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RESEARCH ARTICLE

DM-calendar app as a diabetes self-management education on adult type 2 diabetes mellitus: a randomized controlled trial

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Abstract

Purpose Era Disruption 4.0 demands development in the management of Diabetes Mellitus (DM) by using application-based intervention that can facilitate nursing intervention. The aim was to evaluate the effect of diabetes mellitus calendar app as a Diabetes Self-Management Education (DSME) program on self-efficacy, HbA1c levels, lipid profile, and insulin in adult type 2 diabetes mellitus (T2DM).

Methods It was randomized experimental design — simple random sampling used with a total sample of 30 respondents. The instruments used diabetes management self-efficacy scales and standard of operational procedure blood sampling. The statistical tests used were a Paired t-test, Wilcoxon, and an Independent t-test.

Results DSME with an Android-based DM calendar affected self-efficacy ($p < 0.001$), HbA1c levels ($p = 0.005$), cholesterol ($p = 0.009$), triglyceride ($p = 0.000$), HDL-c ($p = 0.048$), LDL-c ($p = 0.010$), and insulin ($p = 0.000$) compared with the control group. Education with these electronic media has increased the perception of self-efficacy and improved the behavior of good self-management that can be seen from changes in controlled HbA1c level, lipid profile and insulin.

Conclusion The results of this study can be used as a reference for providing educational experimental in patients with Type 2 Diabetes Mellitus (T2DM).

Keywords Diabetes mellitus · Telenursing · Self-efficacy · Lipid profile · Insulin

Introduction

Diabetes Mellitus (DM) is one of the most common chronic diseases and one of the biggest health problems for many countries [1]. Lifestyle factors such as unhealthy diet, obesity, physical activity, smoking, and excessive alcohol consumption are known to increase the risk of Type 2 Diabetes Mellitus (T2DM) [2]. In 2015, Indonesia ranked seventh in the world for the highest prevalence of diabetics in the world, with an estimated number of people with diabetes of 10 million [3]. Individuals with chronic diseases, including diabetes, are open to innovative health education methods; and such people have stated that they want as much information as possible in a readable format and as early as possible after their initial diagnosis [4].

Self-efficacy is one of the most important factors – defined as the confidence of patients in maintaining and improving their medical condition. Low levels of self-efficacy impact on the low success of self-care patients with diabetes mellitus [5]. Self-efficacy, compliance, and social support have a significant influence on a patient's glycemic profile / Glycated Hemoglobin A1c (HbA1c) [5]. The data show that only a small percentage (35%) of patients with T2DM achieve glycemic control (HbA1c <7). If left untreated, it will lead to further medical complications associated with DM [5].

Lack of communication between nurses and patients which can be caused by the distance of treatment and the length of time waiting for the queue during treatment and control causes a lack of effectiveness in the management of DSME and the patient not to visit the hospital [6, 7]. The lack of opportunity for T2DM patients to communicate about perceived complaints causes a lack of knowledge and poor management [8]. The use of communication technology can be a solution to this problem [9] and need interprofessional collaborative between health workers [10].

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The use of technology in the treatment of diabetes can facilitate improved communication between nurses and patients, can lead to more reliable data collection, and can lead to the provision of a more comfortable life for patients. An important goal of treatment with electronic media is to allow patients to maintain their education effectively without interruption [11]. The telenursing method is beginning to be more in demand as a health service to support patients in their own homes [12]. Telenursing refers to the use of communications and information technology in nursing care from a distance, which can help solve patient problems, reduce distance and travel times, and maintain the health of patients in their own homes [12].

Research on the application of telenursing in patients with T2DM recommends that more research is needed to study the impact of technological innovations on the improvement of self-management diseases and medical outcomes, as well as the prevention of complications of diabetes with good glycemic control [11]. Web applications that offer specialized programs to assist in meeting the needs of patients have not been widely studied [12]. Some researchers believe that such applications should be designed to enable individuals to maintain or improve their health status [12].

Based on the authors' description, assume that need to be made an electronic media in the form of a DM calendar to facilitate patients in their maintaining health status. This study aims to determine the effect of a DM-calendar app as a media for a Diabetes Self-Management Education (DSME) program on self-efficacy, HbA1c levels, lipid profile, and insulin in adult T2DM.

Methods

Study design

A randomized experimental design was used to examine the effects of DM-calendar apps designed by researchers as a DSME media to increase self-efficacy value, HbA1c levels, lipid profile, and insulin of patients with T2DM.

Participant sampling

Respondents ($N = 30$; 15 in the experimental group and 15 in the control group). The sample population in this study consisted of patients in North Denpasar, Bali, Indonesia who had been diagnosed with T2DM within the past year. The inclusion criteria were: (a) The patients must be compos mentis; (b) the patients are able to operate an Android phone, (c) the patients must have an uncontrolled glycemic profile (HbA1c) of >7; (d) the patients must be undergoing the same drug therapy for at least three months; and (e) the patients following the research until finished. The exclusion criteria were: (a) Patients with mental disorders; (b) patients with moderate or high-stress levels; (c) patients with a hemoglobin count of <10; and (d) patients with comorbidities such as heart disease, renal failure, anemia, respiratory disorders, blood cell disorders, stroke, or hypertension.

Determination of research samples using random allocation. Respondents in both groups did not know whether they belonged to the experimental group or the control group. In the experiments group, the researchers gave the DM-Calendar application to be obeyed for the next three months, while the control group was given media leaflets. Both groups do not know each other if both are used as research objects. Researchers are assisted by the Puskesmas in determining the groups for research, namely by different villages, so that the two groups do not interact with each other.

A total of 210 patients were diagnosed with T2DM in the Health Primary Care of North Denpasar area. The study was conducted for three months (February–May 2018). From a total of 210 respondents, 80 respondents (40 in the experimental group and 40 in the control group) were found that match the inclusion criteria. A total of 65 respondents (30 in the experimental group and 35 in the control group) were willing to join the study. In the first month there were 15 respondents who resigned because they were unable to follow the specified program. In the second month, there were 20 respondents who resigned (15 were not painstaking in joining the program and there were 5 respondents who moved residence outside Bali). So that in the third month there are 30 respondents who are able to follow the program to completion (15 in the experimental group and 15 in the control group).

The primary outcomes of the research were the self-efficacy and HbA1c levels in patients with T2DM after treated by DM-Calendar apps on experimental group. The secondary outcome was glycemic control value form Health Primary Care before the study conducted.

Setting and location

The study was conducted between February and May 2018 in worked are of Health Primary Care of North Denpasar, Bali, Indonesia. The researchers introduced themselves and explained the benefits, goals and approval procedures by referring to the informed consent form. Preliminary assessments of self-efficacy and HbA1c were measured in both groups. All respondents were given DSME for four sessions of 30 min each. The first session discussed the basic concepts of DM; the second session discussed nutritional therapy and physical activity; the third session discussed foot care and the monitoring that needed to be done; and the fourth session discussed stress management, psychosocial support, and patient access to healthcare facilities. Following the sessions, the experimental group was given a DM-calendar application master to be installed on their mobile phone, while the control group were

given a leaflet containing a diet program, and information about physical activity and blood sugar control. Each group participated in the media program for three months. After this time, a posttest of self-efficacy and HbA1c measurements were performed. The pre and posttest activities were conducted in the Health Primary Care in North Denpasar.

Measurement

DM-calendar app

The DM-Calendar application is an Android-based application designed by the researchers as self-care education media for patients with DM living alone. The application has been provided by the researcher for installation on the respondents' mobile phones. The app contains three of the four 'pillars' of DM, namely a blood sugar control, education program, nutrition therapy, and physical activity. This app system works by reminding the patient to perform a self-management program in the form of notifications on their mobile phones. The app will notify the patient six times a day: at 06.00 (breakfast), 09.00 (morning snack), 12.00 (lunch), 15.00 (afternoon snack), 16.00 (physical activity/diabetic foot gymnastics), and 18.00 (dinner). The reminder for the blood sugar check appears once a month starting from the first login.

Self-efficacy

Measurements of self-efficacy use a diabetes management self-efficacy scale (DMSES), consisting of 15 questions with scores ranging from 15 to 60. Forms of choice range of beliefs using a Likert scale consisting of four options in the following format: 1. Strongly disagree, 2. disagree, 3. agree, and 4. strongly agree. The Likert scale is used to measure the attitudes, opinions, and perceptions of a person or group of people about social phenomena.

Biochemical measures

Blood sampling was performed by competent personnel following appropriate procedures. The HbA1c (normal value 4.5–7.0%) examination was performed using the Turbidimetric Inhibition Immunoassay (TINA) method in adherence to International Federation of Clinical Chemistry (IFCC) standards. Serum concentration of total cholesterol (normal value: ≤ 200 mg/dL), triglycerides (normal value: ≤ 150 mg/dL), HDL-C (high-density lipoprotein cholesterol; normal value: ≥ 60 mg/dL), LDL-c (low-density lipoprotein cholesterol; normal value: ≤ 100 mg/dL) were analyzed by a colorimetric or turbidimetric assay by an automatic analyzer using HDL and LDL / VLDL Cholesterol Assay Kit (ab65390) [13], and insulin (normal value: 5–25 μU/mL) used RayBio ® Human Insulin ELISA Kit [14]. It was performed at the Sanglah Hospital Laboratory, Bali, Indonesia.

Data analysis

Statistical analyses were performed with SPSS [15]. Descriptive statistics such as numbers, percentages, mean, and standard deviation were used to present descriptive characteristics of respondents in both the experimental and control groups. Fisher's exact tests were used to compare baseline variables between the experimental and control groups. The Shapiro-Wilk test was used to evaluate the normal distribution of quantitative variables. The Paired t-test and Wilcoxon test were used to analyze the pre and posttest values of each group. Independent t-test was used for the analysis of changes in self-efficacy and HbA1c values between the experimental and control groups. A p value of <0.05 is accepted as the level of significance.

Ethical considerations

The Ethical Commission has approved this study of Health Research at the Nursing Faculty of X University No. 654-KEPK on 15th February 2018. Written consent was obtained from all centers. The aim of the study was explained to the participants and informed consent forms were collected.

Result

Distribution of demographic characteristics of respondents on the experimental and control group ($n = 30$)

Based on Table 1, the respondent's characteristics based on age were mostly in the age range of 46–55 years (53.3%), there were slightly more females than males (56.7%), the highest level of education was high school (60%), most of the participants were employed (83.3%), and most patients had been suffering from DM for 9–12 months (56.7%). All variables of the respondents' characteristics of the experimental and control groups showed homogeneity ($p > 0.05$).

The distribution of self-efficacy and HbA1c

Based on Table 2, the experimental group and the control group had a significant effect ($p < 0.05$) on the improvement of self-efficacy. If looking at the mean, the experimental group had a higher self-efficacy increase than the control group, as well as the p value of the Independent t-test showing a significant difference between the experimental group and the control group ($p < 0.05$).

Table 1 Distribution of demographic characteristics of respondents on the experimental and control group (n = 30)

Characteristic	Group				*p value*
	Experimental (*n* = 15)		Control (n = 15)		
	n	%	n	%	
Age (years)					
36–45	2	13.3	2	13.3	0.312*
46-55	6	40	10	66.7	
56–65	7	46.7	3	20	
Sex					
Male	7	46.7	6	40	>.999*
Female	8	53.3	9	60	
Education					
High school	9	60	9	60	>.999*
Collage	6	40	6	40	
Occupation					
Not working	3	20	2	13.3	>.999*
Working	12	80	13	86.7	
DM Duration (moon)					
0–4	1	6.7	–	–	0.713*
5–8	5	33.3	7	46.7	
9–12	9	60	8	53.3	

**Fisher's exact test; homogeneity (p > 0.05)*

The HbA1c values in the experimental group was significant ($p < 0.05$) and was not significant in the control group ($p > 0.05$). Independent t-tests also showed significant value ($p < 0.05$) comparison between the experimental group and the control group. The lipid profile (total cholesterol, triglycerides, HDL-c, and LDL-c) in the experimental group was significant ($p < 0.05$) than in the control group. Independent t-tests also showed significant value comparison between the experimental group and the control group.

Most of total respondent in the study has insulin level is under (5μU/mL; normal value: 5-25μU/mL). It was mean, the total value of insulin in blood is lacked than normal. Thus, insulin did not enough to carryout the glucose into cells. The insulin level in the experimental group was significant ($p < 0.05$) than in the control group. Independent t-tests also showed significant value comparison between the experimental group and the control group. These results show that the DM-calendar app used as educational media can reduce the levels of HbA1c, lipid profile, and insulin level compared with the use of conventional media (leaflets).

Discussion

Increased self-efficacy cannot be separated from many factors, one of which is the process of the activation efficacy itself. The efficacy-activated process consists of cognitive processes, motivational processes, effective processes, and selection processes [16]. The cognitive processes in this study are clearly demonstrated from the proviso that education DSME can increase knowledge on how to achieve goals through nutrition programs, activities, foot care, and blood sugar control. The value of self-efficacy in the experimental group and the control group was no different, as both have a significant influence, as can be seen in Table 2. However, if the delta value of each group is compared, and a statistical test is performed, then there was found to be a significant difference between the experimental group and the control group. Both of these results can be interpreted in that giving DSME with a DM-calendar app media means a more significant increase in self-efficacy compared with conventional media (leaflet). The difference in these results can be explained by the fact that every individual need continuous education; and if most information is only available in leaflet form, then they cannot answer the demands for continuous education as leaflets are easily damaged and are not durable by their nature.

The existence of DM-calendar apps that remind patients to perform self-care management can meet the needs of patients and will provide them with long-term education. Previous research has shown similar results to this study. Provision of education by using electronic media can significantly improve self-efficacy [17]. The use of the phone in education provides patients with individual support and allows them to feel listened to and understood, gaining their trust when done well [18]. Patient empowerment improves their ability to take control of their self-care, which in turn can improve self-efficacy and help ease feelings of distress [18]. Self-efficacy in various studies has been expressed as a determinant of physical activity; therefore, its promotion will be an important factor in promoting nutritional management and physical activity [17]. Physical activity is very important to do because it can increase body strength. The most important thing is increased activity can increase insulin receptors to absorb and use glucose properly [19, 20]. Insulin receptors are important for people with DM because they can improve quality of life [21, 22].

The use of "telehealth" effectively improves the self-efficacy of patients with T2DM [23]. Application technology based on mobile phones has been shown to improve service provider communications, is more accessible to patients, and provides appropriate options to facilitate independent management processes and medication adherence [24]. This can be used as the reason why the use of DM-calendar apps can more effectively increase the self-efficacy and activity of patients with T2DM compared with conventional media (leaflets) in the provision of education.

The management of DM requires not only the prescription of proper nutrition and pharmacological systems by doctors but also intensive education. Intensive DM management is

Table 2 The distribution of self-efficacy, HbA1c, Lipid Profile, and Insulin ($n = 30$)

Group	n	Pre-test		Post-test		*p value*	*p value*
		Mean ± SD	Min ± Max	Mean ± SD	Min ± Max		
Self-efficacy							
Experimental	15	33.73 ± 2.4	29 ± 39	49.2 ± 2.54	44 ± 53	<0.001[a]	<0.001[c]
Control	15	31.47 ± 2.75	28 ± 37	41.07 ± 1.94	38 ± 45	<0.001[a]	
HbA1c (%)							
Experimental	15	8.74 ± 1.34	7.1 ± 11.3	7.64 ± 1.29	6.2 ± 11	0.001[b]	0.005[c]
Control	15	8.18 ± 1.02	7.1 ± 10.8	7.91 ± 0.88	7 ± 10.5	0.208[b]	
Cholesterol (mg/dL)							
Experimental	15	201.6 ± 40.13	156 ± 287	182.07 ± 24.03	139 ± 221	0.010[b]	0.009[c]
Control	15	213.6 ± 30.71	156 ± 262	190.03 ± 30.05	151 ± 254	0.088[b]	
Triglyceride (mg/dL)							
Experimental	15	142.67 ± 32.18	101 ± 201	117.73 ± 24.25	89 ± 156	0.035[a]	0.000[c]
Control	15	136.2 ± 32.24	92 ± 201	127.53 ± 21.6	90 ± 156	0.264[a]	
HDL-c (mg/dL)							
Experimental	15	60.67 ± 14.36	42 ± 89	54.33 ± 12.04	40 ± 72	0.002[b]	0.048[c]
Control	15	60.07 ± 11.31	39 ± 79	52.73 ± 12.75	30 ± 72	0.004[a]	
LDL-c (mg/dL)							
Experimental	15	117.67 ± 19.47	78 ± 143	97.25 ± 14.83	76 ± 132	0.007[b]	0.010[c]
Control	15	139.5 ± 37.38	90 ± 202	131.83 ± 30.63	90 ± 179	0.028[b]	
Insulin (μU/mL)							
Experimental	15	4 ± 0.7	3 ± 5.3	4.8 ± 0.42	3.9 ± 5.5	0.002[b]	0.000[c]
Control	15	4.06 ± 0.73	2.9 ± 5.1	3.95 ± 0.64	3 ± 5.1	0.610[b]	

SD, Standard Deviation; HDL-c, High-Density Lipoprotein Cholesterol; LDL-c, Low-Density Lipoprotein Cholesterol; $p < 0.05$

[a] Paired t test

[b] Wilcoxon signed ranks test

[c] Independent t test

necessary to maintain glycemic control by measuring HbA1c levels. The average blood glucose level 30 days previously is a major contributor to high HbA1c levels. The average monthly contribution of blood glucose to HbA1c is 50% from the previous 30 days, 25% from the previous 30–60 days and 25% from the previous 60–120 days earlier [25]. Therefore, it takes an educational program at least 30 days to keep a patient's glycemic profile under control.

The use of electronic media is shown to be one of the right choices in providing continuing education more efficiently. Mobile and internet technologies are widely available, are accessible 24 h a day, and can be utilized to promote disease management and facilitate behavior modification [26]. An electronic education program provides simple communication and consultation systems for patients to keep directly in contact with their health teams and provide them with easy access to effective educational materials to help improve their metabolic control [27]. This is in line with the results of this study, where the use of electronic media, in this case, a DM-calendar app as a DSME, has been shown to decrease HbA1c levels effectively.

Electronic learning has revolutionized education, and this particular method has unique features that the user likes and makes it possible for them to learn anywhere. Electronic media facilitates individual and group learning and allows the tailoring of materials according to user needs [27]. Implementation of electronic or web-based experimental in helping the management of diabetes has exploded in popularity over the past decade, and the majority of them have focused specifically on facilitating the glucose monitoring process, enabling patients to upload monitoring data to enable their doctors to adjust their insulin dosage or other related drugs [24]. The use of text messages containing self-management programs of patients with T2DM also showed significant HbA1c degradation results compared with the control group [28].

The development of a website that teaches users about DM has eliminated many of the limitations that many people used to encounter when accessing diabetes and self-management education programs in terms of cost, time, and availability. Ultimately, these programs are available to people who are unable or unwilling to take part in face-to-face or group education [27]. In line with this study, the use of a DM-calendar app has proved to be more effective and efficient in providing education for self-management programs, as HbA1c levels

can be reduced, and even controlled. Respondents in both groups did use medication to control blood sugar levels. Medication therapy with drugs can indeed help to reduce blood sugar levels, but this cannot last long [29]. Thus, respondents must take the drug continuously and regularly. Based on this, it is necessary to change attitudes, intentions, abilities and support for patients to be adaptive during the treatment process [5]. DM-Calendar is an app that contains three of the four 'pillars' of DM, namely a blood sugar control, education program, nutrition therapy, and physical activity.

Study result showed the change of lipid profile in both groups. Lipid profile (cholesterol and LDL-c) is changed by M-Health intervention [30]. DM Calendar is worked by reminding the patient to perform a self-management program in the form of notifications on their mobile phones. This application can be a reminder and reminder for respondents to consume drugs regularly, physical activity regularly, diet, and education that are important for respondents [31]. This is certainly different from the control group, where the group does not seem to get a "special attention" to do good DM management. Insulin is an indicator that can indicate a disturbance in the metabolic system [32]. The results showed that almost all respondents experienced insulin resistance under normal values. DM-Calendar app can help respondents to remind and guided the time of insulin injection and doses, so that the amount of insulin in the body is stable [33].

Limitation

In this study there were almost 50% of respondents who resigned as research subjects. This can be caused by the characteristics of the people in the area of Health Primary Care, North Denpasar, Bali, Indonesia who are still accustomed to cultural customs such as "Magibung" which is the tradition of gathering and eating together regularly. This is incompatible with dietary management in T2DM patients. This causes the number of samples to only 30 respondents so the results of the analysis of the study have not been described outside if using a large sample size. It is hoped that in the future this research can be carried out with a larger number of samples and in quite a long time. Potential bias in this study if respondents in the experimental group met with respondents in the control group, so that the DM-Calendar App can be given to the control group. But researchers are trying to minimize the bias.

Conclusion

The application of DM-calendar apps as DSME media can increase self-efficacy, decrease the HbA1c levels, lipid profile, and insulin of patients with T2DM. The use of electronics as an educational medium can improve the communication of service providers, can increase patient access, provide the right choice to facilitate the process of self-management, and can increase the patient's self-confidence to do their own self-care effectively. In the end, all these factors can increase life expectancy in patients with T2DM. Future researchers are expected to intervene with DM-Calendar to be able to examine the insulin receptor (IR) and insulin-like-growth factor (IGF), and plasma total antioxidant capacity (TAC).

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Conflict of interest No potential conflict of interest relevant to this article was reported.

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