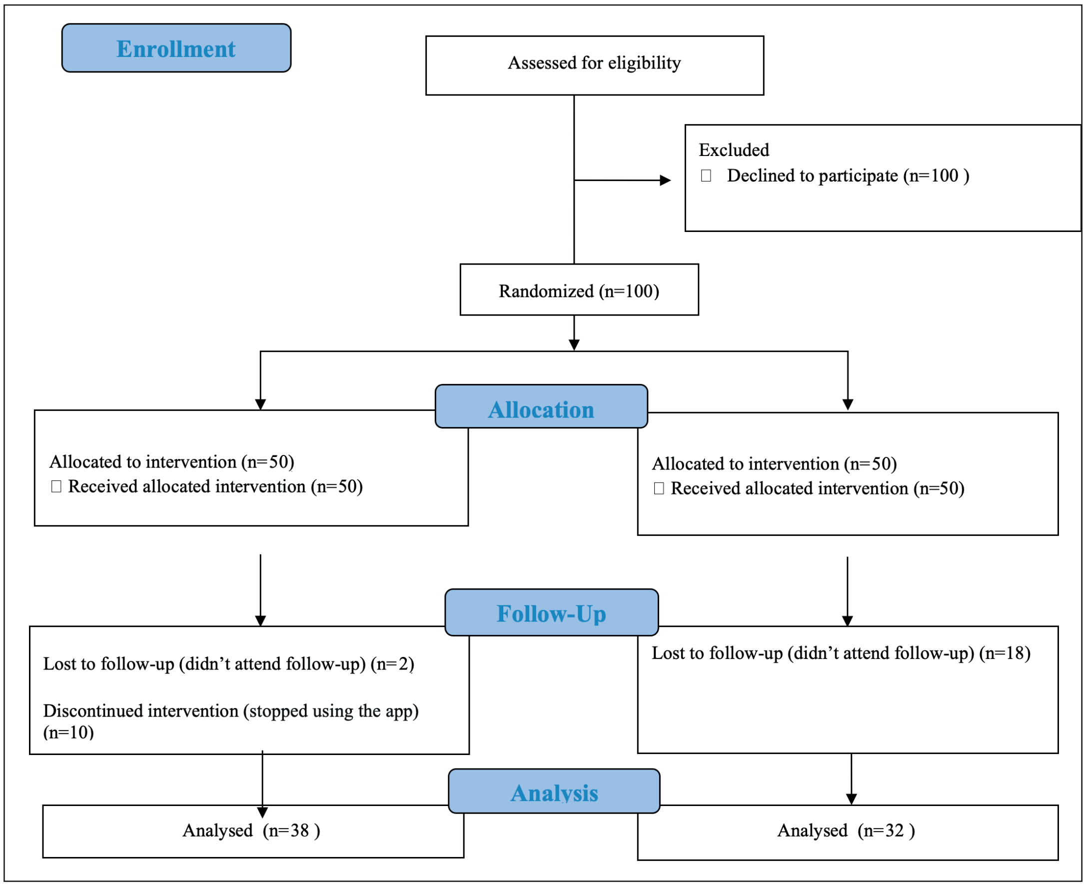

Figure 1: Study of Flow Diagram

Blinding: During data collection, participants were randomly assigned to either the intervention (Group 1) or control (Group 2) group using a computer-generated randomization sequence. The group allocation was known to the researcher interacting directly with the participants. However, the researcher responsible for performing the statistical analysis was blinded to group identities. Blinding of the participants or the practitioners was not feasible in this study.

Diabetes Patient Identification and Follow-up Forms

Developed by researchers through a comprehensive literature review and expert consultation, this form comprises three sections (13-16). Section One encompasses 11 items designed to ascertain the socio-demographic characteristics of the patient. Section Two consists of 32 items to evaluate the patient's attributes related to general knowledge and habits associated with diabetes, including diabetes type, treatment modalities and complications, treatment adherence, dietary and exercise regimens, and foot care practices. Section Three incorporates nine items to assess metabolic control parameters, such as fasting blood glucose, HbA1c, total cholesterol, LDL-cholesterol , HDL-cholesterol , triglycerides, blood pressure, height, weight, and body mass index.

Turkish Multidimensional Diabetes Questionnaire (T-MDQ): This instrument was developed by Talbot et al (17). The Turkish validity and reliability of the scale were evaluated by Cosansu and Erdoğan in 2010 (18). The scale comprises 40 items, seven subscales, and three sections. It is important to note that there was no aggregate score and each subscale was evaluated independently.

Section 1 addresses perceptions of diabetes and social support. This section consists of three subscales and 16 items. The Perceived Interference subscale comprises nine items assessing the extent to which daily, work, social, and recreational activities are negatively affected and constrained by diabetes. Perceived Severity consists of three items that measure an individual's perception of diabetes severity. Perceived Social Support consisted of four items examining perceived social support from significant others, family, friends, and healthcare providers. Responses were recorded on a 7-point Likert scale (0 = none, 6 = very much) in the first section. For each subscale of the questionnaire, the total score was divided by the number of items answered to calculate the mean score. Higher scores indicate greater levels of perceived interference, social support, and severity.

Section 2 examined the frequency of 31 supportive and non-supportive behaviors related to diabetes self-care activities by the patient's spouse or significant others. This section consists of two subscales and 12 items. Positive Supportive Behaviors included eight items identifying positive behaviors by the spouse or significant others that support diabetes management. Misguided Supportive Behaviors consisted of four items aimed at determining the frequency of unsupportive behaviors of the diabetic spouse or significant others, which are intended to support the individual in managing their disease, but may inadvertently cause distress or difficulties. Responses in the second section were recorded on a 7-point Likert scale (0 = never, 6 = always). Individuals living alone do not complete this section.

Section 3 assessed an individual's self-efficacy and outcome expectancy related to disease management. This section comprises two subscales and thirteen items. Self-Efficacy Perception includes seven items evaluating an individual's confidence in performing self-care activities related to the disease. Responses were recorded on a Likert-type scale (0 = not at all confident, 100 = very confident). Outcome Expectancy Perception consists of six items evaluating the perceived effectiveness of self-care behaviors and treatment in achieving metabolic control and preventing complications. Responses were recorded on a Likert scale (0 = not at all important; 100 = very important). Higher scores indicate higher levels of perceived self-efficacy and outcome expectancy (17). In this study, the Cronbach's alpha values calculated for the subscales were as follows: 0.63 for the perceived barriers subscale, 0.76 for perceived severity, 0.91 for perceived social support, 0.85 for positive supportive behaviors, 0.62 for misguided supportive behaviors, 0.94 for self-efficacy, and 0.81 for outcome expectations. Furthermore, the total Cronbach's alpha value was 0.83 for Part 1, 0.86 for Part 2, and 0.92 for Part 3.

Data Collection: Data were collected by the researcher through face-to-face interviews with patients with T2DM who visited the Endocrinology Clinic between May 2021 and December 2023. Patients who met the inclusion criteria were included in this study. Initially, data collection forms (Survey Form and T-MDQ) were administered to patients in both the experimental and control groups. Additionally, clinical test results, including HbA1c, glucose, total cholesterol, HDL-cholesterol, LDL-cholesterol, triglyceride, blood pressure, height, and weight, were recorded. Blood samples were collected by a nurse. The specimens were placed in gel serum separator tubes and centrifuged in an 800D model centrifuge. Following centrifugation, the serum samples were transported to the laboratory without delay. For clinical tests, including LDL cholesterol, total cholesterol, and HbA1c, 2.8 mL of blood collected into these gel separator tubes was analyzed using an Architect model analyzer. For the experimental group, education and monitoring were provided through a mobile application specifically developed for diabetic patients over a period of three months. At the conclusion of this period, the T-MDQ, clinical test results (HbA1c, glucose, total cholesterol, HDL-cholesterol , LDL-cholesterol , and triglycerides), blood pressure, height, and weight measurements were re-administered to the experimental group and simultaneously to the control group (Figure 1).

eDiyabet: eDiyabet incorporates various functional modules designed to support patient self-management. The 'Daily Values' module enables users to input biometric data, while the 'Medications' module facilitates medication therapy tracking. The 'Update Information', 'Notifications', and 'List' modules support personal data management and reminder systems. The 'Frequently Asked Questions (FAQ)' module provides educational videos developed by researchers based on expert opinions to enhance diabetes self-management. These videos cover essential topics including 'Nutrition in Diabetes', 'Exercise in Diabetes', 'The Effect of Stress on Diabetes', 'Diabetes Complications', and 'Infection Prevention for Diabetic Patients'. Additionally, the application's researcher/clinician interface (admin panel) features a 'Reports' module that generates individualized patient reports to facilitate clinical monitoring.

Intervention: The eDiyabet application was developed through an academic-commercial collaboration. While the clinical content and design principles were established by the research team, the technical development and user interface implementation were outsourced to a professional software company. During the initial meeting (preparation phase) with the experimental group, participants were informed about the notifications and diabetes education videos to be transmitted to their mobile devices. Subsequently, patients received notifications three times daily throughout the week. The first notification instructed them to "measure and record their fasting and post-meal blood glucose levels in the morning," the second encouraged "a minimum of 30 minutes of daily physical activity," and the third prompted them to "record the foods and quantities consumed, measure and record evening fasting and post-meal blood glucose levels, and measure bedtime blood glucose." Clinical test results (HbA1c, BMI, total cholesterol, HDL-cholesterol , LDL-cholesterol , and triglycerides), blood pressure, and weight measurements obtained during the clinical follow-up were also documented. Additionally, three times weekly, patients were instructed to "measure and record their blood pressure and weight" and to input this information into the application for each measurement. Throughout the three-month period, individuals continued to receive clinical follow-ups.

Control Group: During the initial meeting, diabetic individuals in the control group were provided with information about the study and completed data collection forms (Survey Form and T-MDQ). Clinical test results (HbA1c, glucose, total cholesterol, HDL-cholesterol, LDL-cholesterol, and triglycerides) were documented. Blood pressure, height, and weight were recorded at the initial meeting. The control group underwent routine clinical follow-ups. At the second meeting, three months later, data collection forms were readministered. Clinical follow-up test results (HbA1c, BMI, total cholesterol, HDL-cholesterol, LDL-cholesterol, and triglycerides), blood pressure, and weight were recorded.

Statistical Analysis

The data collected in this study were analyzed using SPSS v.22 (Statistical Package for Social Science). Descriptive statistics (mean and standard deviation) were used to characterize the numerical variables, whereas frequency and percentage distributions were used to describe the categorical variables. The assumption of normality was assessed using the Kolmogorov-Smirnov test. Frequency and percentage analyses, chi-square analysis, standard deviation, t-tests for dependent groups, and t-tests for independent groups were performed to analyze the data. Results were considered statistically significant at a 95% confidence interval and an error level of $p<0 .05$.

RESULTS

The distribution of the descriptive characteristics of the patients included in the study revealed that the mean age of the patients in the experimental group was 52.5±8.5 years (minimum 35, maximum 65), 63.2% were 51 years of age or older, 39.5% were female, 86.8% were married, 44.7% were self-employed, 57.9% were high school graduates, 89.5% had a medium income level and 92.1% resided in a nuclear family. Among the participants in the experimental group, 60.5% had been diagnosed with a chronic illness in addition to diabetes. A total of 60.5% of the first-degree relatives had a family history of diabetes. It was observed that 89.5% of the patients in the experimental group regularly attended health checkups, 18.4% developed diabetes-related complications, and 60.5% had not received education on diabetes.

In the control group, 59.4% of the patients were aged 51 years and above, 37.5% were female, 87.5% were married, 43.8% were self-employed, and 12.5% were university graduates. The majority of participants in the control group (96.9%) had a middle income level, and 93.8% resided in a nuclear family. Additionally, 56.3% of the participants had an additional chronic illness in addition to diabetes. Of the first-degree relatives, 59.4% had a family history of diabetes, 87.5% attended regular health check-ups, 15.6% developed diabetes-related complications, and 59.4% had not received education on diabetes (Table 1). No significant differences were found between the experimental and control groups in terms of the demographic characteristics.

The mean scores of the metabolic data of the experimental and control groups before and after the application were compared. In the experimental group, the mean HbA1c was 7.71±0.9 before the mobile application and 7.01±0.7 after the mobile application. The HbA1c level decreased by 7 points and this difference was statistically significant ($p < 0.05$). A very large effect size was observed for the reduction in A1C levels from pre-test to post-test in the experimental group (Cohen's d=0.86) (Table 2). The mean total cholesterol level was 217.65±35.5 before the application was 212.37±35.6 after, it demonstrated a statistically significant difference ($p<0.05$). A large effect size was observed for the reduction in total cholesterol levels from pre-test to post-test in the experimental group (Cohen's d=0.64). The LDL-cholesterol level mean 121.63±31.3 before the application was 117.20±30.1 after, and the difference was statistically significant ($p <0.05$). A medium effect size was observed for the reduction in LDL-cholesterol levels from pre-test to post-test in the experimental group (Cohen's d=0.41). The HDL-cholesterol level was 53.84±13.9 before the application and increased slightly to 54.15±14.2, with this difference being statistically significant ($p<0.05$). A very small, negligible reduction in HDL-cholesterol levels was observed from pre-test to post-test in the experimental group (Cohen's d=-0.06). Triglyceride level mean 187.00±97.1 before application and was observed as 177.73±88.3 after. A medium effect size was observed for the reduction in triglyceride levels from pre-test to post-test in the experimental group (Cohen's d=0.34). The BMI observed before the mobile application mean 28.42±4.6 and 27.83±4.5 after, the change being statistically insignificant ($p<0.05$). A medium effect size was observed for the reduction in BMI levels from pre-test to post-test in the experimental group (Cohen's d=0.47). When examining the pre- and post-test metabolic values for the control group, no significant changes were observed in mean scores, except for triglycerides, which increased from 112.09±34.3 to 178.56±102.7, a statistically significant change ($p<0.05$).

Table 1. Distribution of individuals in the experimental and control groups according to their demographic characteristics

Characteristics	Experimental Group (n=38)	Control Group (n=32)
Age group, n(%)		
35-50 years	14 (36.8)	13 (40.6)
51years and over	24 (63.2)	19 (59.4)
Gender, n(%)		
Female	15 (39.5)	12 (37.5)
Male	23 (60.5)	20 (62.5)
Marital Status, n(%)		
Marriage	33 (86.8)	28 (87.5)
Single	5 (13.2)	4 (12.5)
Occupation, n(%)		
Worker	5 (13.2)	5 (13.2)
Civil servant	8 (21.1)	6 (18.8)
Retired	8 (21.1)	7 (21.9)
Self-employed	17 (44.7)	14 (43.8)
Education Level, n(%)		
Primary education	9 (23.7)	7 (21.9)
High school	22 (57.9)	21 (65.6)
University	7 (18.4)	4 (12.5)
Income Level, n(%)		
High	4 (10.5)	1 (3.1)
Moderate	34 (89.5)	31 (96.9)
Family Type, n(%)		
Nuclear family	35 (92.1)	30 (93.8)
Extended family	3 (7.9)	2 (6.3)
Presence of Other Diagnosed Diseases, n(%)		
Yes	23 (60.5)	18 (56.3)
No	15 (39.5)	14 (43.8)
Presence of Diabetes in the Family, n(%)		
None	13 (34.2)	12 (37.5)
First-degree relative	23 (60.5)	19 (59.4)
Second-degree relative	2 (5.3)	1 (3.1)
Regular Check-up, n(%)		
Yes	34 (89.5)	28 (87.5)
No	4 (10.5)	4 (12.5)
Diabetes-related Complications, n(%)		
Yes	7 (18.4)	5 (15.6)
No	31 (81.6)	27 (84.4)
Source of Information, n(%)		
Health personnel	26 (68.4)	20 (62.5)
Diabetic patients	10 (26.3)	9 (28.1)
Media	2 (5.3)	3 (6.3)
Diabetes Education, n(%)		
Yes	15 (39.5)	13 (40.6)
No	23 (60.5)	19 (59.4)

When comparing the pre- and post-test T-MDQ subscale mean scores of the experimental and control groups of patients with diabetes included in the study, a statistically significant difference between the pre-test mean scores of the experimental and control groups on the T-MDQ subscale was observed only between the mean scores of self-efficacy perception (t=2.62, p=0.04). However, no significant differences were observed between the mean scores on the other subscales. In the post-test scores, all the T-MDQ subscales demonstrated statistically significant differences between the experimental and control groups. A very large effect size was observed for the difference in the subscale mean scores between the experimental and control groups at post-test: Cohen's d =-2.38 for Perceived Barriers, 2.76 for Perceived Severity, 2.31 for Perceived Support, -2.18 for Perceived Susceptibility, 1.80 for Perceived Self-Efficacy, and 3.46 for Perceived Outcome Expectation (Table 3).

Comparing the pre- and post-test mean scores on the T-MDQ subscales for diabetic patients in the experimental and control groups, the difference between the pre-test and post-test mean scores on all subscales of the T-MDQ for the experimental group was found to be statistically significant ($p < 0.05$). A very large effect size was observed for the change in subscale mean scores from pre-test to post-test within the experimental group: Cohen's d = 2.25 for Perceived Barriers, -1.75 for Perceived Severity, -3.25 for Perceived Support, -3.05 for Perceived Susceptibility, -1.08 for Perceived Self-Efficacy, and -0.97 for Perceived Outcome Expectation. However, in the control group, no statistically significant differences were observed between the pre- and post-test mean scores on any of the T-MDQ subscales ($p > 0.05$) (Table 4).

DISCUSSION

The short messages and reminders provided through the mobile application offer continuous motivational support to individuals with T2DM, encouraging the adoption and maintenance of self-management behaviors. This approach transforms patients into active participants in achieving their glycemic targets. In addition to enhancing the effectiveness of patient education, this motivational support contributes to improved glycemic control and a reduced risk of diabetes-related complications.

This study aimed to evaluate the effect of a motivational support and self-management-oriented mobile application on metabolic control in patients with T2DM. The primary outcome measures of the study were the changes observed in HbA1c, total cholesterol, and LDL- cholesterol levels following the use of the application.

Table 2: Comparison of metabolic data in the experimental and control groups before and after the mobile application

Variables	Pre- Experimental Mobile Application	Post- Experimental Mobile Application	Cohen's d	Test and Significant	Control Pre-Test	Control Post- Test	Test and Significant	Cohen d
	Mean±S.D.	Mean±S.D.			Mean±S.D.	Mean±S.D.		
A1C	7.71±0.9	7.01±0.7	0.86	t=5.52 ***p=0.001**	7.69±0.9	7.70±0.9	t=0.02 p=0.97	0.004
Total cholesterol	217.65±35.5	212.37±35.6	0.64	t=3.98 ***p=0.001**	203.09±39.9	202.87±40.4	t=0.26 p=0.79	0.05
LDL Cholesterol	121.63±31.3	117.20±30.1	0.41	t=2.56 ***p=0.01**	112.67±34.1	111.73±35.3	t=0.55 p=0.58	0.10
HDL Cholesterol	53.84±13.9	54.15±14.2	-0.06	t=-0.37 p=0.71	54.28±12.2	53.53±12.6	t=9.89 p=0.06	1.75
Triglyceride	187.00±97.1	177.73±88.3	0.34	t=2.10 ***p=0.04**	112.09±34.3	178.56±102.7	t=-6.78 p=0.02	1.20
Body mass index	28.42±4.6	27.83±4.5	0.47	t=2.89 ***p=0.02**	28.95±5.4	29.02±2.7	t=3.78 p=0.67	0.67

S.D.: Standart Deviation, **A1C:** HbA1c, **LDL:** Low-density lipoprotein, **HDL:** High-density lipoprotein, paired t-test *p<0.05

Table 3: Comparison of pre-test and post-test mean scores of the multidimensional diabetes scale subscales in the experimental and control groups

Subscales	Experimental Pre-Test	Control Pre-Test	Test and Significant	Experimental Post-Test	Control Post-Test	Test and Significant	Cohen d
	Mean±S.D.	Mean±S.D.		Mean±S.D.	Mean±S.D.		
Perceived Barriers	2.29±0.74	2.69±0.94	t=5.99 p=0.60	1.24±0.93	3.13±0.64	t=-19.39 ***p=0.001**	-2.38
Perceived Severity	2.58±0.85	2.46±1.08	t=8.04 p=0.72	4.96±0.82	2.33±1.08	t=10.63 ***p=0.001**	2.76
Perceived Support	1.89±0.83	1.84±0.80	t=0.23 p=0.81	4.11±1.07	1.94±0.82	t=9.01 ***p=0.001**	2.31
Perceived MBS	2.68±1.37	2.35±0.88	t=4.59 p=0.58	1.50±0.66	3.57±1.18	t=8.61 ***p=0.001**	-2.18
Perceived Self Efficacy	4.03±1.86	3.86±1.69	t=2.62 ***p=0.04**	6.04±1.10	3.70±1.50	t=7.12 ***p=0.001**	1.80
Perceived Outcome Expectation	4.70±1.32	3.98±1.46	t=1.19 p=0.23	7.97±0.85	3.78±1.51	t=3.88 ***p=0.001**	3.46

S.D.: Standart Deviation, **MBS:** Misguided supportive behaviors, independet sample t testi *p<0.05

LDL-cholesterol before the study, the mean HbA1c was 7.71±0.9, which decreased to 7.01±0.7 following the use of the mobile application. This represents a reduction of 0.7 points, which is statistically significant (p<0.05). Similarly, following a training program by Fortmann, a decrease of 1% was observed in the HbA1c level of the experimental group, which was statistically significant (16). Hansen's video-based study also resulted in a reduction of 0.69% in HbA1c values, a finding that was statistically significant (19). Gülmez and Kurtoğlu's study revealed that follow-up and counseling with mobile devices decreased HbA1c values in the experimental group from 8.8±1.9% to 7.6±0.9%, and this decrease was statistically significant (p< 0.001) (20). The study of Esferjani et al. showed that mobile-based education reduced the HbA1c values of the participants in the experimental group from 7.23±.48 to 7.00±0.46; and this change was statistically significant (21). However, in Erkoç and Tan's study, no significant difference was observed in HbA1c values between the experimental and control groups before and after the training (22).

Patients in the experimental group received information about nutrition, exercise, and stress management through notifications sent to their phones and short videos designed to assist in HbA1c control. They were instructed to measure

Table 4: Comparison of pre-test and post-test mean scores of the multidimensional diabetes scale subscales in the experimental and control groups

Subscales	Experimental Pre-Test Mean±S.D.	Experimental Post-Test Mean±S.D.	Cohen's d	Test and Significant	Control Pre-Test Mean±S.D.	Control Post-Test Mean±S.D.	Test and Significant	Cohen d
Perceived Barriers	2.29±0.74	1.24±0.93	2.25	t=13.89 ***p=0.001**	2.69±0.94	3.13±0.64	t=1.94 p=0.20	0.34
Perceived Severity	2.58±0.85	4.96±0.82	-1.75	t=-10.77 ***p=0.001**	2.46±1.08	2.33±1.08	t=1.29 p=0.21	0.23
Perceived Support	1.89±0.83	4.11±1.07	-3.25	t=-20.01 ***p=0.001**	1.84±0.80	1.94±0.82	t=-1.03 p=0.30	-0.18
Perceived SBBM	2.68±1.37	1.50±0.66	-3.05	t=-18.78 ***p=0.001**	2.35±0.88	3.57±1.18	t=-1.39 p=0.17	-0.25
Perceived Self Efficacy	4.03±1.86	6.04±1.10	-1.08	t=-6.64 ***p=0.001**	3.86±1.69	3.70±1.50	t=1.02 p=0.31	0.18
Perceived Outcome Expectation	4.70±1.32	7.97±0.85	-0.97	t=-6.01 ***p=0.001**	3.98±1.46	3.78±1.51	t=2.67 p=0.22	0.47

S.D.: Standart Deviation, **MBS:** Misguided supportive behaviors, paired t-test, *p<0.05

and record their blood glucose levels by responding to notifications three times daily, every day of the week, to engage in at least 30 minutes of daily exercise, to monitor their food intake, and to record this information using a mobile application. HbA1c levels decreased as a result of continuous monitoring of patient activities and blood glucose levels via a mobile application. This outcome supports our hypotheses. "H1a: The developed mobile application is effective in controlling T2DM."

The change in mean total cholesterol values before and after the mobile application intervention was statistically significant (p<0.05). LDL-cholesterol levels also decreased before and after the use of the mobile device application, and this decrease was statistically significant (p<0.05). In Bayraktar's study, a decrease of 16.25 mg/dl was observed in LDL-cholesterol values, while in Gülmez's study, LDL-cholesterol values of the experimental group decreased from 105.7±33.7 to 101.4±26.0 after the mobile application (20, 23). Similary,in Zhou and et al's study LDL-cholesterol values of experimental group decreased from 2.42±0.81 to 2.34±0.80 after application (24). However, in Erkoç and Tan's study, no decrease was observed in the experimental group in terms of LDL-cholesterol values (22).

In this study, an increase of 0.31 was observed in the mean HDL-cholesterol score of the patients after the mobile application compared to before the application. However, this difference was not statistically significant (p>0.05). Similarly, in the studies by Gülmez and Erkoç, HDL-cholesterol values increased from 41.8±9.1 to 42.8±8.3, and from 46.58±10 to 47.33±10, respectively; however, the observed increases were not statistically significant (20,22). The mean triglyceride values of the patients before and after the mobile application decreased by 9.27, and the difference was statistically significant (p<0.05) (Table 2). In Gülmez and Kurtoğlu's and Erkoç and Tan's studies, it was observed that triglyceride levels had decreased from 171.0±80.0 to 157.8±72.0 and from 170.37±81 to 154.58±67, respectively, but the difference observed in both studies was not statistically significant (20,22). In Bayraktar's thesis study, no difference was observed between the experimental and control groups in terms of triglyceride levels after mobile training videos (p>0.05) (23).

A decrease in the body mass index, a decrease of 0.59 was observed in the experimental group after the intervention. Additionally, the difference in the experimental group before and after the intervention was significant (p<0.05). This result supports our hypotheses. As a consequence of patients adhering to nutritional guidelines and engaging in 30 minutes of daily exercise, a decrease in BMI and LDL-cholesterol values was observed, accompanied by an increase in HDL-cholesterol values. In Bayraktar's thesis study, a statistically significant decrease was observed in the BMI means of the participants in the training group following the implementation of the mobile application (p<0.001) (23). Fortmann et al. reported no statistically significant difference in the BMI values of the experimental group after their SMS-based intervention programs (16). In Erkoç and Tan's study, although the mean BMI of the participants in the experimental group increased, the observed difference was not statistically significant (p>0.05) (22).

In the comparison of the metabolic values between the experimental and control groups, the mobile application demonstrated efficacy for all parameters, except HDL-cholesterol. The difference between the post-test mean scores of the experimental and control groups in the subdimensions of the T-MDQ examined within the scope of the study was statistically significant across all subdimensions (p<0.001). Based on Bayraktar's thesis study, it was determined that the video training program implemented reduced the perceived negativities of individuals with diabetes (23). It was reported that the decrease in the interference perception experimental group's post-test scores compared to the control group's post-test scores was statistically significant (p<0.001) (23). Sezgin demonstrated that participants with diabetes who were included in the SMS program exhibited lower interference perception scores than the other two groups, namely the control and education groups, 12 weeks after the intervention, with the difference being statistically significant (25). In participants with diabetes who were monitored for six months with twice-weekly reminder messages via mobile phone following a two-session training program, a statistically significant decrease was observed in the interference perception scores of the experimental group compared to those of the control group (25).

The perception of severity scores among the experimental group participants who engaged in the study using mobile phones was significantly higher than that among the control group participants who did not participate in the study (p=0.001) (Table 3). In the management of chronic diseases, it is advantageous to decrease the perception of interference and increase the perception of severity. The mobile application implemented in this study is hypothesized to be efficacious. Comparable results were observed in studies by Erkoç and Sezgin (22, 26).

Perception of support scores, which assessed the perception of social support from relatives of participants with diabetes, increased significantly in the experimental group following the application of the mobile intervention (p=0.001) (Table 3). Similarly, Bayraktar's thesis study reported that the social support perception scores of the experimental group receiving mobile education were statistically significantly different from those of the control group (23). In the literature, there are studies that did not identify a statistically significant difference in social support perception scores following educational interventions (23,25).

MSB (misguided supportive behaviors) perception scores were found to be statistically significantly lower in the experimental group (p=0.001) (Table 3). The subscale of misguided support behaviors assesses the perception of unsupportive and misguiding behaviors of spouses or relatives intended to support individuals with diabetes. Consistent with the decrease in scores post-intervention, the difference between the MSB scores was statistically significant in Bayraktar (p=0.001) and Sezgin (p=0.03). Self-efficacy perception and outcome expectancy subscale scores were found to be statistically significantly higher in the experimental group that participated in the training program as a result of the study (p=0.001) (23,26). Other studies have demonstrated that the self-efficacy perception scores of the participants in the experimental group were statistically higher, corroborating the results obtained in this study (25-27).

This study has several limitations. First, its single-center design may limit the generalizability of the findings to other populations or healthcare settings. The results should therefore be interpreted within the context of the specific population and environment in which the research was conducted. Secondly, the study experienced attrition in the intervention group due to challenges participants faced in using the mobile application (for instance, participants discontinuing the use of the app). This attrition rate may have reduced the statistical power of the study potentially affecting the robustness of the findings and increasing the risk of a Type II error.

This study demonstrated a reduction in HbA1c levels in patients using a mobile application. A Comparative analysis of metabolic values between the experimental and control groups revealed beneficial outcomes for the experimental group across all parameters except HDL-cholesterol values. The subscale scores for misguided support behaviors decreased. A statistically significant difference was observed in the mean scores o the T-MDQ subscales between the experimental and control groups after the intervention. The findings of this study indicate that the use of the mobile application by patients led toimproved disease management, as evidenced by the decrease in HbA1c levels. The widespread dissemination of such mobile applications, particularly in developingand less developed countries, is crucial for reducing health inequalities. Furthermore, these applications have the potential to contribute to the national economy by curbing unnecessary healthcare expenditures. Therefore, the implementation of mobile applications is recommended for the management of chronic conditions such as diabetes.

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Author Contributions Statements

Concept: **Rukuye Aylaz, İbrahim Şahin, Devkan Kaleci, Bahri Evren,** Design: **Rukuye Aylaz, İbrahim Şahin, Devkan Kaleci, Bahri Evren, Fidan Balkaya,** Data Collection and/or Processing: **Fidan Balkaya, Tuğçe Merve Kalkanlı,** Analysis and/or Interpre-

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Conflict of Interest

This study was made at Inonu University Turgut Ozal Medicare Center. There is no conflict of interest among the authors or between the authors and third parties.

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Ethical Approval

The necessary approval was obtained from the ethics committee before the commencement of the study (2021/1677). Prior to the initiation of the study, detailed information regarding the purpose, procedures, potential risks, and benefits was provided to all potential participants. Written informed consent was obtained from each individual thereafter. All the study stages adhered to the principles of the Declaration of Helsinki. Due to ethical reasons, the data is not available in the data pool. However, it can be sent by the responsible researcher upon request.

Peer Review Process

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