Effect of using Mobile Messenger for Insulin Injection Education for Glycemic Control: A Randomized Controlled Trial

Kannikar Yingyaun, Suranut Charoensri, Chatlert Pongchaiyakul*

Abstract: The use of a mobile application could be a valuable resource for providing ongoing self-management education and support for people with diabetes. This study is the first in Thailand to assess the efficacy of insulin injection education via mobile messenger applications in adults with type 2 diabetes. An open-label, randomized, three-armed study was conducted. Group 1 (n = 27) received an individual insulin injection education session from a diabetic educator. Group 2 (n = 26) received an initial insulin injection education session in the same manner as group 1, then messages regarding insulin injection knowledge were sent via messenger application twice a week for 3 months consecutively. Group control (n = 27) received only routine care. The primary endpoint was the difference in hemoglobin A1c from baseline to month 6 after the intervention. Outcomes included changes in fasting plasma glucose, and knowledge scores on insulin injection were also evaluated.

Results indicated that participants in both group 2 and group 1 showed a significant reduction in hemoglobin A1c at 6 months compared to controls. However, hemoglobin A1c reduction between groups 2 and group 1 showed no statistical significance. In terms of scores on knowledge of insulin injection, results indicated that the increase in scores on knowledge at 6 months in group 2 was greater than both the control and group 1. This finding demonstrated that insulin injection education is important to improve glycemic control in insulin-treated type 2 diabetes, regardless of delivery methods. Despite no significant difference compared to the education session in terms of glycemic control, a mobile messenger education should be considered as one of the effective interventions in improving knowledge scores on insulin injection. Also, nurses can facilitate ongoing coaching by using smartphones and mobile communication applications, which are easy to use and follow-up in diabetes education.

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Introduction

Insulin therapy effectively lowers blood glucose in people with type 2 diabetes (T2D) who have declined beta-cell function and failed other therapeutic options.[1-3]

Previous studies have shown that insulin therapy prevents complications and mortality as long as therapeutic targets are achieved and maintained.[4,5] Several innovative technologies such as insulin pumps and artificial pancreas for type 1 diabetes (T1D) have emerged to address the barriers to insulin injections.[6–8] In T2D, however, self-injection insulin remains the primary method of insulin administration. In the past 10 years, advances in insulin pen technology have resulted in devices that are more accurate, less painful, and easier to use.[9,10] Nevertheless, poor insulin injection technique remains an important issue that must be addressed. A large multinational survey found that the insulin injection technique was inappropriate in most people.[11,12] A recent study reported high prevalence of local skin complications at injection sites, including 11.8% lipohypertrophy, 7.5% wounds, 21.7% allergies, 55.5% bleeding, 41.3% bruising, and 47.2% pain.[13] Furthermore, an observational study in an Indian tertiary care center found that 51% of participants did not properly mix the cloudy insulin before use, 45% were injecting insulin at an incorrect angle, and 25% were improperly storing insulin vials.[14] These insulin injection technique errors were associated with unfavorable outcomes such as poor glycemic control, increased insulin consumption, and unexpected hypoglycemia.[15]

Diabetes self-management education (DSME) focusing on insulin injection should be implemented in all people with diabetes and caregivers to optimize insulin injection techniques. However, healthcare providers can only educate and encourage formal insulin injection education a few times per year. This contradicts individuals' learning patterns, particularly in the elderly. Moreover, many people do not receive any structured insulin injection education sessions. Some people are taught verbally how to use the pen device without any hands-on demonstration. The consequence of this inappropriate education method is an improper insulin injection technique in most people. The use of mobile communication technology could be one solution for providing ongoing education and support. This method can be a valuable resource for people with diabetes who want to improve their self-management knowledge and skills. The American Diabetes Association (ADA) Professional Practice Committee recommends using digital coaching and digital self-management interventions such as mobile apps and simulation tools as effective methods to deliver diabetes self-management education and support.[16] Diabetes self-management and insulin injection techniques can be improved once mobile health technology has been integrated into diabetes education.[17] Mobile technology is a convenient and flexible health care delivery system in terms of time, location and continuity of access to educational material. Studies involving mobile phone text messages,[18] and mobile applications, such as WhatsApp,[19] yielded promising results in terms of improved diabetic self-management and metabolic control. However, most studies were observational and only a few focused on an insulin injection technique education. As a result, the purpose of this study was to compare the effect of insulin injection technique education between that via a mobile messenger application and a traditional diabetes education at an outpatient clinic treating participants with T2D.

Methods

Study design: An open-label, randomized, three-armed study which is reported here using the CONSORT 2010 checklist of information to include when reporting a randomized trial.

Sampling and Participants: The study was conducted on adults who attended the outpatient diabetic clinic at a university hospital in Thailand from December 2019 to October 2020. The principal investigator approached outpatients at the diabetes clinic while they were waiting to be seen for a regular follow-up visit. The potential participants were invited to participate in the study if all the eligibility criteria were met. These criteria were: 1) aged 18-80 years with a T2D diagnosis for more than 12 months; 2) self-administration of insulin injections by insulin pen for at least three months consecutively without dosage adjustment; 3) smartphone ownership and ability to use a mobile messenger application; 4) ability to speak and read Thai; and 5) full independence with activities of daily living (ADL). Participants who were pregnant or breastfeeding and those with a known history of major psychiatric or neurological disorders were excluded from the study. The sample size was calculated with an alpha of 0.050 and a power of 0.80. The least clinical meaningful difference of HbA1c for hypothesis testing is 1%. The standard deviation of mean HbA1c difference from literature review is 1.2%.[18] Additionally, 20% was added to the estimated sample size for account for a dropout rate. The final estimated sample size was 90 (30 per group) in this study. Participants were randomly assigned to one of the three groups using simple randomization by lotteries without replacement. The CONSORT flow diagram of participants throughout the study is shown in **Figure 1**.

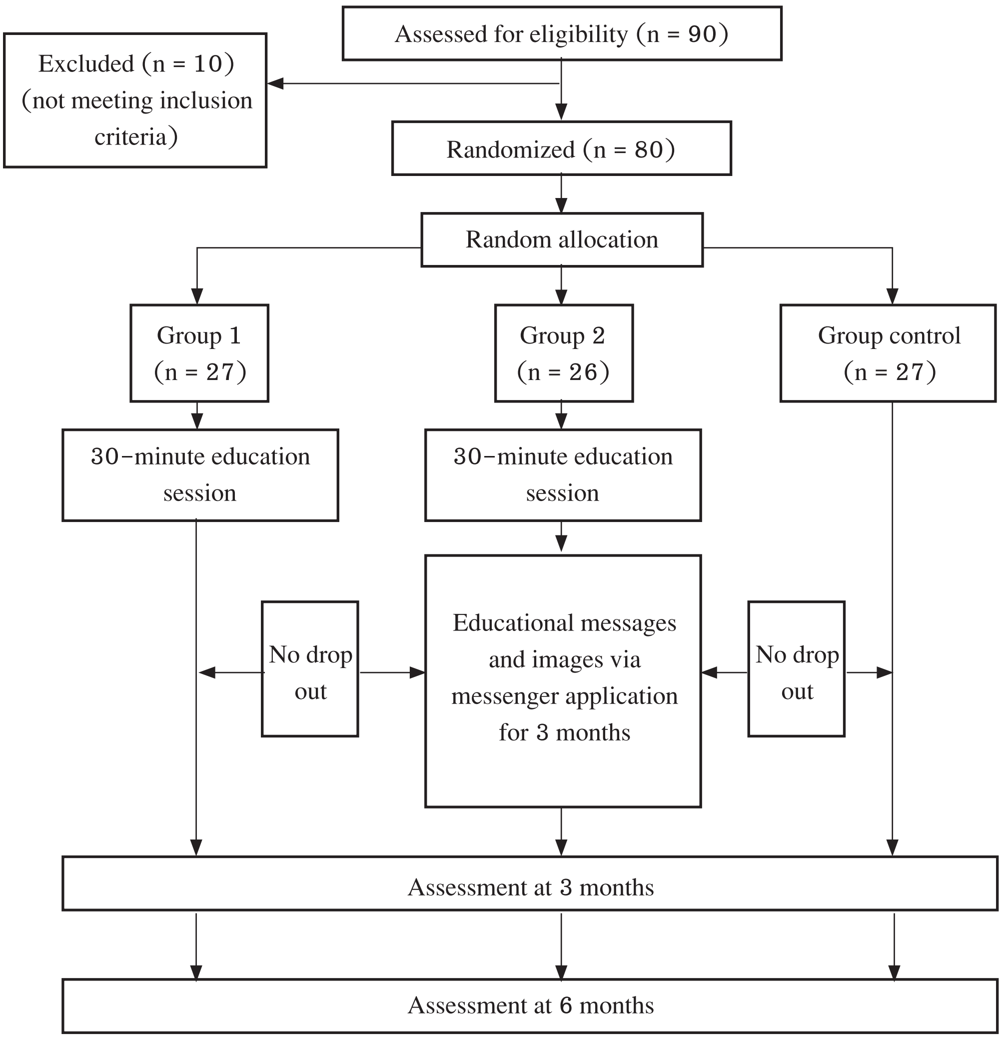


Figure 1 The CONSORT flow diagram of participants disposition throughout the study

Ethical considerations: The study was approved by the Khon Kaen University Ethics Committee (Reference No. HE621417). Once the participants agreed to participate in the study, they were asked to sign a consent form. The participants were informed about study objectives, procedures, and rights, including the right to withdraw from the study at any time without any effect on their quality service. They were given the opportunity to ask questions before signing the consent form. The protection of confidentiality and anonymity of participants and data was assured throughout the study. There was perceived to be no harm or risk involved with participation in this study.

Procedure: An open-label six-month follow-up study was designed to evaluate the effectiveness of different insulin injection education. Data were collected by the researchers between December 2019 to October 2020. Following the completion of the initial evaluation, participants were randomly assigned to one of the three groups using simple randomization by lotteries without replacement, as follows:

Group 1: the participants received a 30-minute face-to-face insulin injection education session from a diabetic nurse educator at the diabetes clinic. Group 2: a 30-minute education session in the same manner as Group 1 was given, then the educational messages and images regarding insulin injection were sent via a mobile messenger application to the participants with simultaneous notification for three months consecutively, reminding them of appropriate insulin injection knowledge and technique. The messages were delivered twice a week to each participant. Each message was delivered five times for three months before being suspended. Group 3, control: no active intervention was provided. Nevertheless, all participants received routine care. Routine clinical follow-up was continued throughout the six-month study period, and the diabetes regimen was adjusted appropriately according to the clinical contexts.

The primary endpoint of the study was the difference in hemoglobin A1c (HbA1c) percentage from baseline to month 6. Changes in fasting plasma glucose (FPG) and knowledge scores on insulin injection were the secondary endpoints from baseline to month 6. The effect of each intervention on endpoints at 3 and 6 months compared to baseline was also evaluated.

Instruments:

1 *Demographic and clinical data* were collected from using a demographic and diabetes-related information form. This form developed by the researchers and consists of 10 questions related to age, gender, marital status, occupation, educational level, body weight, height, duration of diabetes, duration of insulin use, and how many times a day he/she needs an insulin injection.

2 The *Insulin Injection Knowledge Questionnaire* was developed by the researchers to assess the participants' knowledge scores about insulin injection. The questionnaire consists of 11 questions based on the recommendations by The Diabetes Association of Thailand on how to do the proper insulin injection.[20] The first 6 questions assess knowledge of insulin storage, injection sites, time of insulin injection, and the proper use of insulin pen devices. The other 5 questions assess the skill and technique of proper insulin injection, including injection sites rotation, lipohypertrophy avoidance, angle of injection entry, and time the needle remained under the skin. The response and scoring on each item is 1 if the answer is correct, and 0 if the answer is incorrect or not known/uncertain, with a maximum possible score of 11 from 11 questions. There is no cut-off value; the higher the score, the better the insulin injection knowledge. The content validity index (CVI) was evaluated by five external assessors[21,22] using ratings of item relevance by content experts. We analyzed how nurse researchers have defined and calculated the CVI, and found considerable consistency for item-level CVIs (I-CVIs) to validate the quality and completeness of the tool's information. These assessors included one diabetologist, two physicians, and two registered diabetes nurse educators. The CVI was 0.9, calculated by dividing the number of assessors who rated each item

as "very relevant" by the total number of assessors, indicating an acceptable level of content validity.[23]

Glycemic assessment: HbA1c and FPG were collected and measured three and six months after the randomization. Blood samples were collected in the morning after participants had fasted for 8-12 hours. HbA1c was measured using turbidimetric inhibition immunoassay (Cobas 513; Roche Diagnostics, Mannheim, Germany), which was certified by the National Glycohemoglobin Standardization Program (NGSP).[24] Fasting plasma glucose levels were measured using the hexokinase method with an automatic autoanalyzer (Cobas 702; Roche Diagnostics, Mannheim, Germany).

Insulin injection education: The intervention was composed of education content based on recommendations of The Diabetes Association of Thailand.[20] This content was reviewed by the same group of experts who develop the Insulin Injection Knowledge Questionnaire. There were two methods of education in the current study. The first was the insulin injection education session, a face-to-face individual education session that included essential information and demonstrations on insulin injection practice, insulin type and action, insulin storage, injection device and needles, systematic injection site rotation, time gap between insulin and food ingestion, method of mixing insulin before use, disinfection of injection site, needle entry angle, time the needle remained under the skin, lipohypertrophy identification, and needle disposal practice. The second method was education using a mobile messenger application, consisting of eight different educational messages and images in Thai regarding insulin injection knowledge and technique. The content of the messages includes insulin storage, injection pen device and needles, injection site rotation, method of mixing insulin before use, needle entry angle, time the needle remains under the skin, and lipohypertrophy identification.

Routine care: Advice on how to do the insulin injection and general diabetes self-care from the primary physician and pharmacist during each regular outpatient visit were provided, which was similar among the three groups.

Statistical analysis: All primary and secondary analyses were performed, and all participants with any amount of post-randomization data were included. For parametric and non-parametric continuous variables, mean with standard deviation (SD) and median with interquartile range (IQR) were presented, respectively. For categorical variables, proportions (percentage) were used. To compare variables between groups and calculate p-values, one-way ANOVA or Kruskal-Wallis were used as appropriate. The Friedman test for non-parametric repeated measures was used to compare endpoint medians at different time points (baseline, 3 months, and 6 months after intervention) within the same group. Bonferroni tests were used to perform post-hoc multiple pairwise comparisons between each time point. Using data from all participants randomly assigned to interventions treatment, we used a mixed model for repeated measurements to analyze the primary outcome of change in continuous endpoints at 3 and 6 months from each individual baseline. The endpoints were adjusted to account for imbalanced baseline demographics. P-values less than 0.05 were considered statistically significant. The R program was used to conduct statistical analyses.

Results

From 90 eligible potential participants, a total of 80 were enrolled in the randomized trial, while 10 participants were not included due to their being unable to use smartphones. Twenty-seven participants were assigned to Group 1 (30-minute educational session), 26 to Group 2 (30-minute educational session plus 3 months of mobile educational messages), and 27 to the Control Group (received only routine care). The median (IQR) age in all participants was 60 years (IQR 55, 65), with 52.5% being women. Diabetes duration and insulin use medians were 14 years (IQR 10, 20) and 5 years (IQR 2,10), respectively, and did not differ between groups. The median number of insulin injections was twice per day. Except for the occupational and educational status, all groups were balanced on baseline characteristics (**Table 1**). HbA1c levels were higher in Group 1 (9.3%) than in Group 2 (8.7%) and in the Control Group (8.0%) at baseline. FPG, on the other hand, did not differ between the three groups.

Table 1 Baseline characteristics of the study participants

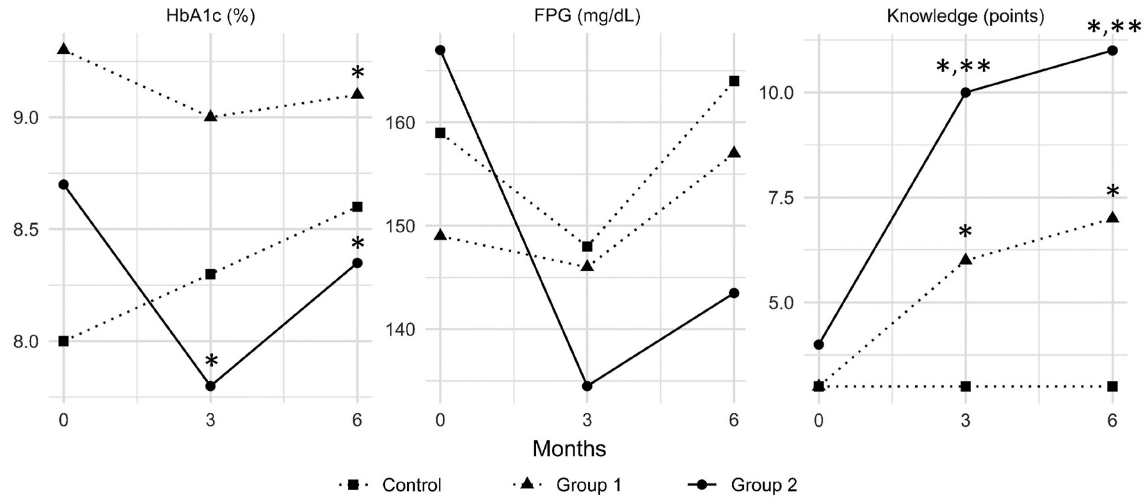
Variables		**Control (n = 27)**	**Group 1 (n = 27)**	**Group 2 (n = 26)**	**p-value**
Baseline data					
Age, median (IQR), years		61 (57,66)	56 (52,66)	60 (57,64)	0.57
Sex	Female, n (%)	18 (66.7)	11 (40.7)	13 (50.0)	0.15
	Male, n (%)	9 (33.3)	16 (59.3)	13 (50.0)	
Marriage	Single, n (%)	2 (7.4)	1 (3.7)	3 (11.5)	0.75
	Couple, n (%)	25(92.6)	26 (96.3)	23 (88.5)	
Occupation	Farmer, n (%)	9 (33.3)	8 (29.6)	2 (7.7)	0.04
	Government officer, n (%)	7 (25.9)	10 (37.1)	17 (65.4)	
	Others, n (%)	11 (40.8)	9 (33.3)	7 (26.9)	
Education	Below college, n (%)	15 (55.6)	12 (44.4)	4 (15.4)	0.01
	College, n (%)	12 (44.4)	15 (55.6)	22 (84.6)	
Weight, mean ± SD, kg		68.7 ± 13.6	68.0 ± 14.2	74.4 ± 14.3	0.20
Height, mean ± SD, cm		158.6 ± 9.3	162.0 ± 9.5	161.1 ± 6.0	0.33
BMI, mean ± SD, kg/m^2		27.2 ± 4.7	26.1 ± 5.6	28.7 ± 5.5	0.20
Duration of diabetes, median (IQR), years		15 (10, 20)	12 (9, 20)	18 (10, 20)	0.66
Duration of insulin use, median (IQR), years		5 (4, 10)	6 (2, 10)	4 (2, 10)	0.43
Number of injections per day, median (IQR), times		2 (2, 2)	2 (2, 2)	2 (2, 2)	0.90
Assessment before intervention					
HbA1c, median (IQR), %		8.0 (7.3, 8.4)	9.3 (7.9, 10.3)	8.7 (7.8, 9.8)	0.04
FPG, median (IQR), mg/dL		159 (123, 179)	149 (112, 186)	167 (142, 211)	0.60
Knowledge scores on insulin injection (points; 0-11), median (IQR), points		3 (2, 4)	3 (2, 5)	4 (3, 5)	0.01

Data were presented as a proportion (%) for categorical variables, mean ± SD, or median (IQR) for a continuous variable as appropriate. One-way ANOVA or Kruskal-Wallis was used to calculate the p-value, as appropriate.

Participants in both Group 2 (baseline 30-minute education, followed by educational mobile messenger messages for 3 months) and Group 1 (baseline 30-minute education alone) showed a significant reduction in HbA1c at 6 months when compared to controls, with adjusted estimated differences of -1.33% (95%CI -2.09 to -0.57), and -1.10% (95%CI -1.87 to -033), both p-values < 0.05. However, the adjusted estimated difference between Groups 2 and 1 was 0.23% (95%CI -0.54 to 0.10), with p-value of 0.56 indicating that the difference was not statistically significant. Meanwhile, at the 3-month follow-up, only participants in Group 2 had a significantly lower HbA1c than the Control Group, but no difference was observed when comparing Group 1 to the Control Group and Group 2 to Group 1. (**Figure 2 and Table 2**)

Although FPG in Group 2 decreased the most from baseline to 3- and 6-month follow-up, the adjusted estimated difference in FPG between Group 1 and Control, Group 2 and Control, and Groups 2 and 1 was not statistically significant. The median increase in knowledge scores on insulin injection from baseline to 3 and 6 months in Group 1 was greater than the Control (the adjusted estimated differences of 2.9 (95%CI 2.1

to 3.6), and 3.7 (95%CI 2.8 to 4.6), respectively). Meanwhile, the median increase in knowledge scores on insulin injection in Group 2 was greater than both the Control and Group 1 (At 3 months; the adjusted estimated differences of 4.7 (95%CI 3.9 to 5.4), and 1.8 (95%CI 1.1 to 2.6), respectively, at 6 months; the adjusted estimated differences of 5.6 (95%CI 4.7 to 6.5), and 1.8 (95%CI 0.9 to 2.7), respectively). (**Figure 2 and Table 2**)



* p-value < 0.05 for estimated difference overtime when compared to Control Group.
** p-value < 0.05 for estimated difference overtime when compared to Group 1.

Figure 2 Medians of HbA1c, FPG and knowledge scores on insulin injection among three groups at 3 and 6 months

Table 2 Median change over time of outcomes and adjusted estimated difference of outcomes between the intervention groups

	Median change from baseline			Group 1 vs Control (Ref.)		Group 2 vs Control (Ref.)		Group 2 vs Group 1 (Ref.)	
	Control (n = 27)	Group 1 (n = 27)	Group 2 (n = 26)	Estimated difference† (95%CI)	p-value	Estimated difference† (95%CI)	p-value	Estimated difference† (95%CI)	p-value
HbA1c (%)									
Month 0-3	0.2 (-0.2, 0.5)	-0.4 (-1.0, 0.3)	-0.6 (-1.3, 0.0)	-0.63 (-1.28 to 0.00)	0.05	-0.92 (-1.56 to -0.28)	< 0.05	-0.29 (-0.92 to 0.35)	0.37
Month 0-6	0.5 (0.1, 1.1)	-0.2 (-1.8, 0.5)	-0.3 (-1.3, 0.4)	-1.33 (-2.09 to -0.57)	< 0.05	-1.10 (-1.87 to -0.33)	< 0.05	0.23 (-0.54 to 0.10)	0.56
FPG (mg/dL)									
Month 0-3	-2 (-27, 15)	1 (-59, 27)	-36 (-66, 3)	-11.0 (-49.4 to 27.3)	0.57	-26.3 (-65.0 to 12.4)	0.18	-15.3 (-54.0 to 23.4)	0.44
Month 0-6	2 (-20, 23)	9 (-37, 41)	-13 (-54, 9)	-6.2 (-53.2 to 40.9)	0.80	-10.1 (-57.6 to 37.4)	0.67	-3.9 (-51.4 to 43.5)	0.87
Knowledge scores on insulin injection (points; 0-11)									
Month 0-3	0 (0, 1)	3 (3, 4)	6 (4, 7)	2.9 (2.1 to 3.6)	< 0.05	4.7 (3.9 to 5.4)	< 0.05	1.8 (1.1 to 2.6)	< 0.05
Month 0-6	1 (0, 1)	4 (3, 6)	7 (5, 7)	3.7 (2.8 to 4.6)	< 0.05	5.6 (4.7 to 6.5)	< 0.05	1.8 (0.9 to 2.7)	< 0.05

† Estimated difference was adjusted by the baseline occupation and educational status.

Each endpoint was also evaluated independently in each intervention group in this study. The knowledge scores on insulin injection in Group 1 increased significantly at 3 and 6 months compared to baseline. However, no significant difference in HbA1c or FPG was found between baseline, 3 months, and 6 months. The knowledge scores on insulin injection in Group 2 significantly increased at 3 and 6 months compared to baseline. Group 2, on the other hand, showed a significant reduction in both HbA1c and FPG from baseline to 3 months, but no significant change was observed from baseline to 6 months. The knowledge scores on insulin injection in the Control Group did not change significantly between baseline, 3 months, and 6 months. In terms of glycemic control, HbA1c significantly worsened from baseline to 6 months in the Control Group, whereas FPG showed no significant difference between baseline, 3 months, and 6 months. **(Table 3)**

Table 3 Endpoints at a different time point (in each intervention group)

	Medians (IQR)		
	Baseline	**3 Month**	**6 Month**
HbA1C (%)			
Control (n = 27)	8.0 (7.3, 8.9)	8.3 (7.6, 9.2)	8.6 (7.9, 10.0)*
Group 1 (n = 27)	9.3 (7.9, 10.3)	9.0 (7.7, 10.2)	9.1 (7.5, 10.0)
Group 2 (n = 26)	8.7 (7.8, 9.8)	7.8 (6.8, 9.2)*	8.4 (7.3, 9.4)
FPG (mg/dL)			
Control (n = 27)	159 (123, 179)	148 (120, 199)	164 (114, 195)
Group 1 (n = 27)	149 (112, 186)	146 (115, 170)	157 (123, 174)
Group 2 (n = 26)	167 (142, 211)	135 (101, 161)*	144 (108, 178)
Knowledge scores on insulin injection (points; 0-11)			
Control (n = 27)	3 (2, 4)	3 (2, 5)	3 (2, 5)
Group 1 (n = 27)	3 (2, 5)	6 (5, 8)*	7 (6, 9)*
Group 2 (n = 26)	4 (3, 5)	10 (9, 10)*	11 (10, 11)*

* p-value < 0.05 when compared to baseline

Data were presented as a median (IQR). Friedman test was used to evaluate the difference between repeated measures. Multiple pairwise-comparison between repeated measures was performed by Bonferroni tests.

Discussion

This study's main finding was that there was no significant difference in HbA1c and FPG reduction between those who received mobile messages and those who received initial insulin injection educational session. However, both mobile messages education and insulin injection educational session alone yielded positive benefits in terms of glycemic control when compared to the Control Group. This finding highlights that formal insulin injection education is important to improve glycemic control, regardless of the methods of delivery. Although a previous meta-analysis showed that mobile text messaging for educating those with T2D appears to be effective on glycemic control, most studies compared the mobile messaging method to the control group who did not receive active education.[25] A recent narrative review supported the use of technology-enabled diabetes self-management education as a tool for improving HbA1c. However, the technology should include four elements as a key to successful diabetes education: (1) communication, (2) patient-generated health data, (3) education, and (4) feedback.[26] These four elements require a platform that allows active two-way communications. The mobile messenger in our study lacked the integration of patient-generated data and feedback from the participants, which may account for the negative finding in this study. Moreover, the sample size in the current study may be too small to demonstrate the statistical difference of glycemic control between Groups 1 and 2.

We found that insulin injection education via mobile messenger application significantly improved HbA1c in T2D compared to those who received only routine care without active intervention. Although the educational messages were only delivered for the first three months, this benefit persisted after six months. Furthermore, participants who received mobile messages had significantly greater insulin injection knowledge than those who received only initial educational sessions or did not receive any intervention. A similar study, conducted by Boels et al., evaluating 6-months outcomes after diabetes self-management education and support via a smartphone application, found conflicting results. The HbA1c reduction associated with mobile education was small (0.08% when compared to control) and clinically insignificant.[27] The effect on HbA1c reduction in Boels' report is clearly lower than in our study (1.10% compared to control), which may be due to their study's lower baseline HbA1c (8.0% vs. 9.3% in our study). Another plausible explanation is that the intervention arm of Boels' study included too many educational topics, such as diet, physical activity, hypoglycemia management, and medication. According to the authors, more than half of the participants did not find the messages relevant and frequently ignored them. In contrast, our study limited the content to the insulin injection technique. We argue that to create successful educational messages using technology, the message content should be focused, single goal-directed, and personalized to the individual's interests and needs.

According to our findings, participants who received only an initial educational session did not significantly improve their glycemic parameters from baseline. Those who received both an educational session and mobile messenger messages, on the other hand, improved in HbA1c and FPG from baseline to 3 months. This effect, however, diminished six months after the educational messages were discontinued (**Table 3**). These findings emphasize the significance of a continuous, ongoing process in facilitating the knowledge and ability required for diabetes self-care in order to maintain long-term proficiency and glycemic benefits.[28,29] Despite the attenuation of the intervention effect, the estimated difference in HbA1c reduction between mobile messenger and no intervention remained significant in our study because those who did not receive any active intervention had worse glycemic control after 6 months of follow-up. Similarly, we discovered that, when compared to the other groups, the mobile application message group had the greatest FPG reduction. However, the estimated difference between groups did not have a large enough effect size to provide statistical significance.

Health information technology has emerged as a viable and effective method of education in medical care, including diabetes. The main advantage of such technology as a method of healthcare delivery is its convenience and flexibility in terms of time and location of access to educational material. However, the use of health information technology among those with diabetes was reported to be low, especially in older people, members of racial minority groups, less formal education, or lower household income.[30] Moreover, previous reports on the implementation and efficacy of technological interventions in diabetes yielded mixed results,[31-35] suggesting that the evidence-based recommendations in the use of such technology were not strong. These contradictory findings could be attributed to the heterogeneity of interventions, such as technology categories (computer-based or mobile-based), educational content types (text, image, or motion video-based), and the compatibility of such technology with the study population. In Thailand, the mobile messenger application is the most popular social platform among people of all age groups, including older people. We had no trouble incorporating educational materials into these applications and received positive feedback from our study populations. As a result, the implementation of health information technology must take into account the variety of preferences, acquaintances, and cultural contexts of each individual.

Although add-on mobile educational messages appear to provide the most benefit in terms of insulin injection knowledge improvement when compared to other interventions in our study, an increase in knowledge scores on insulin injection from baseline after 3 and 6 months was also observed in Group 1, who received insulin injection education session. Routine diabetes advice in a regular outpatient visit in the control group, on the other hand, did not improve the knowledge scores on insulin injection from baseline after 3 and 6 months. This finding confirms that a formal, well-structured DSME is an essential component of successful diabetes self-management, and that it should be implemented as a fundamental routine practice to improve outcomes in people with T2D.[36]

Our study is the first in Thailand to assess the efficacy of insulin injection education via mobile messenger applications. The strength of this trial is the three-armed randomized study design, which allows it to compare the efficacy of add-on mobile message intervention to insulin injection education session and no intervention. Another point of strength is the statistical analysis, which corrected for the imbalance in baseline demographics in each study group. Furthermore, we only included people with T2D, whereas other trials included people with both T1D and T2D. However, some limitations should be mentioned. Because the sample size was small, the difference between groups may not be enough to warrant statistical significance. Furthermore, the six-month follow-up period may not be long enough to reflect the long-term impact of mobile messenger education on glycemic control and knowledge scores on insulin injection.

In conclusion, this study demonstrates that implementing insulin injection education, whether through a diabetes education session or added-on mobile messenger education, is an effective intervention in improving HbA1c control and insulin injection knowledge in T2D. Despite no significant difference compared to education session in terms of glycemic control, mobile messenger education should be considered as one of the effective interventions in improving insulin injection knowledge. Future research on continuing mobile messenger education that focuses on more specific diabetic populations and more personalized intervention, taking individual needs and feedback into account, could provide an even more effective strategy for improving diabetes care.

Implications for Nursing Practice

One of the major roles and responsibilities of the nursing team relating to diabetes care is health coaching to promote appropriate self-management, including the ability to inject insulin correctly in insulin-treated T2D. Structured insulin injection education sessions at clinics or mobile-assisted education both demonstrate benefits in improving insulin injection knowledge and glycemic control. However, ensuring continued follow-up after initial coaching is particularly important in maintaining the knowledge and skill. Nurses can facilitate ongoing coaching by using smartphones and mobile communication applications, which have recently been increasingly used. The authors suggest that mobile technologies, which are easy to use and follow-up, should be implemented in diabetes education. The most effective technology used as a mode of knowledge delivery should allow two-way communications, patient-generated health data analysis, tailored education, and individualized feedback loop.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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การทดลองแบบสุ่มชนิดมีกลุ่มควบคุมเพื่อศึกษาผลของการสอนการฉีดอินซูลินโดยการส่งข้อความทางแอพพลิเคชันต่อการควบคุมระดับน้ำตาล

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บทคัดย่อ: การส่งข้อความทางแอพพลิเคชันอาจจะเป็นวิธีการที่มีประโยชน์ในการให้ความรู้และการสนับสนุนการดูแลตนเองอย่างถูกต้องในผู้ป่วยโรคเบาหวาน การศึกษานี้จึงมีวัตถุประสงค์เพื่อศึกษาประสิทธิผลของการสอนการฉีดอินซูลินโดยการส่งข้อความทางแอพพลิเคชันในผู้ป่วยผู้ใหญ่ที่เป็นโรคเบาหวานชนิดที่สองที่ได้รับการฉีดอินซูลิน โดยเป็นการศึกษาทดลองแบบเปิดโดยการสุ่มชนิดมีกลุ่มควบคุมทั้งหมด 3 กลุ่ม โดยกลุ่มที่ 1 (จำนวน 27 ราย) ได้รับการสอนการฉีดอินซูลินจากผู้ให้ความรู้โรคเบาหวานด้วยตนเอง กลุ่มที่ 2 (จำนวน 26 ราย) ได้รับการสอนการฉีดอินซูลินเช่นเดียวกับกลุ่มที่ 1 และได้รับเนื้อหาเกี่ยวกับการฉีดอินซูลินโดยการส่งข้อความทางแอพพลิเคชัน จำนวน 2 ครั้งต่อสัปดาห์ต่อเนื่องกันเป็นเวลา 3 เดือน และกลุ่มควบคุม (จำนวน 27 ราย) ได้รับการดูแลแบบทั่วไป ผลลัพธ์หลักของการศึกษาคือการเปลี่ยนแปลงของระดับน้ำตาลสะสมเทียบกับตอนเริ่มการศึกษาจนถึง 6 เดือน ผลลัพธ์อื่นๆ คือการเปลี่ยนแปลงของระดับน้ำตาลขณะอดอาหารและการเปลี่ยนแปลงของคะแนนความรู้เกี่ยวกับการฉีดอินซูลินเทียบกับตอนเริ่มการศึกษา

ผลการศึกษาพบว่าผู้เข้าร่วมการศึกษาในกลุ่มที่ 2 และกลุ่มที่ 1 มีการลดลงของระดับน้ำตาลสะสมที่ 6 เดือนมากกว่ากลุ่มควบคุมอย่างมีนัยสำคัญ อย่างไรก็ตาม ระดับน้ำตาลสะสมที่ลดลงระหว่างกลุ่มที่ 2 และกลุ่มที่ 1 ไม่มีความแตกต่างกันอย่างมีนัยสำคัญ ในแง่ของคะแนนความรู้เกี่ยวกับการฉีดอินซูลิน ผลการศึกษาพบว่าผู้เข้าร่วมการศึกษาในกลุ่มที่ 2 มีการเพิ่มขึ้นของคะแนนความรู้มากกว่ากลุ่มที่ 1 และกลุ่มควบคุมอย่างมีนัยสำคัญ จากผลการศึกษาพบว่าการสอนการฉีดอินซูลินสามารถช่วยให้การควบคุมระดับน้ำตาลดีขึ้นได้ไม่ว่าจะใช้วิธีการสอนแบบใดก็ตาม ถึงแม้การสอนโดยการส่งข้อความทางแอพพลิเคชันจะไม่มีความแตกต่างกับการสอนจากผู้ให้ความรู้โรคเบาหวานในแง่ของการควบคุมระดับน้ำตาล แต่ก็เป็นวิธีหนึ่งที่มีประสิทธิผลในการเพิ่มขึ้นของคะแนนความรู้เกี่ยวกับการฉีดอินซูลิน และสามารถใช้เพื่อเอื้ออำนวยการติดตาม ชี้แนะและกำกับเพราะเป็นเทคโนโลยีที่ใช้ได้ง่าย

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