BMC Endocrine Disorders

RESEARCH

Open Access

Positive impact of mobile educational platforms on blood glucose control in patients with nephrotic syndrome and steroid-induced diabetes mellitus: a randomized controlled study

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Abstract

Objective Steroid-induced diabetes mellitus (SDM) is a common complication in patients with nephrotic syndrome (NS) undergoing steroid therapy. Effective blood glucose control is critical for improving outcomes in these patients. This study evaluates the impact of mobile educational platforms on blood glucose control and patient adherence in patients with NS combined with SDM.

Methods A randomised controlled study was conducted involving 56 patients with NS and SDM at Shanxi People's Hospital between April 2019 and December 2020. Participants were recruited using convenient sampling and were randomly assigned to either the intervention group ($n=28$) or the control group ($n=28$). The control group received routine health management, whereas the experimental group was provided with health management via a mobile educational platform. Blood glucose levels (fasting glucose and postprandial blood glucose), self-management efficacy and patient adherence to treatment were assessed over a 6-month period.

Results The 56 participants included in the study had a mean age of 69.0 ± 10.5 years and an average diabetes duration of 7.2 ± 3.5 years. At the end of 6 months, the intervention group showed significant reductions in fasting blood glucose and postprandial blood glucose levels ($P<0.001$). Self-management efficacy, assessed using the Diabetes Self-Efficacy Scale, improved significantly post-intervention (4.42 ± 0.53 vs. 4.15 ± 0.56, $P=0.020$). Additionally, patient adherence to treatment improved by 25% in the intervention group compared with the control group.

Conclusion The use of mobile educational platforms significantly resulted in better glycemic control and treatment adherence in the patients with NS and SDM compared to the control group. These findings suggest that integrating mobile health technologies into routine care can enhance disease management and optimise outcomes.

Trial registration The study was retrospectively registered "ISRCTN23135945" on 05/11/2024.

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Keywords Mobile healthcare, Steroid-induced diabetes mellitus, Nephrotic syndrome, Self-management, Blood glucose control

Introduction

Nephrotic syndrome (NS) is a clinical syndrome defined as massive proteinuria leading to hypoalbuminemia, accompanied by hyperlipidaemia, edema and various complications [1]. The global prevalence of NS is estimated to be approximately 16–20 cases per 100,000 children per year, and the prevalence in adults can be higher. In fact, the condition is estimated to affect millions of individuals [2], with some studies suggesting rates of 7–15 cases per 100,000 people. The KDIGO guidelines propose that glucocorticoids (GCs) are the main drugs used to treat primary NS. Most patients with primary NS require mainly oral moderate-dose GCs.

Steroid-induced diabetes mellitus (SDM), which belongs to the category of secondary diabetes, is a frequent complication in patients with NS who require long-term steroid therapy [3, 4]. The use of GCs, while effective in managing NS, significantly increases blood glucose levels, leading to poor glycaemic control and an increased risk of cardiovascular and renal complications [5, 6]. Despite SDM being less common than type 1 and type 2 diabetes, the hyperglycaemic state of SDM is detrimental to the control of patients' primary disease and can easily lead to various infections [7]. In severe cases, various acute and chronic complications may occur, prolonging hospital stays and increasing disability rates and mortality. Therefore, it is of great significance to control the blood glucose levels in patients with SDM. However, despite the clinical relevance of this issue, there is limited research on effective strategies for managing SDM in patients with NS, particularly with regard to patient education and treatment adherence.

Multiple studies have demonstrated that excellent self-management by patients with diabetes is the key to preventing blood glucose fluctuations, effectively lowering blood glucose, improving metabolic indicators and delaying the onset of complications; furthermore, both personal and environmental factors can affect patient self-management [8, 9]. Nonetheless, the problem of low self-management levels among patients with diabetes remains in China, which is mainly due to the fact that such patients require long-term follow-up by doctors or nurses to help them understand their blood glucose control status and adjust their self-management behaviours and medication accordingly for effective control [10]. However, the lack of and uneven distribution of medical resources in China make it difficult for most patients to access effective follow-ups.

Current guidelines for diabetes management focus on pharmacological interventions; however, the importance of patient education and behaviour modification is often overlooked. Mobile health (mHealth) platforms have emerged as promising tools for improving patient engagement, adherence and outcomes in various chronic diseases [11, 12]. Several studies have confirmed that mHealthcare plays a significant role in improving the self-management behaviours, self-efficacy and blood glucose control of patients with diabetes, ultimately providing a scientific and effective method for the treatment and management of the condition [13].

Moreover, mHealthcare has been widely applied in the health management of patients with diabetes in developed countries, with many mobile platforms already in operation. However, research and applications related to this field are still in the early stages in China, with limited research and, as yet, no mature products available. Recently, internet-based health management has created a diverse array of services, through which users can comprehensively record their personal data via mobile devices such as smartphones, tablets and computers, while healthcare providers can dynamically monitor patients' health data with the help of big data platforms [14]. Nonetheless, the efficacy of mHealth platforms in the context of SDM management in patients with NS has not been comprehensively studied.

This study aims to fill this gap by evaluating the impact of a mobile educational platform on patients with NS combined with SDM. The central hypothesis of this study is that a mobile educational platforms significantly resulted in better glycemic control and treatment adherence in the patients with NS and SDM compared with standard care. By integrating technology into patient care, this study seeks to provide a novel approach to managing SDM, addressing a critical gap in both the literature and clinical practice and providing a reference for formulating personalised management schemes for such patients.

Study participants and methods

Study participants

A total of 56 patients with NS complicated with SDM in Shanxi Provincial People's Hospital between April 2019 and December 2020 were recruited by convenience sampling. This study was designed as a randomised controlled trial with two parallel groups: an intervention group ($n=28$), which received educational support via a mobile platform, and a control group ($n=28$) that received standard care. Randomisation was conducted using a computer-generated randomisation sequence to ensure unbiased group allocation.

The inclusion criteria were as follows: (1) patients with a confirmed diagnosis of NS and SDM for at least 3 months prior to enrollment; NS was diagnosed based on nephrotic-range proteinuria (urinary protein excretion > 3.5 g/day), hypoalbuminemia (serum albumin < 3.0 g/dL) and clinical evidence of edema [15]; (2) SDM was diagnosed using the American Diabetes Association criteria, requiring fasting plasma glucose ≥ 126 mg/dL, 2-hour plasma glucose ≥ 200 mg/dL during an oral glucose tolerance test or haemoglobin A1c (HbA1c) levels ≥ 6.5% [16]; (3) aged > 18 years; (4) patients who were able to use smartphones or computers; (5) with outpatient follow-up for 3 months or above to ensure treatment adherence and stability; and (6) patients whose initial dose of GCs ≥ 40 mg/d (prednisone dose). The exclusion criteria included patients (1) with a history of diabetes or impaired glucose tolerance before GC use and (2) with severe infection, stress response and other factors caused by significantly elevated blood glucose.

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Shanxi Provincial People's Hospital [(2021) Provincial Medical Department Ethical Review No. (272)]. Informed consent was obtained from all participants prior to enrollment in the study.

Blinding

While patients could not be blinded to their intervention, the clinicians evaluating the outcomes were blinded to the group assignments to reduce bias in the interpretation of the results.

Sample size calculation

The sample size was determined based on the mean difference in HbA1c levels being 1.0%, with a standard deviation of 1.5%. Using these parameters, we calculated that a minimum of 50 participants per group would be required to achieve 80% power to detect a significant difference between the intervention and control groups at a significance level of 0.05. To account for potential dropout, we increased the sample size by 10%, resulting in a total target enrollment of 56 participants.

Study methods

The control group received routine health management (group education), where nurses provided collective health education orally and through manuals during hospitalisation, including group education and large classroom-based education. In the group education, patients in the control group were divided into two groups for separate instruction. Common issues among multiple patients were addressed through communication and guidance, with each educational session lasting around 1 h. Large classroom-based education was conducted in the form of lectures without grouping, where nurses explained knowledge related to the prevention and treatment of SDM to patients. Education was provided once a week, with each session lasting around 1.5 h. No access to mobile educational platforms was provided to this group, ensuring a clear comparison with the intervention group. This approach controlled for any influence that patient education might have on blood glucose management, allowing for isolating the effect of the mobile platform.

In contrast, a mobile educational platform was utilised to construct individualised health management (individual education) in the experimental group. First, a 6-member health management team was established on the mobile educational platform, consisting of 1 information liaison officer, 1 health manager, 2 responsible nurses and 2 doctors, all with work experience of > 5 years. For offline education, nurses conducted one-on-one communication and guidance with the patients, with the education content including weight control, balanced diet, moderate exercise, blood glucose monitoring and guidance on self-management skills. Additionally, emphasis was placed on the participation of patients when setting health education goals. During the implementation of the programme, the goals for behaviour changes were refined, and feedback from patients was taken onboard to adjust the programme as needed [17]. Regarding online education, relevant courseware, videos, images, etc. were created and subsequently uploaded to the mobile educational platform, with the content including routine information about NS, risk factors leading to SDM, clinical manifestations, preventive measures, treatment and care. Moreover, remote education was conducted via mobile applications and online platforms to promote the self-management knowledge of patients with NS after using GCs and to enhance their self-management skills.

The mobile educational platform used in this study was developed by a team of healthcare professionals and IT developers from the smart medical technology team of our hospital. The platform was designed prior to the study and allowed participants to access educational materials and monitoring tools via smartphones and personal computers. It was personalised based on each participant's initial health status and one-on-one meetings with healthcare professionals. The intervention duration was 6 months, and all participants received the same level of access to the platform throughout the study period.

Data collection

Collection of questionnaires

The patient's general data, including gender, age, education level, marital status, job type, duration of NS and number of complications were collected. In addition, their Diabetes Self-Management Attitude Scale, Diabetes Self-Management Behavior Scale and Diabetes

Self-Efficacy Scale (DSES) scores, pre-intervention and 3 months after intervention, as well as blood glucose levels after 3 months of intervention, were also collected.

The Diabetes Self-Management Attitude Scale is a subscale of the Diabetes Self-Management Evaluation Scale (KBA scale) developed and simplified by the Chronic Disease Center of the Chinese Center for Disease Control and Prevention [18]. This scale consists of 5 items for evaluating the patient's attitudes towards health education, dietary control, exercise, regular medication and blood glucose monitoring, thus assessing the effect of these factors on the patient's blood glucose control. The scale uses a 5-point Likert scale, where 1 denotes 'very important' and 5 'not important at all', with values assigned as 1.0, 0.8, 0.6, 0.4 and 0.2. The total score of the 5 items indicates the self-management attitude score of the patient. The scale has been tested with a correlation coefficient of 0.20 and a Cronbach's alpha (α) value of 0.78, demonstrating excellent reliability and validity [19].

The Diabetes Self-Management Behavior Scale is also derived from the KBA scale and has been appropriately adapted based on actual circumstances, including changing the survey period from 6 to 3 months to align with the effective duration of glycated Hb. Thus, the frequency of blood glucose control measures taken within 3 months is measured instead of solely focusing on whether patients take such measures, with the original 15 items reduced to 7 items for assessing the diet, sleep quality, exercise, medication and frequency of blood glucose monitoring of the patients. This scale also uses a 5-point Likert scale, where 1 denotes 'never' and 5 'always', with values assigned as 0.2, 0.4, 0.6, 0.8 and 1.0. The total score of each item is taken to calculate the overall self-management behaviour score. Moreover, the original scale has a Cronbach's α value of 0.78, indicating excellent reliability, and each dimension is positively correlated with its corresponding scale, with the factor loadings of all items being greater than 0.40, demonstrating excellent content validity and structural validity [20].

The DSES is an adaption of the scale revised by Wang Xingxuan [21] and introduced for use in China. Due to the excessive items and complexity of the original scale, which made it challenging for patients to complete, this study revised the scale by selecting adherence to medical advice, regular exercise, healthy diet, regular sleep, blood glucose monitoring and regular check-ups as the 6 dimensions to be measured, with each dimension measured by 1 item. The revised scale consists of a total of 6 items and uses a 5-point Likert scale, where 1 indicates 'not very confident' and 5 'very confident', with values assigned as 0.2, 0.4, 0.6, 0.8 and 1.0. The total score of each item was taken to calculate the self-efficacy score of the patients.

Biochemical indicators

The patient is usually instructed to fast overnight (at least 8 h) prior to the initial fasting blood glucose (FBG) measurement. The FBG analysis was performed using the glucose oxidase method (at a concentration of 2 mmol/L), a standard biochemical assay, to ensure accuracy and consistency. The reaction was incubated at 37 °C for 30 min, and glucose levels were determined using a calibrated spectrophotometer (SpectroShade, MHT).

After the initial measurement, the patient consumed a standardised meal or beverage that is typically high in carbohydrates (e.g. a glucose solution) to ensure a controlled intake. Postprandial blood glucose levels were measured 2 h after the meals using standard glucometers. Blood samples were collected using the fingerstick method. Here, a small amount of blood is drawn from the fingertip using a lancet and tested immediately with a glucometer. Point-of-care glucometers can provide immediate results for fingerstick samples, whereas laboratory tests may take longer but offer more accurate results.

Both FBG and postprandial blood glucose tests were performed at 6 months after intervention. Each measurement was performed in triplicate to ensure accuracy. The averaged results were used for analysis. Equipment calibration and reagent preparation were verified before each session to ensure consistency. Incubation times, reagent concentrations and equipment settings were standardised and maintained throughout the study.

Statistical analysis

All statistical analyses were performed using SPSS software (version 26.0). The normality of the data was assessed using the Kolmogorov–Smirnov test. Continuous variables that followed a normal distribution were presented as means ± standard deviations (SD), whereas count data were expressed as frequency (n) or rate (%). For comparisons between the intervention and control groups, independent t-tests were used for normally distributed variables, with the Mann–Whitney U test applied for non-normally distributed data. Paired t-tests were applied to assess pre- and post-intervention scores within each group. Categorical variables were analysed using the chi-square test or Fisher's exact test as appropriate. To control for the risk of Type I errors due to multiple comparisons, the Bonferroni correction method was applied when comparing multiple outcome variables. The significance threshold was adjusted accordingly to ensure that the results remained statistically valid. In addition, effect sizes (Cohen's d) and 95% confidence intervals (CIs) were calculated for key outcomes, including blood glucose levels and self-management scores. Bilateral $P < 0.05$ was considered statistically significant.

Table 1 Baseline characteristics of the two groups

Item	Experimental Group (*n* = 28)	Control Group (*n* = 28)	t/χ^2 value	*P* value
Gender (Male/Female, n)	15 (53.6%)/13 (46.4%)	14 (50.0%)/14 (50.0%)	0.072	0.789
Age (years, x ± s)	69.38 ± 11.33	64.75 ± 11.61	-1.812	0.074
Education level (n)			-	0.065
Primary school or below	14 (50.0%)	7 (25.0%)		
Junior High School/ Secondary School	10 (35.7%)	19 (67.9%)		
College or above	4 (14.3%)	2 (7.1%)		
Marital status (n)			-	1.000
Unmarried	1 (3.6%)	0 (0.0%)		
Married	23 (82.1%)	22 (78.6%)		
Widowed	0 (0.0%)	1 (3.6%)		
Divorced	4 (14.3%)	5 (17.8%)		
Occupation			-	0.714
Ordinary employee	14 (50.0%)	15 (53.6%)		
Cadre	3 (10.7%)	1 (3.6%)		
Retired	11 (39.3%)	12 (42.8%)		
Duration of NS (years, x ± s)	11.14 ± 7.88	9.63 ± 7.64	0.839	0.404
No. of complications (n, x ± s)	1.51 ± 1.54	1.16 ± 1.26	1.095	0.277

Notes: No significant differences were observed between the groups in each item ($P > 0.05$ for all comparisons)

Results

General data

The experimental group consisted of 15 men and 13 women, with an average age of 69.38 ± 11.33 years, and the control group included 14 men and 14 women, with an average age of 64.75 ± 11.61 years. The average duration of diabetes was 11.14 ± 7.88 years in the experimental group and 9.63 ± 7.64 years in the control group. No significant differences were observed in terms of gender, age, education level, marital status, occupation, duration of NS, diabetes duration or the number of complications between the two groups ($P > 0.05$). See Table 1 for further details.

Comparison of scores on self-management behavior scale

Before the intervention, there were no significant differences in total self-management behaviour scores or in the scores of individual dimensions between the experimental and control groups ($P > 0.05$), confirming comparability between the groups at baseline. However, post-intervention, the experimental group exhibited significantly higher total self-management scores (5.03 ± 0.76 vs. 4.62 ± 0.72, t = 2.257, $P = 0.027$), as well as significant improvements in integrated management (0.78 ± 0.13 vs. 0.70 ± 0.15, t = 2.116, $P = 0.038$). No significant differences were observed in terms of healthy diet, high-quality sleep, light exercise and medication adherence ($P > 0.05$), as detailed in Table 2.

Comparison of scores on self-management attitude and self-efficacy scales

Prior to the intervention, the self-management efficacy and attitude scores were comparable between the two groups, with no significant differences observed ($P > 0.05$), confirming that the groups were comparable at baseline. However, following the intervention, significant differences were observed between the groups. The intervention group showed higher self-management efficacy (4.42 ± 0.53 vs. 4.15 ± 0.56, t = 2.332, $P = 0.020$) and improved self-management attitude (4.89 ± 0.41 vs. 4.43 ± 0.52, t = 5.350, $P = 0.005$) compared with the control group. These results highlight the effectiveness of the intervention in improving patients' confidence and

Table 2 Comparison of scores on self-management behavior scale

Scales	Pre-/post-intervention	Experimental Group (*n* = 28)	Control Group (*n* = 28)	t value	*P* value
Total score	Pre-intervention	4.83 ± 1.23	4.75 ± 1.12	0.982	0.330
	Post-intervention	5.03 ± 0.76	4.62 ± 0.72	2.257	0.027
Integrated Management	Pre-intervention	0.72 ± 0.26	0.65 ± 0.28	1.080	0.283
	Post-intervention	0.78 ± 0.13	0.70 ± 0.15	2.116	0.038
Healthy diet	Pre-intervention	0.75 ± 0.19	0.67 ± 0.26	1.304	0.196
	Post-intervention	0.75 ± 0.17	0.69 ± 0.18	1.372	0.174
High-quality sleep	Pre-intervention	0.65 ± 0.27	0.65 ± 0.24	0.244	0.805
	Post-intervention	0.70 ± 0.20	0.67 ± 0.23	0.482	0.631
Light exercise	Pre-intervention	0.75 ± 0.21	0.77 ± 0.26	-0.122	0.903
	Post-intervention	0.82 ± 0.18	0.81 ± 0.18	0.262	0.794
Moderate to high intensity exercise	Pre-intervention	0.63 ± 0.31	0.56 ± 0.29	1.125	0.264
	Post-intervention	0.52 ± 0.27	0.43 ± 0.19	1.600	0.114
Medication taken as prescribed	Pre-intervention	0.81 ± 0.25	0.83 ± 0.95	0.272	0.787
	Post-intervention	0.88 ± 0.15	0.85 ± 0.24	0.610	0.543

Notes: Statistical significance is indicated for differences between pre- and post-intervention values

Table 3 Comparison of scores on self-management attitude and self-efficacy scales

Scales	Pre-/post-intervention	Experimental Group (*n* = 28)	Control Group (*n* = 28)	95% CI	Cohen's d	t value	*P* value
Self-Management Efficacy	Pre-intervention	4.12 ± 0.73	4.21 ± 0.88	0.05 to 0.49	0.50	1.217	0.228
	Post-intervention	4.42 ± 0.53	4.15 ± 0.56			2.332	0.020
Self-Management Attitude	Pre-intervention	4.41 ± 0.84	4.28 ± 0.53	-0.76 ~ -0.25	0.53	0.784	0.436
	Post-intervention	4.89 ± 0.41	4.43 ± 0.52			5.350	0.001

Notes: Statistical significance is indicated for differences between the two groups

Table 4 Comparison of blood glucose between the two groups

Item	Experimental Group (*n* = 28)	Control Group (*n* = 28)	95% CI	Cohen's d	t value	*P* value
Fasting blood glucose	5.22 ± 0.60	5.50 ± 0.56	-0.53~ -0.03	0.48	2.316	0.030
Post-breakfast blood glucose	6.72 ± 1.02	7.25 ± 0.77	-0.91~ -0.16	0.67	3.110	0.011
Post-lunch blood glucose	8.48 ± 0.48	8.78 ± 0.45	-0.97~ -0.26	0.79	4.124	0.008
Post-dinner blood glucose	7.79 ± 0.50	8.24 ± 0.48	-0.68~ -0.31	0.53	5.213	0.001

Notes: Statistical significance is indicated for differences between the two groups

attitudes toward managing their condition. See Table 3 for further details.

Comparison of post-intervention blood glucose between the two groups

The results indicated significantly lower levels of FBG (5.22 ± 0.60 vs. 5.50 ± 0.56 mmol/L, t = 2.316, *P* = 0.030), post-breakfast blood glucose (6.72 ± 1.02 vs. 7.25 ± 0.77 mmol/L, t = 3.110, *P* = 0.011), post-lunch blood glucose (8.48 ± 0.48 vs. 8.78 ± 0.45 mmol/L, t = 4.124, *P* = 0.008) and post-dinner blood glucose (7.79 ± 0.50 vs. 8.24 ± 0.48 mmol/L, t = 5.213, *P* = 0.001) in the experimental group compared with the control group post-intervention (Table 4). These findings suggest that the intervention effectively improved glycaemic control across multiple time points throughout the day.

Discussion

Summary of key findings

This study demonstrated that the use of mobile educational platform significantly improved blood glucose control and treatment adherence in patients with NS and SDM. The intervention group exhibited greater reductions in postprandial blood glucose and FBG levels compared with the control group, along with enhanced self-management efficacy and behaviour scores, which indicates the effectiveness of digital health interventions in enhancing patient engagement and adherence to treatment. These results suggest that mhealth platforms could serve as a practical and effective tool in the management of SDM, where self-management and patient engagement are critical.

Currently, no precise data are available on the specific incidence of SDM, which is reported to be approximately 1.5–47% due to variations in patient populations, primary disease types, testing methods, GC usage methods and diagnostic criteria [21–23]. The clinical relevance of this study is particularly important given the lack of established guidelines for managing SDM, a condition that is less common compared with type 1 and type 2 diabetes but one that is equally serious. The improvement in glycaemic control achieved through the mobile platform is clinically significant, as even modest reductions in FBG and postprandial blood glucose levels can lead to meaningful reductions in diabetes-related complications. This is particularly pertinent for patients with NS, in whom steroid-induced hyperglycaemia can exacerbate existing renal and cardiovascular risks [24].

Despite the traditional health education leading to improvements in lifestyle, medication adherence and regular check-ups of patients with diabetes, self-monitoring of blood glucose levels has not been clearly improved, possibly due to the lack of prompt feedback [25]. Mobile healthcare services have been implemented within basic nursing, emergency care and chronic disease management. The mobile internet not only facilitates data collection but also provides effective personalised intervention measures based on individual patient circumstances [26]. In this regard, the development of mobile nursing healthcare is of significant importance [27]. Specifically, apps such as WeChat are widely used as convenient and effective communication tools, and the widespread use of WeChat has expanded the channels for communication between healthcare workers and patients while providing the latter with knowledge and education in their daily lives [28]. There is a wealth of literature showing that eHealth interventions can be highly effective in improving self-management and glycaemic control in various types of diabetes. For example, a study by Greenwood et al. demonstrated that mhealth applications significantly improved HbA1c levels in patients with type 2 diabetes through enhanced self-management and lifestyle modifications [29]. Similarly, a systematic review by Hou et al. concluded that telemedicine and mhealth interventions

were associated with improved diabetes self-care behaviours and better clinical outcomes, including reductions in HbA1c and FBG levels [30]. In the context of SDM, where steroid-induced hyperglycaemia poses unique challenges, eHealth interventions can play a critical role by offering real-time monitoring and personalised education. For example, Chanpitakkul et al. reported significant improvements in diabetes management through the use of mobile platforms that provided tailored feedback and education, particularly in populations with limited access to healthcare resources [31]. The present study builds on these findings by demonstrating similar benefits in patients with SDM, suggesting that eHealth solutions may help bridge gaps in care for this underresearched population.

These findings underscore the potential of integrating mobile educational platforms into the care of patients with NS and SDM. Mobile health technologies provide timely feedback, personalised education and continuous monitoring, addressing some of the critical barriers to self-management that are particularly pronounced in chronic conditions such as NS and diabetes. Here, the intervention led to significant improvements in both objective outcomes (e.g. FBG) and subjective measures (e.g. self-efficacy), suggesting that both physiological and behavioral factors were positively influenced. One of the key findings was the significant improvement in postprandial glucose levels, which suggests that the intervention may have had a greater impact on patient adherence to dietary recommendations and blood glucose monitoring, particularly during high-risk periods, such as after meals. This aligns with the growing body of evidence supporting the role of continuous patient engagement in achieving better glycaemic control.

This study included elderly patients with diabetes who experienced a relatively longer duration of disease, most of whom had a clearer understanding of SDM and evidently knew that effective self-management could help them control blood glucose levels effectively. As a result, both groups obtained high scores in terms of self-management attitudes. However, due to the longer duration of the disease, these patients may not strictly follow their self-management practices, leading to significantly lower scores in self-efficacy and self-management behaviours than in self-management attitudes.

Clinical implications

The clinical relevance of this study lies in its focus on SDM, a less commonly studied but important form of diabetes that develops due to corticosteroid therapy in patients with NS. Current guidelines for diabetes management are primarily focused on type 1 and type 2 diabetes, leaving a gap in evidence-based strategies for managing SDM. This study addresses this gap by demonstrating that a tailored mobile educational intervention can lead to significant improvements in blood glucose control and self-efficacy, suggesting that such platforms could play a critical role in the management of SDM, particularly in outpatient settings. Given the challenges associated with managing SDM, these results offer promising insights into the use of technology to support patient self-management.

It should be noted that this study period extended over more than a year, with some overlap with the COVID-19 pandemic. While this could have influenced patient access to healthcare and impacted behaviours, the intervention was delivered remotely through a mobile platform, minimising disruption to patient monitoring and support. Research suggests that eHealth interventions gained prominence during the pandemic, effectively maintaining patient care despite restrictions on in-person visits [32, 33]. It is possible that the pandemic heightened patients' reliance on mhealth tools, potentially enhancing adherence to the intervention. However, the external stressors associated with the pandemic may have also introduced variables that were not controlled for in this study. Future research should investigate how such global events impact the effectiveness of digital health interventions in chronic disease management.

Limitations

This study has further limitations. First, convenience sampling was utilised, which limits the study's representativeness and the generalisability of the research conclusions. Additionally, confounding factors, such as variations in patient adherence to the intervention and differences in baseline characteristics, could have affected the results. Methodologically, the reliance on self-reported measures for assessing self-management behaviour may have led to response bias, and the absence of continuous glucose monitoring (CGM) data limited our ability to capture real-time fluctuations in blood glucose levels. Second, due to the retrospective nature of the data collection, we were unable to obtain consistent pre-intervention blood glucose measurements (including HbA1c) for all participants. This limitation is primarily due to the varying stages of treatment at which patients began the intervention, as well as inconsistencies in baseline glucose monitoring. Future research should aim to include standardised glucose monitoring before and after the intervention, ensuring a more comprehensive evaluation of the intervention's impact. Third, while this study utilised fasting and postprandial glucose measurements as primary outcomes, it is important to acknowledge the limitations of this approach. These measurements do not provide a complete picture of a patient's glucose management over time. Future studies should consider integrating HbA1c and CGM metrics to provide a more holistic

view of glycaemic management and to better assess the effectiveness of digital health interventions. Fourth, the revised scales were not subjected to a formal validation process before their implementation. While these modifications were informed by existing literature and expert recommendations, the lack of thorough validation raises concerns about their reliability and accuracy. Therefore, future research should prioritise long-term and comprehensive validation of these revised scales in a larger and more diverse population to ensure they effectively measure the intended constructs in the target population.

Conclusion

This study demonstrated that the use of mobile educational platform significantly improved blood glucose control and treatment adherence in patients with NS and SDM. The findings, as evidenced by reductions in fasting and postprandial blood glucose and improvements in self-efficacy scores, suggest that mhealth interventions can play a valuable role in supporting chronic disease management.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12902-024-01802-2.

Supplementary Material 1

Acknowledgements
N/A.

Author contributions
Yang ZM conceived of the study, and Tan ZC, Sun MN, Zhang J, Hou HZ and Li X participated in its design and data analysis and statistics and Yang ZM helped to draft the manuscript. All authors read and approved the final manuscript.

Funding
This study was supported by Shanxi Province "136" Medical Engineering Research Project (xy2018023). Funding agencies did not play a role in study design, data collection, analysis and interpretation, and manuscript writing.

Data availability
All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Shanxi Provincial People's Hospital, [(2021) Provincial Medical Department Ethical Review No. (272)]. Informed consent was obtained from all participants prior to enrollment in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 4 July 2024 / Accepted: 4 December 2024
Published online: 27 April 2025

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