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EFFECTIVENESS OF SMARTPHONE APPLICATION-BASED LIFESTYLE EDUCATION PROGRAM IN TYPE 2 DIABETES PATIENTS

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ABSTRACT

Background: *Type 2 diabetes mellitus (T2DM) is a growing global health concern. Diabetes self-management education and support (DSMES) is associated with reducing blood sugar levels, body mass index (BMI), and cardiovascular risk factors. Online consultations have become essential for monitoring and medical advice. Data about effectiveness of the DSMES program in Vietnam has been very limited.* ***Objectives:*** *To evaluate effectiveness of smartphone application-based lifestyle education program on improving knowledge and behavior about diabetes, improving BMI and waist circumference, lowering blood glucose and lipid profile in Vietnamese patients with T2DM.* ***Materials and methods:*** *This was a non-blinded, randomized controlled trial study on 168 T2DM at Endocrinology clinic of General Hospital, Binh Dinh province between April 2022 to October 2022. Patients would be randomly classified into intervention group or control group. The intervention group received a 10-week intervention with DSMES program via the Dia-B smartphone application, while control group received standard education program.* ***Results:*** *There were 84 patients in the intervention group and 84 patients in the control group. The two groups were similar regarding main baseline characteristics. After the research period, general knowledge about diabetes management of the intervention group improved significantly from 6.3 points to 7.8 points ($p<0.001$). Body mass index (BMI), waist circumference, fasting blood glucose and HbA1c were statistically significantly lower after every 3 months of intervention. Of notes, after 6 months, while HbA1c in the intervention group decreased by 1.57%, the control group decreased by 0.28% ($p<0.001$).* ***Conclusions:*** *Smartphone application-based lifestyle education program improves knowledge and behavior about diabetes, decreases BMI, waist circumference, fasting blood glucose and HbA1c.*

Keywords: *Type 2 diabetes mellitus, Diabetes self-management education and support, body mass index, waist circumference, HbA1c.*

I. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a growing global health concern, particularly in low-to-middle-income countries like Vietnam [1]. Non-pharmacological interventions, such as diabetes self-management education and support (DSMES), have been shown to effectively reduce blood sugar levels, body mass index (BMI), and cardiovascular risk factors [2-4]. The ADA recommends that all people with diabetes participate in diabetes self-management education and receive support to facilitate the knowledge, decision-making, and skills mastery for diabetes self-care. A study of 364 Vietnamese T2DM patients found that a structured educational program improved disease knowledge and glycemic control [5], but it was

conducted offline. With patients now receiving 2- to 3-month outpatient prescriptions and fewer opportunities for in-person consultations, online consultations have become essential for monitoring and medical advice. More patients are using the internet for healthcare consultations and monitoring, with programs tracking outcomes such as blood glucose, weight, and blood pressure. However, there is limited data from long-term clinical trials on the effectiveness of such programs. Therefore, this study aimed to evaluate the effectiveness of a smartphone application-based lifestyle education program in improving knowledge and behavior about diabetes, improving BMI and waist circumference, and lowering blood glucose and lipid profile at Binh Dinh Provincial General Hospital.

II. MATERIALS AND METHODS

2.1. Materials

We performed a single-center, non-blinded, randomized controlled trial study at the Endocrinology outpatient clinic of General Hospital, Binh Dinh province between April 2022 to October 2022.

- Inclusion criteria: (1) Age between 40 and 70 years, (2) T2DM with 7% < HbA1c < 12%, (3) literacy, (4) using a smartphone to install Zoom and Zalo applications, (5) having a blood glucose meter.

- Exclusion criteria: We excluded individuals with indications of acute metabolic decompensation, being pregnant and having severe chronic comorbidities: heart failure NYHA grade 3, chronic kidney disease GFR ≤ 60 ml/min.

2.2. Methods

- Study size: Sample size was measured based on a formula comparing two percentage.

$$n = 2.\left[\frac{(Z_{2\alpha}+Z_{2\beta})\sigma}{\delta}\right]^2$$

With $\alpha = 0{,}05$, $Z2\alpha = 1{,}96$ and $\beta = 0{,}2$, $Z2\beta = 0{,}84$; the percentage of decreased HbA1c after education according to Davis et al [6] was $\sigma: = 1{,}1$; the standard deviation of HbA1c according to Davis et al was $\delta: = 0{,}5$. From these data, the drawn minimum sample size for each group was 76 patients. Assuming a 10% expected loss of sample rate; we finally selected a total of 168 eligible individuals and included them in the study.

- Study Measurements:

+ Random method: A total of 300 type 2 diabetes patients were randomly selected using the Random function in Excel from those visiting the outpatient department at Binh Dinh Provincial General Hospital. Of these, 168 patients met the criteria and agreed to participate. Randomization was done by assigning 168 numbered pieces of paper into an envelope. The investigator gave each participant an envelope, assigning them to the intervention group if the number was odd and to the control group if the number was even.

+ Conducting method: We collected baseline data, including: disease duration, drugs, weight, height, waist circumference, fasting blood glucose, HbA1c and lipid profile. The drugs used for T2DM and dyslipidemia would continue to be used during the study period. Then, we completed the pre-test questionnaires in the control and intervention groups. The intervention team was trained, including: 2 nurses interviewing patients with questionnaires and collecting baseline parameters; 1 nurse coding patients; 1 nurse scheduling follow-up appointments; 2 doctors and 1 laboratory technician providing online consultations and answering questions on the Zalo group; 1 nutritionist and 1 fitness expert.

+ Intervention group: Patients were offered intervention program in addition to the usual care. The program was standardized to include the following components: (1) installing Zoom, Zalo, DiaB applications (an online comprehensive healthcare application for diabetes patients), (2) initial consultation on blood sugar, blood pressure, and weight goals, (3) group education 2 lessons per week on Saturday and Sunday via Zoom application (1 hour each lesson - 10 lessons in total). The lessons were based on National Standards for DSMES and sent via Zalo application to patients, (4) access to Zalo application that allowed consultation when necessary, (5) reminding to take medicines, diet, exercise every Monday mornings and to follow up at the hospital, (6) taking online lessons and homework via DiaB application.

+ Control group: The patient was examined by the doctor during a routine consultation, which involved addressing any patient inquiries. When blood glucose levels exceeded the target, the doctor advised on medication, diet, and exercise

- Study Outcomes: In the subsequent 3 months and 6 months after program, the patients were re-evaluated BMI, blood pressure, waist circumference, fasting blood glucose, HbA1c and lipid profile.

- Statistical analysis: Statistical analysis was performed using SPSS 18.0. Qualitative variables were described with percentage. The percentages were compared using Chi-square tests ($\chi 2$) or Fisher's exact test. Quantitative variables were described with mean and standard deviation, using t-test for comparison 2 mean values and paired t-test for comparison 2 mean values before and after research.

- Ethics approval: The Research Ethics Committee of Binh Dinh Hospital approved the current study. Signed informed consent was obtained from all of the eligible participants.

III. RESULTS

3.1. Participants

168 patients who met the sampling criteria and agreed to participate in the research were randomly divided into groups: the intervention group (n = 84) and the control group (n = 84). In the intervention group, there were 8 patients who discontinued during the study period; of which 4 patients not having time to study, 3 patients remaining high HbA1c after 3 months, 1 patient changing accommodation. The control group had 76 patients with enough data to study. Analyzing the research results based on the statistics from 76 patients of the intervention group and 76 patients of the control group.

3.2. Baseline characteristics

On the whole, the differences between the initial characteristics of the two groups were not statistically significant ($p > 0.05$)

3.3. Changes in knowledge and behavior about diabetes

According to Table 1, knowledge and behavior about diabetes in the intervention group improved significantly after study period ($p < 0.001$). In addition, after 6 months, the differences about disease, general knowledge and self-care behavior between the intervention and the control group were statistically significant.

Table 1. Changes in knowledge and behavior about diabetes of the two groups

	Intervention group (n=76)		Control group (n=76)		p value
	Before study (1)	After 6 months (2)	Before study (3)	After 6 months (4)	
Physical activities(score)	7.36±2.1	8.28±1.3	7.18±1.5	7.27±1.5	p (1,2)<0.001 p (3,4)=0.084 p (2,4)=0.317
Dietary behaviors(score)	6.15± 2.6	7.52± 1.4	6.02± 2.5	6.32± 2.5	p (1,2)<0.001 p (3,4)=0.069 p (2,4)=0.175
Monitoring parameters(score)	4.01±1.3	7.24±1.4	4.12±1.7	4.42±1.7	p (1,2)<0.001 p (3,4)=0.062 p (2,4)=0.184
Disease(score)	7.81± 1.8	8.43± 1.2	7.9± 1.9	8.12± 1.7	p (1,2)<0.001 p (3,4)=0.054 p (2, 4)<0.001
General knowledge(score)	6.33±1.63	7.87±1.06	6.30±1.5	6.53±1.4	p (1,2)<0.001 p (3,4)=0.084 p (2, 4)<0.001
Self-care behavior(score)	5.11±1.0	7.04±1.1	5.16±1.0	5.29±0.9	p (1,2)<0.001 p (3,4)=0.100 p (2, 4)<0.001

3.4. Changes in clinical and laboratory parameters of the intervention group

According to Table 2, in the intervention group, after every 3 months of intervention, both BMI and waist circumference had statistically significant lower mean values. Similarly, the decrease in glucose, HbA1c and the increase in HDL-Cholesterol after the intervention period of every 3 months were statistically significant.

Table 2. Changes in clinical and laboratory parameters of the intervention group after 3 months and 6 months of research

	Before study (1)	After 3 months (2)	After 6 months (3)	p value
BMI‡ (kg/m^2)	23.85±3.5	23.49±3.2	23.33±3.1	p (1,2) =0.001 p (2,3) =0.042
Waist circumference‡ (cm)	86.61± 10.8	85.90± 9.8	85.37± 3.7	p (1,2) =0.003 p (2,3) =0.027
Glucose‡ (mmol/l)	9.81±3.4	8.48±2.6	7.55±2.2	p (1,2) =0.001 p (2,3) =0.001
HbA1c‡ (%)	8.94±1.3	8.06±1.1	7.37±1.1	p (1,2) =0.001 p (2,3) =0.001
LDL-Cholesterol‡ (mmol/l)	4.28±0.8	4.27±0.7	4.29±0.8	p (1,2) =0.907 p (2.3) =0.720 p (1,3) =0.904
Triglycerides‡ (mmol/l)	2.00 ± 1.3	1.94 ± 1.0	1.91± 0.9	p (1,2) =0.363 p (2,3) =0.562 p (1,3)= 0.749
HDL-Cholesterol‡ (mmol/l)	0.99±0.1	1.01±0.2	1.03±0.2	p (1,2) =0.024 p (2,3) =0.024

†Percent. ‡Mean ± Standard Deviation; Abbreviation: BMI, Body Mass Index

3.5. Changes in clinical and laboratory parameters of the two groups

BMI, waist circumference reduced significantly in the intervention group after 6 months (p=0.001). However, this trend was not observed in the control group.

Changes in Glucose and HbA1c after 6 months were statistically significant in both groups (p = 0.001).

Table 3. Changes in clinical and laboratory parameters of the two groups after 3 months and 6 months of research

	Intervention group (n=76)		Control group (n=76)		p value
	Before study (1)	After 6 months (2)	Before study (3)	After 6 months (4)	
BMI‡ (kg/m2)	23.85±3.5	23.33±3.1	23.83±3.0	23.82±3.0	p (1,2) = 0.001 p (3,4) = 0.084 p (2,4) = 0.317
Waist circumference‡ (cm)	86.61± 10.8	85.37± 3.7	87.62± 9.1	87.38± 9.1	p (1,2) = 0.001 p (3,4) = 0.069 p (2,4) = 0.175
Glucose‡ (mmol/l)	9.81±3.4	7.55±2.2	9.54±3.3	8.82±2.3	p (1,2) = 0.001 p (3,4) = 0.001 p (2,4) = 0.001
HbA1c‡ (%)	8.94±1.3	7.37±1.1	8.82±1.5	8.54±1.4	p (1,2) = 0.001 p (3,4) = 0.001 p (2,4) = 0.001
LDL-Cholesterol‡ (mmol/l)	4.28±0.8	4.29±0.8	4.46±1.0	4.38±0.9	p (1,2) = 0.001 p (3,4) = 0.125 p (2,4) = 0.516
Triglycerides‡ (mmol/l)	2.00 ± 1.3	1.91± 0.9	2.21 ± 1.0	2.19 ± 0.9	p (1,2) = 0.001 p (3,4) = 0.554 p (2,4) = 0.079
HDL-Cholesterol‡ (mmol/l)	0.99±0.2	1.03±0.2	0.99±0.1	0.99±0.2	p (1,2) = 0.167 p (3,4) = 0.630 p (2,4) = 0.166

†Percent. ‡Mean ± Standard Deviation; Abbreviation: BMI, Body Mass Index

IV. DISCUSSION

4.1. Changes in knowledge and behavior about diabetes

In our input survey, the patients‘ knowledge about dietary behaviors and monitoring parameters were still limited at 6.15 and 4.01 on a 10-point scale respectively, which is similar to characteristics of study in developing country [7]. After identifying patients' problems, we trained dietary knowledge and encouraged patients to monitor blood glucose at home. At the end of the study, results of indicators monitoring increased with statistical significance (p < 0.001). Compared with the control group, knowledge of diabetes in the intervention one improved significantly after 6 months. This is the basis of changes in self-management of general disease and people with type 2 diabetes in particular. It is also the foundation for conducting and maintaining education and support programs for diabetic people throughout their lives.

In self-care behaviors, home blood glucose monitoring is one of the most important factors in terms of regulating blood sugar, adjusting the diet and making decisions about choosing exercise.

4.2. The effectiveness of diabetes self-management education program through blood glucose parameters: Glucose, HbA1c

The research results after 6 months of implementing the educational program indicated blood glucose control was improved. This was consistent with Al Omar *et al.* who found that self-management education program through WhatsApp application could help patients with diabetes improve their HbA1c levels [8]. According to a meta-analysis of 34 randomized controlled studies by Norris *et al.*, the effectiveness of educating diabetic patients increased cumulatively over time [9]. However, our results for blood glucose control were more significant, which could be due to differences in methods of education and support. In our study, we intervened through online education incorporating lifestyle intervention such as diet and exercise.

According to our results, the optimal effect appeared in the study period of ≤ 3 months, then there was a tendency to decrease the intervention effectiveness when the time was prolonged, which was consistent with similar studies in this field [8]. There were several reasons to explain that trend over time. First, the decline in effectiveness may result from decreased enthusiasm and motivation. Second, the lack of user-friendliness in the smartphone application could also contribute to the reduction in effectiveness. As the average age of study participants was over 40, technology may not be familiar and friendly to them. However, these findings do not suggest that the intervention period should be shortened. Rather, they highlight the need for strategies to enhance patient compliance and sustain their motivation.

Our findings highlight the role that education program made positive changes in blood sugar, which in turn reducing the acute and chronic complications of diabetes. In this study, the multi-factor education program increased knowledge about diet, exercising, adherence to medication regimen, addressing hypoglycemia, from which patients gained skills and confidence in their diabetes management.

4.3. The effectiveness of diabetes self-management education program on BMI, waist circumference and lipid profile

Based on our results, there was a decrease in BMI, waist circumference at 3 months, 6 months after intervention compared to initial state ($p < 0.01$), which was similar to findings of Marina Trento *et al* [10]. The reason of this trend in intervention group was that we and participants jointly set a goal of weight loss rate, created motivation about diet and exercise from the beginning of the study. Previously, Juma M.A. had shown that planning and maintaining action was strongly influenced by self-efficacy and individuals were more likely to change and maintain their behavior if they had beliefs [11].

In terms of lipid profile, there were differences in LDL-Cholesterol and Triglyceride levels compared to the baseline characteristics in the intervention group. However, there was no difference between the intervention group and the control group at the end of the study. These results were also observed in the meta-analysis of Steinsbekk [12].

4.4. Limitation

Our study has several limitations. First of all, we did not control changes in the dose of antidiabetic, antihypertensive, and lipid-lowering medications, which affected the results of the study. The second one is that there was no random matching on disease duration, education level, HbA1C level …. during sample selection.

V. CONCLUSION

Smartphone application-based lifestyle education program improved knowledge and behavior about diabetes, decreased BMI, waist circumference and HbA1c.

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