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The use of mobile health applications in empowering self-management of type 2 diabetes: a literature review

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ABSTRACT

The use of mobile health applications is vital for achieving glycemic control, promoting lifestyle changes, and empowering self-management in individuals with type 2 diabetes. This literature review aims to assess the effectiveness of mobile health applications in empowering self-management among type 2 diabetes patients. A thorough search was conducted in databases like PubMed, CINAHL, Web of Science, Cochrane Library, Scopus, ULAKBIM National Database, and Medline between January 2020 and March 2023, using keywords such as "mobile health, mobile applications, type 2 diabetes, diabetes self-management, nursing." The search yielded 525 articles, out of which 34 studies in Turkish or English that evaluated the effectiveness of mobile health applications in individuals aged 18 years and above with type 2 diabetes were included in the review. Recent studies demonstrate a growing utilization of mobile health applications for the management of treatment and care in individuals with type 2 diabetes. These applications have been shown to empower self-management by promoting dietary adherence, regular blood sugar monitoring, regular physical activity, reduced medication requirements, and decreased HbA1c levels. Additionally, mobile health applications have been found to reduce face-to-face counseling time and healthcare costs. In conclusion, mobile health applications offer promising solutions for improving self-management and healthcare outcomes for individuals with type 2 diabetes. Further research and continued integration of these applications into clinical practice are essential to optimize their benefits and address the challenges faced by diabetes patients worldwide.

Keywords: Diabetes self-management, nursing, mobile applications, mobile health, type 2 diabetes

Diabetes Mellitus is one of the most prevalent chronic diseases today, and its prevalence continues to increase. Type 2 diabetes constitutes approximately 90% of the entire diabetic population. When type 2 diabetes is poorly managed, complications such as coronary heart disease, stroke, kidney failure, retinopathy, and foot ulcers can occur. These complications progressively lead to significant morbidity and mortality rates over time [1]. Unhealthy lifestyle factors play a significant role in the pathogenesis of type 2 diabetes. Therefore, one of the key elements in preventing and treating diabetes is promoting and adopting healthy lifestyle changes in individuals [2].

Due to the lack of a definitive cure for type 2 diabetes, the concept of self-management plays a vital role throughout the lives of individuals with diabetes.

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Self-management is a term used to define individuals' responsibilities in maintaining and sustaining their health. It involves enabling individuals to control their blood glucose levels, which is considered the most crucial factor in preventing diabetes complications [3]. Self-management also promotes individuals' autonomy, facilitates disease monitoring outside clinical settings, and has the potential to reduce the burden on the healthcare system [4]. Self-management strategies for type 2 diabetes encompass multidimensional components such as regular blood sugar monitoring and recording, healthy lifestyle changes including proper diet, regular physical activity, smoking cessation, weight management, stress coping mechanisms, adherence to pharmacological treatment, and education. Studies have shown that medical nutrition therapy and regular physical activity contribute to achieving glycemic control and improving the quality of life in individuals with type 2 diabetes [5-7]. Despite the significant role of self-management in the treatment and care of individuals with type 2 diabetes, it has been reported that individuals generally have low levels of self-management. This low level of self-management results in fluctuations in blood sugar levels, increasing the risk of complications and reducing individuals' quality of life [8].

The increasing prevalence of type 2 diabetes worldwide and the growing number of affected patients necessitate the development of new strategies for diabetes treatment, adherence to treatment, lifestyle changes, and care. The rising prevalence of type 2 diabetes puts pressure on healthcare systems to enable individuals to manage their conditions effectively [9]. Consequently, numerous mobile health (mHealth) applications have been designed to enhance self-management of type 2 diabetes as a new strategy [10].

The World Health Organization (WHO) recognizes mHealth as a component of electronic health. According to WHO, mHealth is defined as "the use of mobile communication devices for the delivery of health services" [11]. mHealth involves the transmission and structuring of health information through mobile communication and multimedia technologies, such as mobile phones, computers, and wireless communication infrastructure [11]. A report published by the Health Information Institute in 2015 stated that the number of mHealth applications available to consumers has exceeded 165,000 [12]. The majority of existing mHealth applications focus on promoting healthy lifestyles, diet, and exercise. The fact that approximately one-fourth of existing mHealth applications are intended for the management of chronic diseases indicates the increasing interest in their use [13]. A study investigating the use of mHealth applications for health search behavior reported that 36% of individuals with smartphones or tablets use mHealth applications. It further revealed that 60% of individuals who use these applications find them helpful in achieving health-related goals, 35% consider them useful for making decisions about medical care, and 38% find them valuable for asking questions or seeking advice from healthcare professionals [14].

Currently, there are many mHealth applications available for enhancing self-management in individuals with diabetes. These applications enable individuals to be closely monitored, receive feedback, and overcome geographic barriers. The use of mHealth applications facilitates the delivery of healthcare services outside clinical settings [13]. mHealth applications have been integrated into various aspects of daily life and are increasingly being utilized for disease management. Literature indicates the existence of over 2,000 applications that can be used for diabetes self-management [14, 15]. Compared to web-based applications, mHealth applications are considered more accessible, cost-effective, and convenient in terms of accessing information due to their enhanced technological features such as portability, increased interaction with healthcare professionals, compatibility with other devices, and ease of data collection [16]. A systematic review and meta-analysis published in the literature demonstrated the effectiveness of mHealth applications in empowering self-management across a wide range of disease management and lifestyle change areas [2]. The American Diabetes Association's guidelines also suggest that mHealth applications can be a beneficial component in achieving effective lifestyle changes for diabetes prevention [1].

The empowerment of self-management in individuals with type 2 diabetes is important from the perspective of healthcare professionals. However, due to the limited number of medical appointments that can be provided, healthcare professionals are often only able to assess and encourage diabetes self-manage-

ment a few times a year. Moreover, the increasing number of individuals with type 2 diabetes and the inadequate number of healthcare professionals in some countries necessitate innovative and cost-effective solutions, such as mHealth applications, to promote self-management [17]. The use of mHealth applications allows continuous contact with nurses, and nurses play educational and organizational roles in this field. Additionally, mHealth applications contribute to individuals' autonomous living and minimize their need for prolonged hospital stays [9].

To enhance self-management in individuals with type 2 diabetes, continuous and regular education is necessary. It has been observed that routine follow-ups and support for self-management are insufficient due to the heavy workload in hospital settings. The need for support in home environments has become even more apparent due to the recent pandemic, both globally and in our country. This increased need further emphasizes the importance of conducting studies in this field. The aim of this literature review is to determine the effectiveness of mHealth applications used in empowering self-management of type 2 diabetes.

METHODS

This literature review conducted a search in the PubMed, CINAHL, Web of Science, Cochrane Library, Scopus, ULAKBİM National Database, and Medline databases between March 2020 and May 2023 without any year limitations. The search was performed using Turkish and English keywords such as "mobile health, mobile applications, type 2 diabetes, diabetes self-management, nursing." As a result of the literature search, a total of 525 articles were identified using the specified keywords. The titles and abstracts of the identified articles were individually examined, and their subject content, which evaluated the effectiveness of mHealth applications in enhancing self-management of individuals with type 2 diabetes, were independently evaluated by the researchers. Based on this evaluation, a total of 34 studies including systematic reviews, meta-analyses, and randomized controlled trials, which were published between 2020 and 2023, were included in the literature review.

RESULTS

In recent years, mobile health (mHealth) applications have been increasingly used in the care of individuals with Type 2 diabetes. Studies in the literature have shown that mHealth applications used in Type 2 diabetes self-management have a positive impact on individuals' health outcomes [8-23]. The findings obtained from the literature review were grouped and analyzed based on the effects of mHealth applications on patient outcomes, their impact on self-management behaviors, and the factors influencing the use of mHealth applications.

Impact of Mobile Health Applications On Patient Outcomes

Studies have shown that mHealth applications have positive effects on patient outcomes such as HbA1c levels, blood pressure, lipid profile, self-efficacy, quality of life, utilization of health services, and patient satisfaction. Research studies in the literature have demonstrated that mHealth applications used for diabetes self-management significantly reduce HbA1c levels in individuals [24-26]. In a meta-analysis conducted by Cui *et al*. [2], it was observed that individuals using mHealth applications had a significant 40% reduction in HbA1c levels compared to standard diabetes care ($P<0.05$). No statistically significant difference was found in blood pressure, lipid profile, or weight loss [2]. Another meta-analysis by Wu *et al*. [4] reported that mHealth applications assist in strengthening self-management in individuals with Type 2 diabetes and result in a clinically significant reduction in HbA1c levels ($P<0.05$) [4]. A randomized controlled study involving 163 patients with Type 2 diabetes found that a comprehensive mHealth application reduced HbA1c levels by 1.9% ($P<0.05$) in the intervention group [27]. Koot *et al*. [23] conducted a study examining the effect of mHealth applications on HbA1c levels and found that 59% of application users experienced a decrease of ≥1 in their HbA1c levels ($P<0.001$). Another meta-analysis indicated that the use of mHealth applications for diabetes self-management resulted in an average reduction of 0.5% in HbA1c levels over a 6-month follow-up period ($P<0.001$) [24]. A 1% decrease in HbA1c levels leads

to a 21% reduction in mortality rate, a 14% decrease in myocardial infarction, and a 37% reduction in the risk of developing microvascular complications [24]. Other studies have also identified a statistically significant difference in HbA1c levels between intervention and control groups, indicating the effectiveness of mHealth applications [28, 29]. The reduction in HbA1c levels among individuals with diabetes is attributed to the interaction and feedback between individuals and healthcare professionals, the intensity of self-management interventions in applications, and the effective use of techniques to promote healthy lifestyle changes [2, 16].

However, alongside studies demonstrating the significant reduction in HbA1c levels achieved by mHealth applications for diabetes self-management, there are also studies indicating no statistically significant difference. Agarwal *et al*. [10] found no statistically significant difference in HbA1c levels between the intervention and control groups (P>0.05). Additionally, no significant impact of mHealth applications was observed on secondary outcomes such as self-efficacy, quality of life, and utilization of health services. This may be attributed to inadequate utilization of the application, as nearly half of the participants in the intervention group had minimal interaction with the application. It was noted that many features of the applications, including diet and exercise tracking, which have been shown to play a significant role in Type 2 diabetes self-management, were underutilized [10].

In addition to studies demonstrating the benefits of mHealth applications, there are also studies evaluating the interest and satisfaction of individuals with Type 2 diabetes regarding these applications [30, 31]. It has been found that the recommendation of health applications by healthcare professionals and interaction with them are factors that increase individuals' satisfaction. Individuals also express their belief that the use of mHealth applications enhances interaction between themselves and healthcare professionals. One participant in the study conducted by Lie *et al*. [32] expressed their interaction with healthcare professionals as follows: "Previously, after routine tests during standard care, I used to leave without having time to express my emotions and thoughts. However, with these applications, I can finally communicate with healthcare professionals on this matter." A study by Veazie *et al*. [33] suggested that when mHealth applications are associated with healthcare professional support, they can have a greater impact on diabetes-related outcomes, especially HbA1c levels. A study examining the feedback systems in applications indicated differences between automated feedback and personalized feedback provided by healthcare professionals. While automated feedback offers the advantage of being interactive and dynamic, it is believed to have limitations in predefined pathways. Personalized feedback provided by healthcare professionals is considered more individualized and valuable, particularly in emergency situations [26].

In a study comparing feedback-receiving and non-feedback-receiving groups among individuals using mHealth applications, it was found that individuals receiving feedback through the application engaged in more physical activity after a 3-month follow-up period, with an average daily difference of 10.59 minutes compared to the non-feedback group ($p < 0.001$) [34]. Georgsson and Staggers [35] reported that individuals who used the mHealth application perceived the benefits of receiving feedback and indicated positive lifestyle changes after using the application. The majority of participants in the study stated that mHealth applications were useful for healthcare services and mentioned personal advantages associated with their use. They also emphasized that mHealth applications facilitated disease monitoring and management and supported interaction with healthcare professionals. Participants stated that the use of mHealth applications reduced their need for medical appointments and recommended the applications to others [35]. In another study, individuals reported that receiving weekly SMS reminders related to their self-management would enhance their effective use of the application [22]. Koot *et al*. [23] found that individuals using the application were generally satisfied with it and would recommend it to others for diabetes self-management.

Impact of Mobile Health Applications On Self-Management Behaviors

Studies have indicated that mHealth applications have positive contributions to self-management behaviors such as healthy lifestyle changes, physical activity, and medication adherence. It has been emphasized that healthy lifestyle changes, including the implementation of a healthy diet, increased physical activity, and regular blood sugar monitoring, which are essential

for diabetes self-management, significantly improve with the use of mHealth applications. Regular blood sugar monitoring is particularly beneficial for individuals with high blood sugar levels who struggle to control them. Additionally, mHealth applications are reported to support and guide individuals in achieving healthy lifestyle changes, including individuals at risk of developing prediabetes [36]. Koot *et al*. [23] found that the use of mHealth applications significantly increased the rate of regular blood sugar monitoring among individuals with Type 2 diabetes (P<0.001). Furthermore, 68 out of 80 participants (85%) reported positive changes in their diets after using the mHealth application (P<0.001). It was determined that individuals using the application consumed the recommended amounts of vegetables and fruits, avoided fatty foods (P<0.001), lost an average of 2.3 kilograms, and 20% of individuals achieved a weight loss of ≥5% of their initial body weight (P<0.001) [23]. A meta-analysis by Cui *et al*. [2] concluded that mHealth applications have a moderate effect on adopting healthy lifestyle changes, including daily physical activity and medication requirements.

The use of mHealth applications for strengthening Type 2 diabetes self-management has been shown to increase the level of physical activity among individuals. In a study by van der Weegen *et al*. [34], individuals using a self-management-based mHealth application engaged in more physical activity compared to the standard care group (P<0.001). In the study conducted by Koot *et al*. [23], although 30 out of 80 participants (38%) reported an increase in their weekly physical activity levels due to the use of the mHealth application, there was no statistically significant difference in the number of days with at least 30 minutes of physical activity compared to the control group (P>0.05).

mHealth applications used for strengthening diabetes self-management include various reminders for blood sugar, insulin treatment, nutrition, and physical activity measurement and recording. It is stated that all types of reminders included in these applications are effective in improving medication adherence among individuals with Type 2 diabetes. Studies have shown that receiving reminder messages through SMS and being monitored encourage medication adherence [37, 38]. In a study by Huang *et al*. [39], it was found that more than half of the included studies had medication reminder features, 16.8% had medication adherence monitoring features, 5.6% provided medication information, and 4.2% sent motivational messages to encourage medication intake. Similarly, Martinez *et al*. [40] found that fewer than half of the mHealth applications included features for medication adherence monitoring. Although many applications have comprehensive feature lists, including calorie tracking and cloud backup, it was determined that medication reminders were not present in mHealth applications despite forgetfulness being a significant non-adherence factor. Therefore, it is emphasized that more importance should be given to the design of medication management features in mHealth applications, and further evidence-based research should be conducted to improve medication adherence among individuals with diabetes [39].

Existing studies demonstrate that mHealth applications are feasible tools for improving individuals' self-management [26, 36]. The use of mHealth applications has been shown to result in positive self-management behaviors such as adherence to TBT, increased physical activity, and regular blood sugar monitoring [36, 41]. A study by Adu *et al*. [42] found significant improvements in TBT adherence, blood glucose levels, and self-management skills among individuals using the mHealth application (P<0.05). Moreover, after the intervention, the skills and self-efficacy of individuals in the intervention group increased significantly (P<0.05). Participants stated that the application provided motivation to enhance their self-management and encouraged their engagement in various aspects of self-management, such as regular blood sugar monitoring, healthy eating, and physical activity [42]. In a study examining the effects of an mHealth application-based continuous care, Wang *et al*. [8] found that individuals in the intervention group had increased awareness levels and improved self-management skills compared to the control group (P<0.05). Furthermore, when compared to the control group, the intervention group had significantly reduced readmission frequencies and lower hospital readmission rates within 6 months after discharge (P<0.05) [8]. Puzozerov *et al*. [43] determined that mHealth applications encouraged individuals to engage in regular blood sugar monitoring and TBT adherence, gradually strengthening their self-management skills. Similarly, Hoppe *et al*. [44]

reported that nursing care-based mHealth applications significantly improved individuals' self-management skills. In a study by Torbjørnsen *et al*. [45], a positive relationship was found between high self-management ability and mHealth applications, indicating that the applications were beneficial for treatment adherence.

In a cross-sectional study on the current use of mHealth applications in Australia, it was found that the use of multiple functions in mHealth applications, such as monitoring blood glucose levels, setting reminders, and accessing information on nutrition and exercise, was associated with increased self-management behaviors. Furthermore, it was observed that individuals who received recommendations from healthcare professionals were more likely to use mHealth applications for diabetes self-management [46]. The study conducted by Carroll and Richardson [47] revealed that individuals who used mHealth applications to manage their diabetes reported improved self-management behaviors, including increased physical activity, healthy eating, blood glucose monitoring, and medication adherence.

Factors Influencing The Use of Mobile Health Applications

The utilization of mHealth applications for Type 2 diabetes self-management is influenced by various factors, including individual characteristics, technological factors, social factors, and healthcare system-related factors. Individual characteristics, such as age, gender, education level, digital literacy, and motivation, play a significant role in the adoption and use of mHealth applications. It has been found that younger individuals, females, and those with higher education levels are more likely to use mHealth applications for self-management [10, 11, 16, 48]. Studies have also shown that individuals with higher levels of digital literacy and motivation have a higher likelihood of using mHealth applications [48]. In a study by Lie *et al*. [32], it was determined that older individuals had less confidence in using mHealth applications and felt that these applications were time-consuming. Similarly, Agarwal *et al*. [10] found that older individuals had difficulty using mHealth applications due to factors such as unfamiliarity with smartphones, visual impairment, and difficulty in understanding the application's functions. Therefore, it is important to consider individual characteristics when designing and implementing mHealth applications to ensure inclusiveness and accessibility for all user groups.

Technological factors, including the usability, design, and functionality of mHealth applications, influence individuals' adoption and continued use of these applications. Studies have highlighted the importance of user-friendly interfaces, intuitive navigation, clear instructions, and compatibility with different devices and operating systems [10, 16, 31, 48]. It has been noted that mHealth applications should provide personalized and tailored features to meet individual needs and preferences [10, 16]. Furthermore, the integration of mHealth applications with other technologies, such as wearable devices and sensors, can enhance their effectiveness in diabetes self-management [16].

Social factors also impact the use of mHealth applications for Type 2 diabetes self-management. Peer support and social interactions facilitated through mHealth applications have been found to positively influence individuals' engagement and adherence to self-management behaviors [16, 49]. In a study by Schnall *et al*. [49], it was observed that individuals who used a social networking-based mHealth application for diabetes self-management reported increased motivation and support from peers. Similarly, Osborn *et al*. [16] found that social support and encouragement from family and friends influenced individuals' engagement with mHealth applications and their self-management behaviors.

Healthcare system-related factors, including healthcare professionals' recommendations, support, and integration of mHealth applications into clinical practice, play a crucial role in the adoption and sustained use of these applications. Studies have shown that healthcare professionals' endorsement and encouragement of mHealth applications can increase individuals' trust and confidence in using them [10, 31, 32]. Moreover, healthcare professionals' involvement in the monitoring and feedback process through mHealth applications can enhance individuals' adherence to self-management behaviors [26, 34]. However, challenges related to the integration of mHealth applications into clinical workflows, data privacy and security concerns, and reimbursement issues need to be addressed for successful implementation in healthcare settings [31, 50].

CONCLUSION

The use of mHealth applications for Type 2 diabetes self-management has shown promising results in improving patient outcomes, self-management behaviors, and patient satisfaction. These applications have been found to significantly reduce HbA1c levels, improve medication adherence, facilitate healthy lifestyle changes, and support regular blood sugar monitoring. Factors such as individual characteristics, technological factors, social factors, and healthcare system-related factors influence the adoption and continued use of mHealth applications. To maximize the effectiveness of mHealth applications, it is crucial to consider user preferences, ensure usability and compatibility, promote social support and interaction, and integrate these applications into clinical practice with the support and guidance of healthcare professionals. Further research is needed to explore the long-term effects, cost-effectiveness, and scalability of mHealth applications for type 2 diabetes self-management.

Authors' Contribution

Study Conception: PÖ; Study Design: PÖ; Supervision: PÖ; Funding: N/A; Materials: N/A; Data Collection and/or Processing: PÖ; Statistical Analysis and/or Data Interpretation: PÖ; Literature Review: PÖ; Manuscript Preparation: PÖ and Critical Review: PÖ.

Conflict of interest

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