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# The effect of Type 2 diabetes management using a smartphone-based blood glucose management training program

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# 모바일 자가혈당관리 교육프로그램을 이용한 2형 당뇨병 관리 효과 분석

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**Abstract Background**: Diabetes education is an important factor in blood glucose control. Reinforced education is necessary for effective diabetes education. However, it is difficult to provide reinforced diabetes education within Korea's medical environment. Therefore, we want to analyze the effect of continuous diabetes education using mobile health care that can effectively provide repeated education without having to face the patient. **Methods**: This study is a multicenter, randomized, controlled, pre-post design study conducted to analyze the effect of a continuous diabetes education method. A total of 109 people were registered at five hospitals in south Korea, and they were randomly assigned to the app group (34 people) who received real-time coaching and repetitive training, the logbook group (37 people) who received face-to-face training after writing a blood glucose logbook, and the general group (38 people) who received a one-time diabetes education. The study was conducted for a total of 24 weeks. Twenty-one patients withdrew their consent and failed to perform an HbA1c. A final 88 patients were analyzed. The difference in HbA1c, Self-management behavior, and Quality of life before and after education was analyzed. **Results**: The study involved 51 (58%) male subjects, mean age was 55.8 years and mean duration of diabetes was 7.6 years. After 24 weeks of intervention, there was no significant difference in self-care behavior and quality of life between the three groups, but the HbA1c of the app group significantly decreased after education compared to the logbook group and the general group (F=4.62, p=.013). **Conclusion**: It can be seen through the app group that receiving real-time education is more effective in improving blood glucose management and continuous diabetes education is important.

**Key Words :** Diabetes education, HbA1c, Self-care behavior, Quality of life

**요 약 배경**: 당뇨병 교육은 혈당조절의 중요한 요소이다. 효과적인 당뇨병 교육을 위해서는 반복적인 추가 교육이 필요하다. 하지만 한국의 의료환경에서는 반복적인 당뇨병 교육을 수행하기가 어려운 실정이다. 이에 환자를 대면하지 않아도 반복 교육을 효과적으로 할 수 있는 모바일 헬스케어를 이용하여 지속적인 당뇨병 교육의 효과를 분석하고자 한다. **방법**: 본 연구는 지속적인 당뇨병 교육 방법의 효과를 분석하기 위해 진행된 다기관 무작위 대조군 사전 사후 설계연구이다. 한국소재 5개 병원에서 총 109명이 등록되었고 무작위 배정으로 실시간 코칭 및 반복교육을 진행한 모바일 app 군(34명), 혈당수첩 작성 후 면대면 방문교육을 진행한 logbook 군(37명), 1회 당뇨병 교육만 진행된 general 군(38명)으로 총 6개월간 진행되었다. 21명은 동의 철회 및 당화혈색소 미실시로 연구 중단하여 최종 88명을 분석하였다. 교육의 효과는 교육 전과 후의 당화혈색소, 자기관리행위, 삶의 질에 대한 변화량의 차이를 분석하였다. **결과**: 본 연구 대상자는 남자 51명(58%), 평균연령은 55.8세, 평균 이환 기간은 7.6년이었다. 중재 24주 후 자기관리행위, 삶의 질은 세 그룹 간에 유의한 차이가 없었지만 당화혈색소는 app 군이 logbook 군과 general 군에 비해 교육전에 비해 교육 후 유의하게 감소하였다(F=4.62, $p$=.013). **결론**: 실시간 교육을 진행한 app 군이 혈당 개선에 보다 효과적이며 지속적인 당뇨병 교육이 중요함을 알 수 있었다.

**키워드 :** 당뇨병, 당화혈색소, 자기관리, 삶의 질

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## 1. INTRODUCTION

Diabetes is a chronic disease that requires lifelong treatment and self-care behavior. The main goal of diabetes management is to improve diabetes-induced symptoms, maintain normal blood glucose levels, and prevent acute and chronic complications, so as to improve the quality of life [1]. The DCCT and UKPDS studies show that the occurrence and progression of complications of diabetes can be prevented by maintaining normal blood glucose levels [2-4]. In order to maintain normal blood glucose, the self-management behavior of diabetic patients is most important [5]. In diabetic patients, self-management refers to blood glucose monitoring, diet, physical activity, and medication necessary for diabetes management, and if self-management is neglected, blood glucose worsens and diabetes complications occur, resulting in poor quality of life [6].

To perform effective self-care, patients must have sufficient knowledge of diabetes, and thus patient education is the basis of diabetes management [7]. However, self-management sometimes affects the quality of life of diabetics. While physical activity improves the quality of life, self-monitoring of glucose has been reported to lower the quality of life [6, 8]. It is important to improve the quality of life through encouragement and placing emphasis on the importance of self-management for diabetic patients in diabetes education [9]. In addition, diabetes education should not only provide knowledge about diabetes, but also requires continuous patient education and evaluations for an effect of improving blood glucose through self-management [5, 10]. According to a recent study, patients with diabetes who received active doctor and nutritionist education four times at two-week intervals had improved blood glucose control levels, such as blood glucose and HbA1c, as well as improved knowledge, attitude scores, and dietary self-care compared to those who had been trained once during routine outpatient visits [10]. Through this study, it was found that continuous diabetes education is necessary to improve blood glucose control and self-management of diabetic patients. According to the current diabetes education carried out in Korea, among hospitals authorized by the Korean Diabetes Association, 98% conduct group education and 90.2% conduct individual education, and among unauthorized hospitals, 100% conduct group education and 78.9% conduct individual education. However, post-education evaluation was performed by 37.7% of the authorized hospitals and 36.8% of the unauthorized hospitals, which indicates that post-education evaluation and continuous diabetes education are generally not being performed. are required to measure blood glucose and interpret results[15, 19]. However, while there are many active diabetes-related apps, most patients play only an auxiliary role in controlling blood glucose themselves, making it difficult to identify the clear effect of diabetes education.

Therefore, this study attempted to confirm the appropriate form of diabetes education by comparing and analyzing the usual one-time education, face-to-face intensive education, and continuous coaching education through the blood glucose management app by developing a diabetes education mobile blood glucose management app and diabetes logbook. Therefore, most of the current diabetes education is conducted in lecture-type education and interviews, and it is difficult to motivate patients to manage blood sugar, and continuous education is conducted insufficiently due to the lack of manpower and time of diabetes educators [12]. For continuous diabetes education, it is necessary to develop various diabetes education programs other than lectures and counseling. Diabetes education through

telephone counseling [13] or text message [14] are such forms of continuous education. Recently, diabetes-related apps are being used as self-management tools for diabetic patients. In some studies, it has been reported that the diabetes management app has a significant effect on the reduction of HbA1c in diabetic patients and the improvement of self-management behavior [20, 21]. In order for diabetes-related apps to become self-management tools for diabetic patients, feedback or interaction between patients and providers, and continuous intervention by medical staff to measure blood glucose and interpret results are required [15, 19]. However, while there are many active diabetes-related apps, most patients play only an auxiliary role in controlling blood glucose themselves, making it difficult to identify the clear effect of diabetes education.

Therefore, this study attempted to confirm the appropriate form of diabetes education by comparing and analyzing the groups that received a one-time general diabetes education, face-to-face intensive education alongside a diabetes logbook, and continuous coaching education through a blood glucose management mobile app developed for the study.

## 2. METHODS

### 2.1 Subjects

This study utilized a multi-center, randomized pretest-posttest control group design to see if there were differences in HbA1c levels, self-care behaviors, and quality of life among the mobile blood glucose management application group (hereinafter 'app group'), the logbook education group (hereinafter 'logbook group'),and the general education group (hereinafter 'general group').

Subjects in this study were those among type 2 diabetic patients who visited the department of endocrinology at five hospitals in Korea from April 20, 2016 through January 13, 2017 and understood the explanation of the investigators and agreed to participate in the study. Subjects were also those who had ≥7% of HbA1c at the time of the screening and used a mobile app via smartphone with data transmission available through Near Field Communication (NFC). Patients with accompanying severe diabetic complications or other diseases were excluded. The total number of subjects was 84, which was calculated using G* Power 3.1 software with a significance level of .05, statistical power of 80%, and effect size being 0.35. A total of 109 patients were included to account for the dropout rate of 30%. The subjects of the study were randomly assigned to diabetes education groups: the app group that conducts non-face-to-face coaching through a mobile blood glucose management application, the logbook group that receives intensive diabetes education face-to-face multiple times, and the general group that receives a one-time education (as shown Fig. 1).

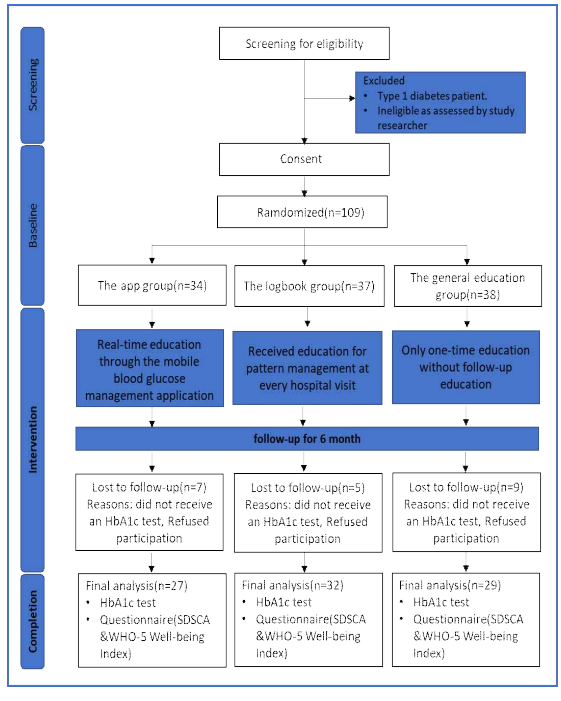


Fig. 1. Study flow diagram

### 2.2 Interventions

After randomly assigning the subjects to diabetes education groups: the group using a mobile blood glucose management application (app group), the intensive diabetes education group using glucose logbooks (logbook group), and the group given a one-time general education only (general group), all three groups received the same initial diabetes educational content. Diabetes education was conducted in the same environment at the participating hospitals by an educator with a certificate of diabetes education issued by the Korea Diabetes Association-authorized institution. After the initial diabetes education, the app group installed a mobile blood glucose management application developed for the study on their cell phones and trained them to send data to the hospital when self-monitoring of blood glucose levels, meals, exercise, and drugs are recorded on their mobile. Based on this data, diabetes educators conducted real-time (during educator working hours) blood glucose management coaching training through SMS (short message service). In addition, fixed phrases were periodically sent to patients through SMS to promote blood glucose management (as shown Fig. 2). After the initial education, the logbook group received blood glucose control education (e.g. pattern management) 3-4 times through face-to-face education when visiting a hospital for treatment and used the glucose logbook and smart self-monitoring booklet developed for this study. The general group received the glucose logbook after initial diabetes education, but only one initial education was provided without follow-up management education. The total education period was six months (as shown Fig. 1).

### 2.3 Measurements and definitions

#### 2.3.1 Smartphone-based blood glucose management app

Smart diabetes management APP, developed by the Diabetes Education Nurses Association, is an app that sends self-glucose measurement results to patients, guardians, medical staff's smartphones, and tablet PCs (NFC-enabled devices) to provide various analyses (e.g. logs, graphs, statistical analyses) and send results to medical staff and friends by e-mail. The app aids in self-management of blood glucose through the transmission of blood glucose levels to medical staff who can relay help through real-time messages. In addition, exercise and meal logs can be easily filled out and transmitted to educators, and this data can help with real-time blood sugar management(as shown Fig. 2).

**Fig. 2. Smartphone-based blood glucose management app**

| 날짜 (요일) | 구분 | 아침 식전 | 아침 약/인슐린 | 아침 식후 | 점심 식전 | 점심 약/인슐린 | 점심 식후 | 저녁 식전 | 저녁 약/인슐린 | 저녁 식후 | 취침전 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 혈당 | 120 | 자속형 : 10단위 | 220 | 100 | | 150 | 120 | | 260 | 145 |
| 4/20 (월) | 식사 운동 기타 | 운동 : 0 분 밥2/3공기, 장채, 김치찌개 | | | 운동 : 10 분 배를 짬봉 2/3그릇 | | | 운동 : 30 분(산책 밥1공기, 동태전, 두부부침, 굴 1개 | | 3,000보 | |
| | 혈당 | 110 | 자속형 : 10단위 | 150 | 60 | | 300 | 140 | | 250 | 120 |
| 4/21 (화) | 식사 운동 기타 | 운동 : 15 분(계단 오르기) 밥2/3공기, 우유 1컵, 나물 | | | 운동 : 15 분(산책) 밥1공기, 김치찌개, 라면사리 1/2개, 계란말이, 돼지고기 기둥 | | | 혈당검사 후 운동 : 40 분(산책) 밥1공기, 청국장 | | | |
| | 혈당 | 80 | 자속형 : 8단위 | 150 | 85 | | 260 | 130 | | 150 | |
| 4/22 (수) | 식사 운동 기타 | 운동 : 15 분(계단 오르기) 밥2/3공기, 연두부 1개, 나물 | | | 운동 : 0 분 밥2/3공기, 순대국, 김자볶음 | | | 운동 : 40 분(산책) 밥2/3공기, 부대찌개 | | | |

* 3가지 색상의 형광펜을 준비하여 혈당조절 목표범위에서 벗어난 혈당수치에 다음과 같이 색칠합니다.
- 저혈당 등(혈당치 70mg/dL 이하 : 파랑색( ))
- 공복 고혈당 등(혈당치 140mg/dL이상) : 핑크색( )
- 식후 고혈당 등(혈당치 200mg/dL 이상) : 주황색( )

* 저혈당과 고혈당의 원인(예: 식사, 운동, 기분, 약물 등)을 찾아서 개선합니다.

**Fig. 3. Glucose logbook**

#### 2.3.2 Glucose logbook

It was prepared as shown in Fig. 3 so that

the patient could easily fill out meals and exercise logs with a diabetes logbook. Intensive blood glucose management was performed through this diabetes logbook.

#### 2.3.3 Diabetes booklet

The booklet is designed to keep the blood glucose level within the target range by smartly using the results of self-glucose measurement so they can be used for follow-up management education after patients receive diabetes education.

#### 2.3.4 Self-care behavior scale

The self-management behavior of diabetic patients was measured using the Summary of Diabetes Self-Care Activities Questionnaire (SDSCA), a Korean version of the tool developed and revised by Toobert [22, 23]. The Korean version of the SDSCA consists of 9 items in total, 3 items on diet, 2 items on exercise, 2 items on blood glucose tests, and 2 items on foot care and by deleting 1 item on diet and 1 item on smoking from Toobert's SDSCA consisting of 11 items. When asked, "How many days have you been tested for blood glucose in the past 7 days?" the subject selects the day when the action was performed among the numbers from 0 to 7. The higher the score, the higher the degree of self-management performance, and the lowest possible score is from 0 to 63 points. The reliability of the Korean version of this tool was Cronbach's $\alpha$ =.69 and in this study, Cronbach's $\alpha$ was .86.

#### 2.3.5 Quality of life

The WHO's (World Health Organization) Well-Being Index was used to assess the quality of life for diabetics. The WHO-5 Well-Being Index is the latest version created in 1998, and the Korean version of the WHO-5 Well-being Index was used, which was translated by Kim Hyun-ji and others [24]. Depending on the subject's rating of their feelings, the total possible score is 25 from a lowest possible score of zero, with a potential 5 points for each item and 5 points given for "Always Yes" and 0 points for "Not at all." A higher score indicates a better quality of life.

The reliability of the tool's Korean version was Cronbach's $\alpha$=.87 and the Cronbach's $\alpha$ in this study was .86.

#### 2.3.6 Glycated hemoglobin (HbA1C)

Glycated hemoglobin refers to a hemoglobin that combines glucose in the blood and is an indicator of blood glucose control over the past two to three months. The normal range is 4.5 to 5.7%.

### 2.4 Data collection

The subjects of this study were type 2 diabetes patients who visited the endocrine department of a general hospital in Seoul and Gyeonggi-do and received a prescription for diabetes education. Registration of subjects began on April 20, 2016, and by January 13, 2017, a total of 109 people were registered with 34 people in the app group, 37 in the logbook group, and 38 in the general group, and the follow-up investigation was completed on June 20, 2017. The study subjects measured HbA1c, self-management behavior, and quality of life before and 24 weeks after intervention. Finally, a total of 88 subjects were analyzed, excluding the 21 subjects (7 in the app group, 5 in the logbook group, and 9 in the general group) who were insufficient responders or did not receive an HbA1c test.

### 2.5 Statistical analysis

The collected data were analyzed using IBM SPSS Statistics software Version 26.0 (IBM, Armonk, New York, USA) as follows. Regarding homogeneity testing for general and

disease-related characteristics in the three groups, analysis was made using frequency and percentage, the $x2$-test, Fisher's exact test, and ANOVA, and the normality of the data was verified by the Kolmogorov-Smirnov test. Intragroup differences in HbA1c, self-care behaviors, and quality of life were analyzed using the paired t-test, and post-pre differences of changes in HbA1c, self-care behaviors, and quality of life were analyzed by ANCOVA, with duration of diabetes and insulin treatment or not as a covariate, and post analysis performed by the Scheffe test.

### 2.6 Ethics statement

This study was approved after review by the institutional review boards of SMC (IRB No. SMC 2015-12-162), KHNMC (IRB No. KHNMC 2015-12-026), AMC (IRB No. S2016-0047-0001), ISPAIK (IRB No. ISPAIK 2016-01-013), and KIRB(IRB No. KIRB-신20170908-138). The study recruitment and consent process was conducted by the investigators. Personal identification information was collected in a confidential manner by removing all the personal identification information to protect the identity of the subjects who refused to participate in the study. The purpose and process of the study were explained to each subject, informed consent forms for study participation were obtained, and subjects completed the questionnaires in 30 to 40 minutes.

## 3. RESULTS

### 3.1 Verification of general characteristics and homogeneity

General characteristics of a total of 88 subjects are shown in Table 1. 27 subjects were assigned to the app group, 32 to the logbook group, and 29 to the general group.

**Table 1. General characteristics (N=88)**

| Variables | Categories | Total (n=88) N(%) | App (n=27) N(%) | Logbook (n=32) N(%) | General (n=29) N(%) | F or $x^2$ | $p$ |
|---|---|---|---|---|---|---|---|
| Gender | Male | 51 (58.0) | 17 (63.0) | 21 (65.6) | 13 (44.8) | 3.10 | .212 |
| | Female | 37 (42.0) | 10 (37.0) | 11 (34.4) | 16 (55.2) | | |
| Age (yr) | - <40 | 9 (10.2) | 1 (3.7) | 3 (9.4) | 5 (17.2) | | .329† |
| | 40-<50 | 21 (23.9) | 8 (29.6) | 7 (21.9) | 6 (20.7) | | |
| | 50-<60 | 18 (20.5) | 9 (33.3) | 6 (18.8) | 3 (10.3) | | |
| | 60-<70 | 26 (29.5) | 7 (25.9) | 11 (34.4) | 8 (27.6) | | |
| | >70- | 14 (15.9) | 2 (7.4) | 5 (15.6) | 7 (24.1) | | |
| Education | ≤High school | 38 (43.2) | 11(40.7) | 11 (34.4) | 16 (55.2) | 2.77 | .250 |
| | >University | 50 (56.8) | 16 (59.3) | 21 (65.6) | 13 (44.8) | | |
| Occupation | Yes | 59 (67.0) | 20 (74.1) | 24 (75.0) | 15 (51.7) | 4.60 | .100 |
| | No | 29 (33.0) | 7 (25.9) | 8 (25.0) | 14 (48.3) | | |
| Marital Status | Yes | 78 (88.6) | 24 (88.9) | 30 (93.8) | 24 (82.8) | | .443† |
| | No | 10 (11.4) | 3 (11.1) | 2 (6.3) | 5 (17.2) | | |
| Smoking | Non-smoker | 47 (53.4) | 12 (44.4) | 15 (46.9) | 20 (69.0) | 5.22 | .265 |
| | Current smoker | 17 (19.3) | 5 (18.5) | 7 (21.9) | 5 (17.2) | | |
| | Ex-smoker | 24 (27.3) | 10 (37.0) | 10 (31.3) | 4 (13.8) | | |
| Drinking | Yes | 26 (30.2) | 12 (44.4) | 9 (29.0) | 5 (17.9) | 4.64 | .098 |
| | No | 60 (69.8) | 15 (55.6) | 22 (71.0) | 23 (82.1) | | |
| Exercise | Yes | 47 (53.4) | 10 (37.0) | 18 (56.3) | 19 (65.5) | 4.72 | .094 |
| | No | 41 (46.6) | 17 (63.0) | 14 (43.8) | 10 (34.5) | | |
| Family History | Yes | 37 (42.0) | 15 (55.6) | 15 (46.9) | 7 (24.1) | 6.14 | .052 |
| | No | 51 (58.0) | 12 (44.4) | 17 (53.1) | 22 (75.9) | | |
| Insulin | No | 49(55.7) | 8(29.6) | 22(68.8) | 19(65.5) | 10.78 | 0.005 |
| | Yes | 39(44.3) | 19(70.4) | 10(31.2) | 10(34.5) | | |
| BMI (kg/㎡)* | | 25.66±3.94 | 24.83±3.05 | 25.21±3.47 | 26.94±4.85 | 2.43 | .094 |
| Duration of diabetes(years)** | | 7.64±8.16 | 8.70±9.22 | 7.50±8.66 | 6.79±6.57 | 0.39 | .682 |

†Fisher exact test *Body mass index, M±SD ** M±SD

Male subjects accounted for 58.0% (51 subjects) of the total number of subjects, more than the number of female subjects, and the mean age of the subjects was 55.76±12.66 years. The number of subjects with a university diploma or higher was 16 (59.3%) in the app group, 21 (65.6%) in the logbook group, and 13 (44.8%) in the general group. The number of subjects with an occupation was 20 (74.1%) in the app group, 24 (75.0%) in the logbook group, and 15 (51.7%) in the general group. Most of the subjects in the three groups were married. There was no difference in general characteristics among the three groups, such as gender, age, education, occupation, and marital status, duration of diabetes, body mass index (BMI), treatment method, family history, smoking and drinking habits, and exercise.

The mean duration of diabetes in all the subjects was 7.64±8.16 years and the BMI was 25.66±3.94 kg/m2.

Of all the subjects, 37 (42.0%) had a family history of diabetes: 15 (55.6%) in the app group, 15 (46.9%) in the logbook group, and 7 (24.1%) in the general group. Among all the subjects, 19.3% (17 subjects) were smokers, 30.2% (26 subjects) drank alcohol, and 53.4% (47 subjects) exercised regularly. When classified under insulin user or not, there were 19 insulin users (21.6%) in the app group, thus there was a difference between the three groups, so homogeneity was not secured.

### 3.2 Verification of characteristics and homogeneity of study variable

The HbA1c level was 9.87±2.10% in the app group, 9.14±1.80% in the logbook group, and 9.06±1.23% in the general group, which indicates that there was no significant difference among the three groups (F=1.81, p=.170). The self-care behavior score was 28.69±16.50 in the app group, 23.63±15.99 in the logbook group, and 27.72±14.20 in the general group, which indicates that there was no significant difference among the three groups (F=.85, p=.429). The quality of life score was 12.96±5.31 in the app group, 12.63±5.56 in the logbook group, and 12.04±6.25 in the general group, which indicates that there was no significant difference among the three groups (F .18, p=.833). (as shown Table 2)

### 3.3 Changes in study variables after intervention

#### 3.3.1 Differences in HbA1c levels among the three groups

Table 3 shows the differences in HbA1c levels between the three groups. The HbA1c levels decreased in the app group, the logbook group, and the general group. After 24 weeks, in the difference between the three groups, only the app group showed a significant decrease in HbA1c after education compared to the logbook group and the general group (F=4.62, p=.013).

#### 3.3.2 Differences in self-care behavior among the three groups

Table 4 shows the differences in self-care behavior between the three groups. The self-care behavior increased in the app group, the logbook group, and the general group. After 24 weeks, there was no significant difference in self-care behavior after education compared to before education in all three groups (F=0.84, p=.436).

#### 3.3.3 Differences in quality of life among the three groups

Table 5 shows the differences in quality of life between the three groups. The quality of life increased in the app group, the logbook group, and the general group. After 24 weeks, there was no significant difference in quality of life after education compared to before education in all three groups (F=0.54, p=.588).

**Table 2. Verification of disease-related characteristics and homogeneity (N=88)**

| Variables Categories | Total (n=88) | App (n=27) | Logbook (n=32) | General (n=29) | F or $x^2$ | *p* |
|---|---|---|---|---|---|---|
| | M±SD | M±SD | M±SD | M±SD | | |
| HbA1c[a] | 9.34±1.76 | 9.87±2.10 | 9.14±1.80 | 9.06±1.23 | 1.81 | .170 |
| Self-care | 26.58±15.53 | 28.69±16.50 | 23.63±15.99 | 27.72±14.20 | .85 | .429 |
| QOL[b] | 12.53±5.67 | 12.96±5.31 | 12.63±5.56 | 12.04±6.25 | .18 | .833 |

[a]Glycated hemoglobin [b]Quality of life

**Table 3. HbA1c intra group changes and differences among the three groups (N=88)**

| Group | HbA1c (M±SD) | | | Source | F | *p* | *Scheffe test* |
|---|---|---|---|---|---|---|---|
| | Pre test | Post 24 weeks | Post-pre difference | | | | |
| App[a] | 9.87±2.10 | 6.96±0.67 | -2.91±2.37 | Insulin treatment or not | 7.52 | .007 | |
| Logbook[b] | 9.14±1.80 | 7.37±0.64 | -1.77±1.87 | Duration of diabetes | 9.50 | .003 | |
| General[c] | 9.06±1.23 | 7.38±0.52 | -1.68±1.68 | Group | 4.62 | .013 | a)b,c |

[a]Real-time coaching training using the application [b]Intensive training 3 to 4 times face-to-face [c]A one-time training

**Table 4. Self-care behavior & Quality of life intra group changes and differences among the three groups (N =88)**

| Group | Self-care (M±SD) | | | Source | F | *p* |
|---|---|---|---|---|---|---|
| | Pre test | Post 24 weeks | Post-pre difference | | | |
| App[a] | 28.69±16.60 | 38.52±11.40 | 10.20±15.63 | Insulin treatment or not | 0.24 | .624 |
| Logbook[b] | 23.63±15.99 | 33.25±12.27 | 9.00±12.77 | Duration of diabetes | 0.12 | .733 |
| General[c] | 27.72±14.19 | 35.51±11.71 | 8.79±13.84 | Group | 0.84 | .436 |

**Table 5. Quality of life intra group changes and differences among the three groups (N =88)**

| Group | Quality of life (M±SD) | | | Source | F | *p* |
|---|---|---|---|---|---|---|
| | Pre test | Post 24 weeks | Post-pre difference | | | |
| App[a] | 12.96±5.31 | 14.41±6.01 | 1.15±6.35 | Insulin treatment or not | 0.01 | .942 |
| Logbook[b] | 12.63±5.56 | 13.78±5.39 | 1.16±3.81 | Duration of diabetes | 0.01 | .999 |
| General[c] | 12.04±6.25 | 12.76±6.30 | 0.45±5.46 | Group | 0.54 | .588 |

[a]Real-time coaching training using the application [b]Intensive training 3 to 4 times face-to-face [c]A one-time training

## 4. DISCUSSION

The purpose of this study was to compare the effects of diabetes education among the app group, the logbook group, and general group. Self-care behaviors and HbA1c levels improved in all three groups at 24 weeks post education. This shows consistent results with previous studies that diabetes education improves self-management behavior in diabetic patients [25-27], and consequently improves HbA1c [7, 27-29]. The improvement in self-management behavior and HbA1c in all three groups including the general group is a result of showing that diabetes education at a

Korean general hospital is effective in controlling blood glucose in diabetic patients. The educational content presented to the three groups was provided with structured diabetes education based on self-monitoring of blood glucose (SMBG), and the subjects received self-care education that identified their blood glucose patterns such as hyperglycemia and hypoglycemia using the results of SMBG, including lifestyle and insulin dose adjustments in their daily life.

In addition, there was no difference in self-care behavior among the three groups before education and after 24 weeks, but the HbA1c level was significantly reduced in the app group when compared to the logbook group and the general group. Overall, all three groups showed effects of reducing self-management behavior and HbA1c, but it was confirmed that the app group was an effective educational method to improve blood glucose management. The effect of reducing HbA1c in the app group was consistent with the results of previous studies that diabetes management apps were effective for diabetes education [15-20]. The logbook group which performed face-to-face management using a diabetes logbook were also provided feedback according to blood glucose measurements, but the significant decrease in HbA1c in the app group compared to the logbook group and the general group is thought to be due to feedback being received immediately through real-time coaching according to blood glucose measurements.

Diabetes education is based on SMBG. This study confirmed that it is effective in controlling blood glucose when the patient's SMBG results are interpreted and influences behavior, or when the educator provides meaningful feedback to the patient based on their SMBG [19, 30-33]. As a result, it was confirmed that diabetes education improved the self-management behavior of diabetic patients [25-28], and consequently improved HbA1c [7, 27-29], and diabetes education was an essential element of diabetes management [7].

The quality of life of the study subjects improved in all three groups after 24 weeks, but there was no significant difference. Some studies have shown that SMBG is associated with poor quality of life [8], but the absence of poor quality of life in this study is in line with reports that SMBG combined with structured or intensive education does not lead to poor quality of life in diabetic patients [30-33]. SMBG-based preventive diabetes management improves blood glucose control and decreases morbidity and mortality associated with diabetes, resulting in improved quality of life through normal blood glucose management in the long term [30].

In diabetes management, diabetes educators have difficulties in providing patients with information for continuous blood glucose management [34]. Obviously, diabetes education is effective in preventing complications in diabetic patients. However, diabetes education requires manpower and time. Therefore, it is necessary to combine the latest technology with complementary measures or alternatives to patient education and behavioral intervention [35]. As seen in this study, it is encouraging that the app group had a greater effect on improving HbA1c of subjects than the intensive education group using the logbook.

Through this study, it was shown that diabetes education using the app can be applied as a form of continuous diabetes education. Today, health care apps for smartphones are used for patient self-management [36], but there are not many cases of application after confirming the actual

effectiveness. There are some smartphone applications developed and verified for self-management of diabetes [21], but diabetes management apps which relay feedback from diabetic education nurses are lacking. Nevertheless, in a situation where the diabetes education was operated by one or two diabetic education nurses, the app group of this study easily conducted blood glucose pattern management education by sharing the results of self-glucose measurement, meal logs, and exercise logs of the study subjects in real time . If the aspect of personal information management of the subjects who use health care apps is supplemented, it is highly likely to be applied in practice after the study is completed and it is expected to be highly utilized in diabetes education.

Although some diabetes-related apps have been reported to improve and maintain blood glucose over a 12-month period [16], it is unclear how long the positive effects of blood glucose control interventions observed in this study will be maintained. In addition, since the study was conducted 5 years ago, many smartphone-related applications have been developed since then, but their uses are still insufficient for diabetes education. Therefore, the continuing effects of the app with regard to blood glucose management warrant future research.

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