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ORIGINAL RESEARCH

Effect of Health Literacy Intervention on Glycemic Control and Renal Function Among Thai Older Adults at Risk of Type 2 Diabetes Mellitus

Katekaew Seangpraw[1], Parichat Ong-Artborirak[2], Sorawit Boonyathee[3], Sasivimol Bootsikeaw[1], Supakan Kantow[1], Pitakpong Panta[4], Prakaipetch Winaiprasert[5]

[1]School of Public Health, University of Phayao, Phayao, 56000, Thailand; [2]Faculty of Public Health, Chiang Mai University, Chiang Mai, 50200, Thailand; [3]School of Medicine, University of Phayao, Phayao, 56000, Thailand; [4]School of Nursing, University of Phayao, Phayao, 56000, Thailand; [5]Faculty of Nursing, Thammasat University, Pathum Thani, 12121, Thailand

Correspondence: Pitakpong Panta, Email pitakpongp@gmail.com

Purpose: Diabetes patients with low health literacy often have poor health and clinical outcomes. The study aimed to assess the effectiveness of a health literacy intervention on glycemic control and renal function among Thai older adults at risk of type 2 diabetes mellitus (T2DM).

Methods: A quasi-experimental study was carried out in rural areas of Phayao Province in northern Thailand. The participants were older adults with T2DM who recorded blood glucose levels ranging from 140 to 180 mg/dL and who were not receiving prescribed medication. The intervention lasted 12 weeks, and data were collected at three points: baseline, post-intervention, and at 3 months' follow-up. The study outcomes included the measurement of fasting blood sugar (FBS), hemoglobin A1C (HbA1c), and glomerular filtration rate (eGFR) levels after the intervention. A linear mixed model and generalized estimating equations model were used to assess the intervention effect for continuous and binary outcomes, respectively.

Results: From baseline to post-intervention, FBS and HbA1c decreased more in the intervention group than in the control group by 8.2 mg/dL ($p < 0.001$) and 0.1% ($p = 0.029$), respectively, whereas eGFR increased by 8.0 mL/min/1.73m2 ($p < 0.001$). The absolute effect of the intervention at follow-up was −9.8 units for FBS, −0.4 units for HbA1c, and 14.0 units for eGFR. Abnormal HbA1c level (≥6.5%) of the intervention group was reported as 70.3% at baseline, 31.3% at post-intervention, and 9.4% at follow-up. Compared to baseline levels, the T2DM patients who received the intervention were 0.31 times less likely to have abnormal HbA1c levels than the control subjects at follow-up ($p = 0.003$) who received no intervention.

Conclusion: Our findings suggest that this intervention may potentially improve diabetes self-management and prevention behaviors, thereby reducing the diabetes burden in rural communities in northern Thailand.

Keywords: health literacy, glycemic control, renal function, older adults

Introduction

Diabetes is a major public health issue worldwide, as it results in considerable health and economic burdens. Indeed, this condition has a negative economic impact on individuals, healthcare systems, and nations alike. The highest prevalence of diabetes is found among elderly people aged 60–79 years.[1] Elderly people are particularly vulnerable to heart disease, cancer, and diabetes, and these conditions may result in lower quality of life and increased mortality in this age group.[2] Moreover, previous reports have indicated that diabetes is associated with multiple health complications among the aging population, and it causes the deaths of 1 in 4 people aged 60 years and over.[3] In Thailand, the 2008 health report showed that there were 11,389 deaths attributable to diabetes in 2008, an average of 32 people per day, while only 37.9% of diabetes patients had good control of their blood glucose levels.[4] If patients are unable to control their diabetes, it may lead to serious health complications, such as kidney disease, cardiovascular diseases, and other related physical problems, resulting in high healthcare costs, thus affecting the economic status of their families as well as the nation.[4] In addition,

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elderly patients with diabetes are at an increased risk of hypertension, depression, dementia, cognitive impairment, and cardiovascular diseases compared to those of the same age without diabetes.[5] A study in China found that the prevalence of diabetes continues to increase in the Chinese population; as a result, health spending on treatment, medicine, and prevention of health complications has increased from $90 billion in 2015 to $110 billion in 2017.[6] Since regular diabetes treatments and medicines are expensive, health knowledge, self-care skills, and self-management of diabetes are key components for patients in the treatment, prevention, and control of the disease.[6]

Phayao, a province in northern Thailand, is one of the seven northern provinces in which the number of patients with chronic non-communicable diseases continues to increase rapidly.

According to Phayao Province's Health Data Center, the rate of new diabetes patients aged 15 and up rises from 2017 to 2021: 553.02, 567.39, 612.81, and 572.24 per 100,000 people, respectively. The percentages of new cases of diabetic patients from the at-risk group were 2.68%, 2.68%, 3.13%, and 3.03%, respectively. According to the local health report,[7] most patients were unable to achieve control of their blood glucose levels, as shown in these percentages: 23.42%, 23.04%, 24.6%, and 27.19%, respectively. Moreover, it was found that the major behavioral risk factors of diabetes patients were unhealthy food consumption, smoking tobacco, drinking alcohol, and increased body mass index (BMI) in the population aged 15 years and over, with percentages of 40.0%, 5.6%, 7.0%, and 22.3%, respectively.[7] Moreover, elderly patients often experience changes in nutrient intake and organ dysfunction, resulting in an increased risk of hypoglycemia.[5]

The World Health Organization defines health literacy (HL) as

> An individual's ability to obtain, read, understand and use healthcare information in order to make appropriate health decisions and follow instructions for treatment.[8]

Health literacy is associated with health outcomes and chronic health conditions.[9] Several studies have shown that patients with low health literacy may have difficulty reading prescriptions and medicine labels, obtaining health information, and getting medical advice, and they generally have less knowledge about the disease, thus resulting in worse clinical outcomes.[10,11] In the United States (US), low health literacy or numeracy (the ability to understand and use numbers in daily life) is associated with limited adherence to recommendations, poorer glycemic control status, and worse clinical outcomes, even after adjusting for potential confounders, such as educational level.[12,13] Indeed, a randomized controlled trial (RCT) study showed that health literacy was an important factor in predicting HbA1c improvement among patients in an intervention group.[14] It suggests that health literacy interventions can improve the patient's health and clinical outcomes.[14] In Thailand, many diabetes patients experience hypoglycemia and other adverse health effects, so new approaches aimed at the prevention and control of diabetes are needed to address barriers to diabetes management among elderly people with the disease. To date, no studies in the Phayao study area have assessed the effectiveness of a health literacy program combined with the self-efficacy concept to modify self-care behaviors as a research framework. Therefore, we designed an intervention program that focused on health literacy among elderly diabetes patients by employing self-efficacy theory with the aim of modifying patient behavior. This study introduced self-efficacy theory to increase health beliefs resulting from the patient's own ability to succeed in their self-care behaviors and diabetic management and to increase empowerment in the prevention and control of the disease.[15] Hence, the purpose of this research was to examine the impact of health literacy intervention on glycemic control and renal function among Thai older adults at risk of type 2 diabetes mellitus (T2DM) living in rural communities of a northern Thailand province.

Methodology

Study Design and Sample Selection

This study employed a quasi-experimental pretest and posttest design, and participants were divided into experimental and control groups. The research was conducted between September 2021 and February 2022 in rural communities of Phayao Province, Thailand. Purposive sampling was used to select a study area from 15 sub-districts of Muang District, Phayao Province. The selection criteria for the healthcare setting were a rural area with increasing number of elderly

people with type 2 diabetes registering as a risk group at an area hospital where health promotion administrators were available and willing to cooperate in the research. Next, a simple random sampling using a lottery technique was used to select the research sites, namely: (A) a health promotion hospital used as the intervention group, and (B) a health promotion hospital used as the control group. G*Power 3.1.9.2 was used to compute the sample size for determining the difference in two independent means. The calculation set the effect size to 0.5 (medium), alpha to 0.05, and power to 80%. The minimum sample size for each group in this study was 64. By adding 5% to the expected dropout rate, the final sample size for each group was 67. The 67 samples in each group were randomly selected from the list of patients registered in the Hospital Information Extreme Platform Program (Hosxp) of Phayao Hospital and the Phayao Provincial Health Data Center (HDC Phayao), as shown in the participant flow diagram (Supplementary Figure 1). Participants from both experimental and control groups were similar in terms of their socio-demographic characteristics as well as the contexts of their communities. The two selected study sites were approximately 5 kilometers apart thus preventing data contamination.

The inclusion criteria for participants in the study were older persons (both females and males) aged 60 years or above; with a blood glucose level between 140 and 180 mg/dL measured twice consecutively within 1 year; with abnormal blood lipid levels but not taking medication; diagnosed by a medical doctor as a patient at risk for diabetes; having no mental or physical abnormalities such as senile dementia or paralysis; and willing to participated in the research voluntarily.

Instrument

The interview questionnaires (Supplementary File 1) were used as research tools to obtain the required information from the participants. The contents of the interview questionnaires were validated by two experts in the fields of geriatrics and public health. The tools were applied from previous research and health theories and developed to be suitable for rural areas and the prevalent living context among older adults in northern Thailand.[16–18] The questionnaire consisted of 4 parts (the categories of these variables are shown in Supplementary File 1 Part 2):

- Part 1 included sociodemographic characteristics including gender, age, marital status, education, occupation, income sufficiency, BMI, comorbidity, alcohol intake, smoking, and dietary habits/favorite foods, caregiver, and DM duration.
- Part 2 included health-literacy questions regarding diabetes knowledge.[16,17] The questions were divided into 6 aspects: (a) skills to access to information and health services; (b) cognitive skills to understand causes, symptoms, and prevention and control of diabetes; (c) communication skills to increase knowledge and understanding about diabetes; (d) decision-making skill towards health; (e) self-management skill towards health; and (f) media literacy which is a skill to acquire diabetes information. There were 6 questions on each aspect, thus giving a total of 36 questions. The participants chose from 3 multiple-choice answers: Yes, Not Sure, and No. A correct answer scored 1 point, and a wrong answer scored 0 points. The total score range was 0–36 points divided into 3 levels: critical literacy (≥28 points), interactive literacy (21–27 points), and functional literacy (≤20 points).
- Part 3 included self-efficacy towards diabetes prevention and comprised 10 items.[16,18] There were 3 possible answers (Disagree, Not Sure, and Agree) giving a total score of 0–30 points. The measurement scale was divided into 3 levels: high (≥24 points), moderate (18–23 points), and low (≤17 points).
- Part 4 included health behavior towards diabetes prevention and control and consisted of several (50) items including (i) food consumption 20 items, (ii) exercise 10 items, (iii) stress management and rest—10 items, and (iv) diabetes management behavior—10 items.[16,17] There were 3 possible answers: Never Practiced, Rarely Practiced (1–3 times/week), and Regularly Practiced (4–7 times/week), which were divided into 3 scoring levels. High scores were greater than or equal to 80% (≥120 points), moderate scores were between 60 and 79% (90–119 points), and low scores were less than 60% (≤89 points).

The questionnaire was validated for content validity by 2 experts in the fields of aging and non-communicable diseases. The researcher conducted a tryout on 30 samples with similar characteristics of the elderly and the living area.

For Part 2 of the questionnaire, the reliability value of Kuder-Richardson Formula: KR20 was = 0.82. For Part 3 and Part 4 of the questionnaire, the questionnaire's reliability was analyzed by Cronbach's alpha coefficient giving values of 0.81 and 0.80, respectively.

Blood Pressure Measurement

We used an automatic blood pressure monitor with an air bag circumference around the arm of approximately 27–34 cm.[19] The arterial blood pressure measurement was done according to the standardized procedure recommended by the World Health Organization.[20] After a rest of 10 minutes, two sitting blood pressure (BP) readings were taken 5 minutes apart on either arm. The average of these two readings was used as the final BP reading.

Glycemic Control and Renal Function Measurement

Blood samples were collected after an overnight fasted. Three biomarkers were recorded: eGFR, fasting blood glucose, and HbA1c. Blood was collected and analyzed at Phayao Hospital before being examined. The research assistants recorded biomarker data (eGFR, HbA1c, and fasting blood glucose) three times during the study. The laboratory equipment had passed quality inspections mandated by the standards of the Nephrology Society of Thailand standard of CKD-EPI for adults, and Schwartz Equation was used to calculate eGFR.

Health Literacy Intervention

The intervention used in this study was applied based on the relevant health concepts and theories.[9,18] This program was organized to provide the elderly with health knowledge and self-efficacy in order to modify their behavior in risk diabetes prevention during the research activities. The research assistants included 2 public health scholars, 2 nurses, and 4 village health volunteers recruited from the study areas. The requirement for the health volunteers was that each person must have completed training on aging population course from the Department of Health Service Support, Ministry of Public Health.[21] The researcher held a 2-hour meeting to clarify the research objectives, data collection technique, tools used in the study, and related research process so that the research assistants all understood the procedures. Research assistants were observed and evaluated their knowledge and understanding about the research after the meeting.

For the intervention group, the participants were given a diary and self-care behavior manual created by the researcher based on application and review of the literature to record their daily activities based on the Diet, Exercise, Weight Management, and Diabetes Health Awareness Elements Guideline.[9,18,22] The whole intervention program ran for 12 weeks. Each planned activity was done once a week. The duration of each session was approximately 180–240 minutes or in accordance with the appropriateness of the activity and convenience time of the sample group.

The activities for the intervention program included:

Week 1: The program consisted of 2 activities. (i) Relationship-building activities such as self-introductions, explanation and understanding of the research objectives, and a group discussion to share individuals' experience, including problems encountered in daily life, problem solving, and self-care behaviors to gain mutual knowledge (ii) Information access skills under the topic "knowing and paying attention to health" activities. The researcher surveyed the participants on their cellphone use, internet access skills, and social media activities at the sub-district health promotion hospital. In addition, the participants were given a diary of daily activities designed to record their self-management behaviors and daily activities, such as of diet, exercise, and weight management. The participants were encouraged to perform and record these activities consistently on a daily basis. The research assistants would follow up weekly to evaluate the participants' diary entries.

Week 2: Activity cognitive skills under the topic "health awareness, diabetes can be prevented". The objective of this activity was to educate the participants on being aware of their diabetes and understanding its systems pathogenesis, causes, symptoms, prevention and control, severity of the disease, and health complications of diabetes. The researcher created and presented a diabetes model entitled "diabetes warning signs".

Week 3: Communication skills under the topic "understanding the silent threat" were covered. The objective of this activity was to enable the participants to correctly explain what they had learned about diabetes. The activity focused on engaging the participants so that they could share knowledge about their self-care experiences, diabetes prevention, and

control; learn reading skills to better understand medicine labels and prescriptions; learn how to calculate BMI; and observe abnormal symptoms. In addition, there was a skill-enhancing activity entitled "matching-knowing the meaning". This was designed so that the participants could practice verbalizing and understanding diabetes terms. This was done by dividing them into small groups and each participant then prepared their presentation to present to the class.

Week 4: A decision skills activity under the topic "analyze your own advantages and disadvantages" was conducted. The objective was to enable the participants to analyze their own strengths and weaknesses so that they could share their past experiences about self-care behaviors regarding diabetes through group discussion topics; for instance, eating behavior, exercise, and stress management. There was also a skill-enhancing activity of 60 minutes entitled "good dream and nightmare" for the participants to share their worries, fears, or stress once they were diagnosed with diabetes.

Week 5: An self-management skills activity entitled "overcoming diabetes" was conducted with the aim of teaching the participants about nutrition, exercise, and stress management. This activity was divided into 3 sub-activities. (i) Skills to practice choosing local food, understanding an herbal food menu, using local fruits to control blood sugar levels, and recommended meal replacements. A menu was given using a 6:6:1 formula for 1 day of meals (a limit of up to 6 teaspoons of sugar: up to 6 teaspoons of oil: and up to 1 teaspoon of salt).[22] In addition, the participants practiced organizing menus according to 3 color codes: "red" represents foods that contains high levels of fat and sugar so should not be eaten often; also, the elderly should avoid drinking alcohol and smoking; "yellow" represents foods containing medium levels of fat and sugar, so these foods should also be avoided or eaten less; and "green" represents foods low in fat and sugar.

Participants were told to focus on food-containing fiber such as fruits and vegetables and these should be eaten often. (ii) A physical activity "move your body, relax, and reduce diabetes" was then undertaken. This activity focused on emphasizing the benefits of daily exercise. The participants exercised together using fun and happy local music during the workout while dancing to the rhythm of the music. The researcher asked the participants to promise that they would also exercise at home by watering plants, sweeping the house, walking around a garden or a field close to their home, and other related activities. It was recommended that the participants do this exercise at least 4–5 times a week for 30–40 minutes at a time. (iii) Stress management activity: this 90-minute activity allowed the participants to perform breathing exercises, muscle relaxation training, and meditation together in small groups.

Week 6: Activity media skills this 120-minute activity empowered the participants to access reliable diabetes information and to make good, informed decisions in the interests of their health. The participants learned this material via an educational video created by the researcher. The video examined information from trusted sources about the disease such as dietary supplements, advertisements, treatment information, and accessing emergency medical services. Another 90-minute activity then concentrated on enhancement skills "together, bonding and promise". All participants in the intervention group were asked to write about how they would take care of themselves after participating in the activity and to list their goals for diabetes prevention.

Weeks 7–12: This week consisted of 2 activities: (i) Counseling skills (emphasizing communication and self-empowerment and including the following topics): eating three meals a day, physical exercise, self-motivation, access to health information, self-decision making, reading medication labels and prescriptions, listening to problems, and counseling approaches appropriate for the elderly. (ii) Follow-ups and positive reinforcement activities consisted of two 30–40-minute home visits. Some elderly people were not home at the time of the visit, so the researcher would phone them (for 20–30 minutes) to encourage them to do the daily activities learned in the intervention program.

Finally, a follow-up phone call was made to the participants to review and access their comprehensive knowledge and to encourage to them take actions to prevent diabetes and its complications. Summary of health literacy intervention (Supplementary Table 1) and flow schedule of health literacy intervention (Supplementary Figure 2). The control group participants received regular health advice from community health facilities, as well as a health diary from the area's local sub-district health promotion hospital. The pre-test data were collected prior to the intervention, and the posttest data were collected following the 12-week intervention. The researcher then used the same interview questionnaires for both groups to collect follow-up data 3 months after the post-intervention to determine whether there were any changes in health literacy, self-efficacy perceptions, and diabetes prevention behaviors.

Statistical Analyses

Data were analyzed using Stata/IC (version 16.0) for Windows software (StataCorp LP, College Station, TX, USA) after being checked and cleaned. The results indicated no missing data. The Chi-squared test was then used to compare the general information of the participants in the intervention and control groups. The independent *t*-test was used to test mean differences in the studied outcomes between the intervention and control groups at each measurement time. The linear mixed model with interaction between intervention and time was used to perform difference-in-difference analysis for assessing the magnitude of the intervention effect at post-intervention and follow-up. The generalized estimating equations (GEE) model was additionally employed to determine the intervention effect on abnormal HbA1c level (≥6.5%) at post-intervention and follow-up compared to baseline. The analysis with a log link function for measuring relative risk and an ex-changeable correlation function was then performed. The level of significance was set at 0.05 for all statistical tests.

Results

The general characteristics of the 128 participants (64 in the intervention group and 64 in the control group) are shown in Supplementary Table 2. The mean age of participants was 65.9 years (range 60–82 years; SD = 5.4). The mean duration since risk diabetes mellitus diagnosis was 4.2 years (range 1–12 years; SD = 2.4). There were no statistically significant differences between the intervention and control groups in sex, age, marital status, education, income status, favorite foods, alcohol intake, smoking, having a caregiver, DM duration, comorbidity, BMI, or blood pressure levels.

Supplementary Table 3 compares the outcomes of the participants in the intervention and control groups at baseline, post-intervention, and follow-up. Before starting the intervention, there were no statistically significant differences in FBS, HbA1c, eGFR, diabetes health literacy, self-efficacy, or self-care behaviors between the intervention and control group participants. At post-intervention and follow-up, the mean FBS and HbA1c levels in the intervention group were significantly lower when compared to the control group ($p < 0.05$). However, the mean eGFR, diabetes health literacy, self-efficacy, and self-care behaviors in the intervention group were significantly higher than those in the control group ($p < 0.05$).

The magnitude of the overall effect of the intervention is shown in Supplementary Table 4. From baseline to post-intervention, fasting blood sugar and HbA1c decreased more in the intervention group than in the control group, by 8.2 mg/dL ($p < 0.001$) and 0.1% ($p = 0.029$), respectively, whereas eGFR increased by 8.0 mL/min/1.73m2 ($p < 0.001$). Diabetes health literacy, self-efficacy, and self-care behaviors increased 2.9, 2.2, and 7.2 points more in the intervention group than in the control group ($p < 0.001$). From baseline to follow-up, the absolute effect of the intervention was −9.8 units for fasting blood sugar, −0.4 units for HbA1c, 14.0 units for eGFR, 3.1 units for diabetes health literacy, 2.9 units for self-efficacy, and 10.4 units for self-care behaviors. Abnormal HbA1c level of the intervention group was reported to be 70.3% at baseline, 31.3% at post-intervention, and 9.4% at follow-up (Supplementary Tables 5 and 2). The intervention group was 0.57 times less likely to have an abnormal HbA1c level than the control group at post-intervention ($p = 0.003$). At follow-up, the intervention effect showed relative risk at 0.31 times ($p = 0.003$).

Discussion

The results of the program demonstrated significantly increased scores for health literacy and health behavior modification among the participants with risk diabetes mellitus after they received the health literacy intervention. This can be explained by the fact that the program provided components of health literacy and self-care activities for diabetes prevention which consisted of 6 components using health promotion strategies such as giving lectures, demonstrations, games, singing songs, exercise, and group work activities once a week for approximately 180–240 minutes each time. This resulted in reductions of eGFR, FBS, and HbA1c levels when compared to the control group over the course of the 3-month study.

After the participants joined the program, their scores for health literacy, self-efficacy, and preventive behaviors toward prevention of diabetes mellitus increased significantly. Hence, the use of skills based on health literacy components that applied in conducting health activities appropriate to the cultural context and native language made it

easy for the participants to communicate and understand the course content. Each week, activities would focus on making changes and health improvements based on defined program objectives, which is consistent with the concept described in advanced cognitive skills in conjunction with social skills that can be applied to analyze critical data and to have greater control over life event and situations.[9] Systematic reviews indicated that health literacy-based activities can lead to tangible rewards both at the individual and community levels by improving health and wellbeing, reducing the number of hospital visits and other related costs.[23] Also, similar to another study, diabetes patients who received appropriate health literacy intervention had a higher percentage reduction in A1c (A1c difference of −2.0 ± 1.3 vs −1.0 ± 2.2; P = 0.02) and fewer hyperglycemic events per week (0.1 vs 2.1; P = 0.04).[24]

In term of diabetes health awareness, a statistically significant increase in mean scores occurred after the program and the follow-up periods when compared to the control group. Hence, the aim of health literacy intervention was to provide knowledge and understanding on health literacy in cognitive skills. The participants in the intervention program received an educational video entitled "health awareness, diabetes can be prevented" that explained about pathophysiology the cause and effect of the disease such as abnormal functioning of the pancreas; signs and symptoms of diabetes such as frequent urination, frequent hunger, weight loss; using medical and treatment of diabetes and behavioral modification; and personalized treatment information such as control of comorbidities, complications and prophylaxis approaches appropriate to the context of their rural areas. Moreover, a diabetes model "diabetes warning signs" was used to explain how insulin works in the body. The model demonstrated blood sugar function and severity of diabetes complications that affect renal function. The video was modified by including the local language which made it easier for the elderly people from northern Thailand to understand the content. During the follow-up period, the researcher used phone calls and home visits to reinforce the participants' knowledge, and this knowledge was enhanced by the use of a diary given to the participants. This is consistent with a systematic review study, which indicated that health literacy is an important part of patient's empowerment, knowledge, and self-management skills.[25] Similar to a previous study, this health literacy program provided significant health improvements, knowledge, and better self-management behaviors towards type 2 diabetes mellitus.[26] Also consistent with a previous study, participants showed a statistically significant improvement in their diabetes knowledge score and had significantly decreased HbA1c levels after they received the intervention program.[27] Moreover, in the access skills activity under the topics "knowing and paying attention to health" and "media skills", the participants could join the activity in a friendly and welcoming environment where they could relax and receive the required health knowledge information. The activity also gave them motivation to ask questions and review their own health problems and gave them the opportunity to communicate and share knowledge information and recommendations among other elderly patients with diabetes as well as health providers. In the program, elderly people were taught how to access online information using a computer and/or mobile phone. Moreover, they were able to search for diabetes information from trusted sources with good decision-making for their health. This is consistent with a study indicating that after participating in a program, participants had significantly higher diabetes skills and knowledge than those in a control group.[28]

In term of self-efficacy, the mean scores of the older adults in the intervention group increased after the program and the follow-up period, with scores higher than the control group. This can be explained by the health literacy intervention activities that focused on health literacy components for individuals to practice. However, in the first and second week of the program, the participants were educated according to the health literacy components, namely "access skills" which gave them knowledge regarding health access, thus enabling them to successfully search for diabetes information. Moreover, there was an activity that emphasized communication and self-empowerment; for instance, practice reading skill, calculating BMI skill, and observing abnormal symptom skills. Furthermore, the skill enhancing activity entitled "matching-knowing the meaning" allowed the participants to practice speaking and to understand simple diabetes medical terms through group presentations. As a result, they became more self-confident in communicating and sharing knowledge with others. This finding is consistent with the idea of Bandura's theory in which an individual's self-efficacy results from a belief in one's ability to plan and execute the actions necessary to manage expected situations.[29] This is because self-efficacy determines what a person does with the knowledge and skills they possess.[29,30] Also consistent with previous studies showing that after educational activities, the mean scores of the experimental group increased, and there was a significant difference in mean scores of self-efficacy between the experimental and the control groups (t = 0.099,

p = 0.001).[31] As shown in a previous study, the results of the experimental group receiving the effect of a diabetes self-efficacy-enhancing program showed that participants had higher confidence in their self-efficacy, resulting in a significant increase in their anti-diabetic behavior and a significant lower HbA1c level compared to the control group.[32]

Regarding preventive behaviors toward prevention of risk T2DM, the mean scores of the elderly in the intervention group increased after the program and follow-up period and were significantly higher than the control group. The results are in line with the concept of self-management that focuses on personal behaviors in order to achieve goals in 6 steps: goal setting, self-monitoring and reflection, decision-making, planning and action, self-evaluation, and management of resulting health outcomes.[33] In this study, we used activity-based learning to enable the participants to manage themselves according to the components of health literacy. With the health literacy intervention, health literacy developed from basic communication skills, and comparative information could be analyzed to enable proper choices, as in daily life. Similarly, previous studies indicated that health literacy was an important factor in the organization of diabetes awareness-raising activities. The results of the diabetes management program suggested that health literacy is particularly useful for patients with low literacy because it enhances their ability to analyze information and increases their knowledge when accessing health services.[14]

The results of this study were influenced from the application of health literacy theory. Under the self-management skill "overcoming diabetes", this activity allowed the elderly to management themselves related to self-care management, stress management, exercise, and a limited 6:6:1 plan for daily meals (up to 6 teaspoons of sugar: up to 6 teaspoons of oil: up to 1 teaspoon of salt). The participants were divided into groups and had to demonstrate what they learned from the program such as making local dishes from herbs, processing local fruits to reduce sugar, and recommending meal replacements. This activity enabled the participants to enjoy exchanging and learning food menus. We also included games to encourage participation in the practice of nutrient selection and food selection according to color zones in order to motivate and reinforce their understanding and comparative analysis of food choices to reduce blood sugar level. Consistent with previous research, it showed that participants in the intervention group who participated in the program to improve their dietary habits resulted in a significant increase in self-care behavior after the intervention compared to the control group (p = 0.001).[34] Many studies also showed that after participating in a diabetic self-management program, the experimental group had more self-care behavior scores than the control group.[14,32,35]

As for exercise activities, we used the slogan "move your body, relax, and reduce diabetes" when using local music for participants to dance to order to integrate knowledge during the activity. Indeed, the participants enjoyed dancing with their new friends in a fun and happy environment during the exercise while learning to reduce their blood sugar levels. At the end of this activity, the researcher and assistants asked the participants to do a skill-building activity "together, bonding and promise" so that they promised to exercise 30–40 minutes a day three times a week while recording their exercise in the diary. Similar to a quasi-experimental (pretest–posttest) study in Indonesia, an experimental group received a diabetes self-management program for patients in which their activities focused on providing patients with exercise knowledge and a personal plan for daily exercise for 30 minutes. After the end of the study, it was found that the experimental group had higher exercise behavior scores and lower Hba1c level scores than those in the control group ($p < 0.005$).[36] This is consistent with another diabetes study indicating that regular exercise for patients with T2DM had positive effects on glycemic control levels and disease complications.[37] Moreover, several studies found that educating and enhancing self-management skills for people with diabetes, such as food management, exercise, and medication, can be implemented to improve physical, mental and behavioral health outcomes among people with diabetes.[38–41]

Regarding FBS and HbA1c levels recorded in this study, the intervention group participants had decreased cumulative glycemic levels after the program as well as in the follow-up period. In addition, the scores were statistically significantly lower than those in the control group. Hence, we can conclude that significant reductions in diabetes biomarkers resulted due to the implemented program. Importantly, counseling and advice were provided to the participants through program activities, including home visits and phone calls after the end of the program. This encouraged the participants to adhere to the prescribed recommendations. This is consistent with a previous study that found that when participants who participated in a program were followed up with health education, counseling and telephone calls, improved self-care behaviors and lower HbA1c levels were seen compared to those in the control group.[32] Other studies also found positive outcomes in

diabetes self-care activities after patient knowledge improved after the telemedicine method was used.[42] Moreover, a systematic review also indicated that implementation of a diabetes care program could reduce HbA1c levels by 1 to 2%.[43]

In addition, an improvement in participants' eGFR levels was seen after the program. Specifically, the eGFR levels of the elderly in the intervention group increased both after the program and the follow-up periods. Moreover, the scores of the intervention groups were significantly higher than the control group. This is because in this research program we reinforced the participants' self-esteem via the use of several activities thus giving positive effects on their self-care management. In addition, self-efficacy is the mediator or mediator of the concept of self-management.[44]

The outcomes of the study were successful as several components of health literacy were incorporated in activities, including cognitive skills, communication skills, decision-making skills, and self-management skills. Each activity focused on knowledge, education, and self-care when managing diabetes. As a result, the participants were able to make informed decisions to modify their self-care behaviors.[44] Our research program included a scheme whereby daily meal menus were organized according to a color-zone diet model, a local diet based on the 6:6:1 formula from the health guidelines, exercise instruction, daily diary for health recording, and follow-ups including phone calls and home visits. Consistent with a South Korean study, the self-care practice scores among experimental group participants after joining the program increased significantly compared to those in the control group. Moreover, the participants' self-care practices changed significantly over time ($p < 0.001$) indicating that physiological indicators of renal function, including BUN, creatinine, and eGFR, were altered.[45]

Limitations and Recommendations

There are several limitations present when interpreting the results. This was a quasi-experimental study using pretest–posttest design between two groups of elderly participants; therefore, the inference of conclusions is limited to that group. This study was also conducted during the COVID-19 pandemic; and the Thai government implemented many prevention measures, such as social distancing and home isolation. Therefore, the data obtained during these preventive measures may have been influenced by changes in the scores of the intervention group. Therefore, during the activities, it may have been necessary to carefully control the variables before using statistics for analysis considering that participants were to be retested for HbA1c at the 12-week post-program and the 3-month follow-up period. Thus, to make valid recommendations, it is necessary to investigate the long-term effects of program activities and to track the persistence of health literacy and health prevention behaviors on glycemic control in the elderly. Furthermore, the health literacy program used in this study in Phayao Province may not be representative of other populations. However, the program can be applied to people at risk of diabetes or other diseases in rural areas, as well as in conjunction with other approaches. Future research should include lipid levels as indicators and qualitative research methods to obtain insightful information in order to deeply explore the inner feelings of risk type 2 diabetic patients toward health literacy and self-care behaviors.

Conclusion

The intervention program outlined in this study applied relevant principles, concepts, and theories in designing activities with the aim of positively changing and improving health behaviors of elderly persons with risk T2DM. As a result, the participants used their own ability to access health information and better understand diabetes, as well as the benefits of self-management and health behaviors. This significantly affected their decision-making by changing their self-behaviors in controlling blood sugar levels and preventing diabetes. These health components should be supported by health policy, and collaboration among health networks, communities, and key people in the community in diabetic care planning for patients and risk groups should also be considered.

Data Sharing Statement

The datasets generated during and/or analyzed during the current study will be available upon reasonable request from the first author. Email: eungkaew@gmail.com

Ethical Approval

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the University of Phayao Human Ethics Committee, Thailand (2/090/61 approved 10 May 2019). The trial was registered at Thai Clinical Trials Registry (https://www.thaiclinicaltrials.org/), and the registration number is TCTR20210524006 (approved 24 May 2021). The trial was registered and participants gave a written informed consent prior to data collection.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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