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Effectiveness of the NERSD program in reducing HbA1c levels in patients with uncontrolled diabetes in Northern Thailand

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ABSTRACT

Background: Uncontrolled diabetes mellitus (DM) is a public health problem that has a large impact on the economics of caring for individuals over the long term. This study aimed to evaluate the effectiveness of proper food consumption, regular exercise, Roy's adaptation model, stress management, and regular drug taking (NERSD) program to reduce HbA1c in patients with uncontrolled diabetes. **Methodology:** A randomized control trial was used to implement a NERSD program designed to control HbA1c levels among patients with diabetes in Wiang Chiang Rung District, Chiang Rai Province, Thailand. Intervention and control groups were assigned by a random allocation method after careful screening for uncontrolled blood glucose among 60 DM patients, indexed by HbA1c>7.0. The intervention program took 9 months to complete. A t-test and repeated measures analysis of variance was used to detect a significance level of α=0.05. **Results**: A total of 60 patients with uncontrolled diabetes were recruited for the study, with 30 patients each in the intervention and control groups. Among the interventions, 80.0% of the patients were female, 50.5% were aged between 50 and 59 years, 66.7% had graduated from primary school, 83.4% were farmers, 90.0% were paid 5,000 baht per month, and 43.4 were diagnosed with diabetes for 1–5 years. In the control group, 70.0% of the patients were female, 53.4% were aged between 50 and 59 years, 86.7% had graduated from primary school, 76.7% were farmers, 96.7% were paid 5,000 baht per month, and 73.3% were diagnosed as having diabetes for 1–5 years. At the end of the intervention, knowledge of the disease and drugs (*P*-value <0.001) and preventive skills (*P*-value = 0.004) were found to be different between the groups. HbA1c levels between the control and intervention groups were statistically significant (*P*-value <0.001). **Conclusion**: The NERSD program was found to be effective in reducing HbA1c levels among patients with uncontrolled diabetes in district hospitals of northern Thailand. This program should be promoted for use in other district hospitals that handle similar populations in Thailand.

Keywords: *Uncontrolled diabetes, Exercise, Nutrition, Stress, Drugs, Roy's model*

Introduction

Diabetes mellitus (DM) is a major health threat [1-2]. According to the World Health Organization (WHO),422 million patients have diabetes and 1.5 million die of diabetes each year globally [3]. It was found that 80% of these diabetes patients were living in low- and middle-income countries, including in Thailand [4]. Diabetes is clearly demonstrated as one of the major contributors to the reduction of a patient's quality of life (QOL) [1]. After being diagnosed with diabetes, patients and their families often face several adverse consequences, such as financial burden due to medical consultation and treatments [5], loss of daily income [6], reduction in the quality of life of [7], and complications [8].

Uncontrolled diabetes is defined as uncontrolled blood sugar after taking medicines, which is indicated by HbA1c levels >7% [9]. Poor control of blood glucose in patients with diabetes leads to life-threatening complications, such as diabetic ketoacidosis (DKA) [3], heart attack [4], and stroke [5]. Chronically high blood sugar levels lead to damage to the nerves, blood vessels, and vital organs [6]. In Thailand, more than half the patients with diabetes have uncontrolled blood glucose levels [10]. Therefore, the health system of Thailand is faced by challenges in terms of both an increased number of diabetes patients and health problems from the complications of uncontrolled blood glucose. Uncontrolled blood glucose in patients with diabetes is related to several factors such as improper quality and quantity of food consumption [7], no regular exercise [8], poor stress management [11], and poor knowledge regarding the prevention and control of diabetes [12]. According to Roy's model, setting up both physical and other essential information could positively address a health problem effectively [9-10].

District hospitals in Thailand have been designated as one of the important health institutes in the country [13]. A hospital's duty is to respond to all medical and public health missions to support people's health including medical care, prevention, and promotion [14]. Because of its scale and associated complications, diabetes consumes most of a hospital's resources [15]. A significant amount of hospital finance is spent on caring for non-communicable diseases, especially for diabetes [16]. Caring for diabetes patients has been the responsibility of the healthcare professionals, rather than integrating both health care professionals and patients for more effective results, as mentioned in Roy's model.

Chiang Rai is located in northernmost Thailand and a large proportion of people in this province work in the agricultural sector [17]. People living in this area have poor education and economic status [18-20]. In line with their occupation conditions, most people spend their time on farms and experience economic constraints, especially during the coronavirus disease 2019 (COVID-19) pandemic. During an epidemic, the challenges associated with accessing health institutes increase [21]. Considering the current COVID-19 pandemic and the need to improve the uncontrolled blood glucose condition in diabetes patients, it is necessary to develop a proper model to facilitate the minimization of the problem.

Therefore, this study aimed to examine the effectiveness of proper food (N), proper and regular exercise (E), modification of the environment in terms of improvement under the concept of Roy's model (R), stress management ability (S), and adherence to taking drugs (D) (NERSD Program) in controlling HbA1c among diabetes patients who were classified as having uncontrolled blood glucose at a district hospital in northern Thailand.

Methodology

Study setting

This study was conducted at a DM clinic in Wiang Chiang Rung Hospital, Chiang Rai Province, Thailand.

Study design

A randomized control trial was used to examine the effectiveness of the NERSD program.

Study sample and sample size calculation

The sample size was calculated using a standard formula for randomized control trials. The comparison between the two groups with the endpoint was done using quantitative data, and it was given as follows: $n = 2SD^2(Z_{\alpha/2}+Z_{\beta})^2/d^2$ [13], where standard deviation (SD) was used as the value from the previous study, which was 0.2 [14]; $Z_{\alpha/2}$ was a type-I error at the 95% confidence interval, which was 5.0%; $Z_{\alpha/2}$ was 0.84 at 80% power of the test; d was the effect side or the difference between means, which was 0.6 [14]. From the calculation, it was found that 30 participants were required for each group.

Intervention

The NERSD Program was designed and provided to the intervention group. The program focused on providing appropriate knowledge regarding nutrition, exercise, Roy's adaptation concept, stress management, and information regarding DM at the first session of the intervention, which was classified into three phases. In phase one, the intervention group was provided appropriate knowledge regarding nutrition, exercise, stress management, appropriate drug intake, and information regarding DM prevention control and care. In phase two, the intervention group was provided knowledge, information demonstrations for appropriate cooking practices, and introduced to nutrition profiles of several kinds of food. Finally, in phase three, the intervention group was provided information and given demonstrations for appropriate exercise. The intervention was performed between November 2020 and October 2021.

Measurements

Questionnaires were developed based on the literature review. This was validated before use. The final version of the questionnaire consisted of three parts. Part one consisted of 12 questions which were used to collect general characteristics of participants, such as age, sex, education, occupation, and so on. In part two, eight questions were provided to collect participants' knowledge regarding DM disease prevention and control. In part three, 42 questions were used to collect participant's knowledge about preventive practices on DM with respect to the NERSD program.

The item-objective congruence (IOC) method was used for the content validation of questionnaires. During the IOC, three experts (one internal medicine, one non-communicable disease expert, and one nutritionist) were invited to assess the quality of the questions. Each question was scored -1 if non-relevant to the context, 0 if a question presented as relevant but required some revision, and +1 if a question presented relevancy to the context.

Scores from the experts were pooled before final interpretation. Questions that scored 0.5 were deleted from a set of the questionnaire; questions that scored 0.60-0.70 were revised and put into the set of the questionnaire, while questions that scored 0.7 were pooled into the set of the questionnaire.

Afterwards, the questionnaire was administered to 15 selected people who had similar characteristics as the participants, with the purpose of testing the feasibility, understandability, and order or sequence of the questions. Finally, Cronbach's alpha was calculated to determine its reliability for parts two and three, which was found to be 0.81.

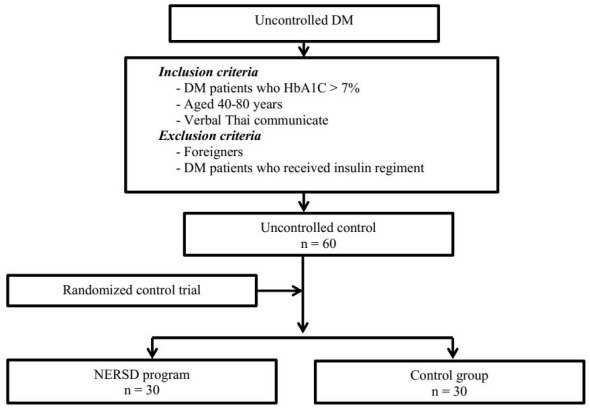

Figure 1 Experimental procedure

Procedure

Patients with uncontrolled DM were recruited from a hospital DM list. Participants were recruited according to the following inclusion criteria: 1) HbA1c level > 7%; 2) aged ≥40 years; and 3) able to use Thai. Those receiving an insulin regimen were excluded from the study (Figure 1).

According to the inclusion and exclusion criteria, 60 patients were invited to participate in the study and allocated into the intervention group (30 patients) and control group (30 patients).

The three phases were executed among those participants who were allocated to the intervention. During the intervention, knowledge and preventive practice according to diabetes prevention, control, and care were measured at baseline and 3, 6, and 9 months. The HbA1c level was also measured at these times.

The participants in the control group, were not provided any intervention, however all participants were assessed by the measurements used among the interventions. Furthermore, participants of this group were provided with all interventions as provided to the intervention group after completion of the final assessment. This was done to cooperate with ethical issues for intervention research to maintain the rights of participants in the control group.

Statistical analysis

Descriptive data analysis was performed accordingly. Categorical data were analyzed as percentages, while continuous data were presented as means and standard deviations. A chi-square was used to detect different proportion between groups. A t-test was used to detect means between groups at a significance level of 0.05. Two-way repeated measure analysis of variance was used to assess the different means within the group measured multiple times.

Ethical consideration

All study concepts and intervention protocols were approved by the Chiang Rai Provincial Public Health Research Ethics Committee on Human Research (CRPPHO No.67/2563). All participants were provided information regarding the study before obtaining their informed consent. All participants were interviewed accordingly.

Results

A total of 60 participants (30 each in the intervention and control groups) were recruited into the study. Of them, 50.0% were females, 51.7% were aged between 50 and 59 years (mean=57.5, SD=6.2), 88.3% were married, 76.7% had graduated from primary school, 80.0% worked in the agricultural sector, 93.3% were paid < 5,000 Thai Baht (THB)/month (median= 3,000, IQR=1,500), and 58.3% had been diagnosed with uncontrolled DM for 1–5 years (mean=5.5, SD=3.8) (Table 1).

In the intervention group, 80.0% of the patients were female, 50.5% were aged between 50 and 59 years (mean=58.8, SD=6.1), 88.3% were married, 66.7% had graduated from primary school, 83.4% worked in the agricultural sector, 90.0% were paid <5,000 THB/month (median= 3,000, IQR=1,500), and 43.4% had been diagnosed with uncontrolled DM for 1–5 years (mean=6.4, SD=4.3) (Table 1).

Of the patients in the control (30 participants) group, 70.0% were female, 53.4% were aged between 50 and 59 years (mean=56.2, SD=6.0); 93.3% were married; 86.7% had graduated from primary school; 76.7% worked in the agricultural sector; 96.7% were paid <5,000 THB (median= 3,000, IQR=1,500), and 73.3% were diagnosed with DM diagnosed for 1–5

years (mean=4.5, SD=2.9). The general characteristics of the two groups were found to be non-statistically significant (Table 1).

The scores on practicing diabetes drug taking, healthy food consumption, regular and proper exercise, and having individual stress management were found to be statistically significant in months 3, 6, and 9 (*P*-value < 0.001). Only drug taking was not found to be statistically significant at the 0 month between the groups (Table 2).

While looking closer into each group during the study period, we detected the statistical change of HbA1c: the decreased means in the intervention and fluctuation means in the control group. In the final model, repeated measures were compared between the two groups, and the results were statistically significant (Table 3).

Table 1 General characteristics of participants

Characteristics	Total n (%)	Intervention n (%)	Control n (%)	χ^2	*P*-value
Sex					
Male	15 (50%)	6 (20.0)	9 (30.0)	0.80	0.371
Female	45 (50%)	24 (80.0)	21 (70.0)		
Age (years)					
40-49	7 (11.6)	2 (6.6)	5 (16.6)	2.04	0.360
50-59	31 (51.7)	15 (50.5)	16 (53.4)		
≥60	22 (36.7)	13 (43.3)	9 (30.0)		
	Mean=57.5, SD= 6.2	***Mean=58.8, SD=6.1***	***Mean=56.2, SD=6.0***		
Marital status					
Married	53 (88.3)	25 (83.3)	28 (93.3)	1.45	0.228
Other	7 (11.7)	5 (16.7)	2 (6.7.0)		
Education					
Illiterate	6 (10.0)	4 (13.3)	2 (6.7)	3.45	0.178
Primary school	46 (76.7)	20 (66.7)	26 (86.7)		
≥High school	8 (13.3)	6 (20.0)	2 (6.6)		
Occupation					
Unemployment	2 (3.3)	0 (0.0)	2 (6.7)	1.76	0.643[a]
Employment	10 (16.7)	5 (16.6)	5 (16.6)		
Agriculture	48 (80.0)	25 (83.4)	23 (76.7)		
Income (THB)					
< 5000	56 (93.3)	27 (90.0)	29 (96.7)		
≥ 5000	4 (6.7)	3 (10.0)	1 (3.3)	1.12	0.612[a]
	Median= 3,000 IQR=1,500	***Median=3,000, IQR=1,500***	***Median=3,000, IQR=1,000***		
Length of having been DM diagnosed (years)					
1-5	35 (58.3)	(43.4)	22 (73.3)		
6-10	17 (28.4)	11 (36.6)	6 (20.0)		
11-15	8 (13.3)	6 (20.0)	2 (6.7)	5.61	0.069[a]
	Mean= 5.5, SD=3.8	***Mean=6.4, SD=4.3***	***Mean=4.5, SD=2.9***		

** Significant level at α=0.05*

[a] Fisher's exact test

Table 2 Preventive practices score on diabetes drug taking, proper food consuming, regularly exercise, and stress management

Characteristics	Intervention		Control		t-test	*P*-value
	mean	SD	mean	SD		
Drug						
0th day	10.7	2.1	10.4	1.9	*0.59*	*0.558*
3 months	12.3	0.9	4.8	1.9	*19.90*	*<0.001**
6 months	12.1	1.3	4.8	1.9	*17.54*	*<0.001**
9 months	12.4	0.9	5.7	2.0	*16.40*	*<0.001**
F= 11.21, *P*-value = <0.001*			F=73.86, *P*-value <0.001*			
F=76.34, *P*-value <0.001*						
Food						
0th day	38.7	4.7	42.0	2.8	*-3.33*	*0.002**
3 months	45.2	2.4	33.5	5.1	*11.42*	*<0.001**
6 months	41.8	3.5	33.5	5.1	*7.39*	*<0.001**
9 months	45.4	2.8	33.2	5.2	*11.33*	*<0.001**
F= 31.41, *P*-value <0.001*			F=33.99, *P*-value <0.001*			
F=60.28, *P*-value <0.001*						
Exercise						
0th day	5.7	1.7	4.1	1.6	3.83	<0.001*
3 months	7.3	1.5	4.1	1.6	8.13	<0.001*
6 months	6.3	1.2	4.1	1.6	6.11	<0.001*
9 months	7.5	1.5	4.3	1.5	8.42	<0.001*
F= 11.83, *P*-value <0.001*			F= 0.21, *P*-value = 0.801			
F=5.16, *P*-value = 0.003*						
Stress management						
0th day	23.0	4.8	16.9	0.8	*6.84*	*<0.001**
3 months	26.6	0.5	17.5	2.3	*21.19*	*<0.001**
6 months	18.8	2.0	17.5	2.3	*2.23*	*0.030**
9 months	22.2	2.7	16.7	1.6	*9.59*	*<0.001**
F= 35.43, *P*-value <0.001*			F= 1.43, *P*-value = 0.246			
F=25.19, *P*-value <0.001*						

** Significant level at α=0.05*

Table 3 Means of HbA1c of participants in different phases

Characteristics	Intervention		Control		t-test	*P*-value
	mean	SD	mean	SD		
HbA1c						
0th day	9.0	1.4	8.7	1.1	*0.76*	*0.451*
3 months	7.8	1.7	9.3	1.6	*-3.49*	*0.001**
6 months	8.6	1.5	9.7	1.4	*-3.15*	*0.003**
9 months	7.5	1.1	9.3	1.6	*-4.98*	*<0.001**
F= 8.99, *P*-value = 0.001*			F= 4.04, *P*-value = 0.016*			
F=8.51, *P*-value <0.001*						

** Significant level at α=0.05*

Discussion

The diabetes patients with uncontrolled blood glucose in Wiang Chiang Rung Hospital, Chiang Rai Province, Thailand tended to be female, older, and with poor socioeconomic status (SES) with an average year of diabetes diagnosis at 5.5 years. The NERSD Program significantly reduced the HbA1c levels in the intervention group compared to the control group after 9 months of intervention.

Our study showed that the NERSD program could improve the knowledge and skills of diabetes patients that are essential for blood glucose control, such as the knowledge of drug taking, healthy food consumption, regular exercise, and coping with individual stress appropriately under the environmental conditions of Roy's concept. These practices are essential to maintain the patients' blood glucose levels. Roy's concept of creating a friendly environment to support patients' learning to maintain desired behaviors is also important. Our findings are supported by a randomized

controlled trial on a web-based educational intervention to improve knowledge of healthy diet and lifestyle in women with diabetes conducted in Australia [15]. Another study in China [16] reported that educational intervention program in primary care can increase diabetes awareness among patients with type 2 DM. In Thailand, Ratipark et al. [17] also reported that community-based interventions could improve knowledge and attitudes toward diabetes prevention. Therefore, providing knowledge regarding diabetes disease and preventive care are key tools for improving diabetes patients' self-care.

The main challenge of this study was that all patients with uncontrolled blood glucose diabetes were with SES. This posed challenges in terms of how healthcare professionals could maintain healthy food among the patients given their socioeconomic conditions. Moreover, regular exercise was also a critical point because many studies in Thailand reported that people were living in a stage of poor regular exercise [22-24].

Stress has been defined as one of the contributing factors to health, especially in diabetes, particularly during the COVID-19 pandemic. With the integration of SES and COVID-19, people in northern Thailand have been suffering from stress. Northern Thailand has been reported as a crisis for COVID-19 [25]. Therefore, providing patients with knowledge and skills on personal stress coping was clearly shown in their integrated impact of the reduction of HbA1c.

This study has some limitations. First, some patients in the intervention could not completely adhere to the protocols, especially exercise, due to their old age. Second, with regard to having healthy food, it was found that some patients were unable to prepare food in daily life. Other family members prepared for some participants in their daily lives, and it was difficult to educate those individuals regarding healthy food preparation practices. Finally, although the study had two separate groups (intervention and control) and interventions to the control group was carefully avoided, some points of intervention, such as knowledge on having healthy food, exercise, stress coping, and taking drugs was regularly and commonly provided to all patients attending the clinic of the hospital. This may have interfered with the results.

Conclusion

The NERSD program is effective in reducing HbA1c levels in patients with uncontrolled diabetes after providing knowledge and skills on diabetes, drugs, food, exercise, and stress coping skills in Roy's environment. Nine months of intervention, including education and skill development, helped patients control their blood glucose. Motivating patients to be informed about these practices helps reduce HbA1c levels.

The NERSD program should be promoted in all district hospitals to address uncontrolled blood glucose levels in diabetes patients. This should be considered as one of the tools added to the standard care for diabetes patients, which might improve the patients' health and eventually reduce the health economics of a country.

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