ผลของโครงการโรคเบาหวานระยะสงบต่อระดับน้ำตาลในเลือดและดัชนีมวลกาย ในคนไข้เบาหวานชนิดที่ 2 ของโรงพยาบาลบ้านนาและโรงพยาบาลองครักษ์ จ.นครนายก

Effects of DM Remission Program on Blood Glucose Control and Body Mass Index in Type 2 Diabetes Patients at Banna Hospital and Ongkharak Hospital, Nakhonnayok Province, Thailand

นิพนธ์ต้นฉบับ

Original Article

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บทคัดย่อ

วัตถุประสงค์: เปรียบเทียบค่าระดับน้ำตาลปลายนิ้ว (capillary plasma glucose; CPG) โดยวิธี DTX, ระดับน้ำตาลในเลือดสะสม (HbA1c) กับค่าดัชนีมวลกาย (body mass index; BMI) ก่อนและหลังเข้าร่วมโครงการโรคเบาหวานระยะสงบ (DM Remission) และทดสอบความสัมพันธ์ของ CPG และ HbA1c กับ BMI **วิธีการศึกษา:** การศึกษากึ่งทดลองแบบกลุ่มเดียวทดสอบก่อน-หลัง กลุ่มตัวอย่างเป็นผู้ป่วยเบาหวานชนิดที่ 2 จำนวน 352 คน ที่ รพ.บ้านนาและรพ.องครักษ์ (n = 302 และ 50 คน ตามลำดับ) มีการเรียนรู้และฝึกปฏิบัติปรับเปลี่ยนพฤติกรรม 3 ครั้ง คือ ที่ 0, 1 และ 3 เดือน เปรียบเทียบค่า CPG, HbA1c และ BMI ก่อนและหลังโครงการด้วยสถิติ paired t-test และทดสอบความสัมพันธ์ระหว่าง CPG และ HbA1c กับตัวแปรต้นคือ BMI ที่หลังการทดลองด้วยการวิเคราะห์ความถดถอยเชิงเส้นตรง **ผลการศึกษา:** หลังโครงการ ค่า CPG ลดจาก 144.23 เป็น 139.90 มก./ดล (P-value = 0.035) และ HbA1c ลดจาก 8.11% เป็น 7.06% (P-value < 0.001) ส่วนค่า BMI ลดจาก 27.43 เป็น 26.87 mg/m^2, P-value < 0.001) เมื่อพิจารณาแยกโรงพยาบาล พบว่ามีนัยสำคัญทางสถิติคือที่ รพ.บ้านนา HbA1c ลดจาก 7.90% เป็น 7.04% (P-value < 0.001) และ BMI ลดจาก 27.33 เป็น 26.71 mg/m^2 (P-value < 0.001) ส่วน รพ.องครักษ์ CPG ลดจาก 147.10 เป็น 135.22 mg/dl (P-value = 0.0345) และ HbA1c ลดจาก 9.38% เป็น 7.14% (P-value < 0.0014) หลังโครงการ BMI สัมพันธ์ทางบวกกับ HbA1c (r = 0.118; β = 0.12, P-value 0.027) **สรุป:** โครงการ DM Remission 3 เดือนลด HbA1c และ BMI ได้ และ HbA1c สัมพันธ์ทางบวกกับ BMI ซึ่งสะท้อนประสิทธิผลของการปรับพฤติกรรมในการควบคุมระดับน้ำตาลและภาวะเมตาบอลิกของผู้ป่วยเบาหวาน

คำสำคัญ: เบาหวานชนิดที่ 2; การควบคุมระดับน้ำตาลในเลือด: การปรับพฤติกรรม; โรคเบาหวานระยะสงบ

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Abstract

Objective: To compare capillary plasma glucose (CPG) measured by CPG, HbA1c and BMI before and after the DM Remission program and examine the associations of CPG and HbA1 with BMI in type 2 diabetes patients. **Methods:** This quasi-experimental study use the one-group pretest-posttest design. Participants were 352 type 2 diabetes patients at Banna Hospital and Ongkharak Hospital, Nakhonnayok province, Thailand (n = 302 and 50, respectively) participating in the behavioral modification learning and training with 3 sessions (i.e., at 0, 1 and 3 months). Mean values of CPG, HbA1c and BMI before and after the program were compared using paired t test. Associations of CPG and HbA1c with BMI as the independent variable were tested with linear regression analysis. **Results:** After the program, CPG decreased from 144.23 to 139.90 mg/dl (P-value = 0.035) and HbA1c decreased from 8.11% to 7.06% (P-value < 0.001); while BMI decreased from 27.43 to 26.87 mg/m^2 (P-value < 0.001). Regarding the two hospitals, significant decreases were found in Banna Hospital for HbA1c (from 7.90% to 7.04%, P-value < 0.001) and BMI (from 27.33 to 26.71 mg/m^2, P-value < 0.001), and in Ongkharak Hospital for CPG (from 147.10 to 135.22 mg/dl, P-value = 0.0345) and HbA1c (from 9.38% to 7.14%, P-value < 0.0014). At the end of the program, BMI was significantly positively associated with HbA1c both with correlation (r = 0.118, β = 0.12, P-value 0.027). **Conclusion:** The 3-month DM Remission program decreased HbA1c and BMI. HbA1c was positively associated with BMI indicating the effectiveness of this behavioral modification program to control blood glucose and metabolism of type 2 diabetes patients.

Keywords: type 2 diabetes patients; blood glucose control; behavioral modification; diabetes remission; DM remission program

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Introduction

Type 2 diabetes is a major non-communicable disease worldwide with an ever-increasing incidence. The World Health Organization (WHO) and the International Diabetes Federation (IDF) estimated a total of 783 million diabetic patients in 2045. With its increasing worldwide incidence, diabetes has been posing more burden on economic and health system.[1] Effective glycemic control needs medical treatment and lifestyle modifications which are recommended by the American Diabetes Association (ADA).[2] In Thailand, 300,000 new cases of diabetic patients annually have been found with an increasing death rate from 2015 to 2019. Proportion of patients with poor glycemic control has been substantial.[3]

Diabetes Remission program (or DM Remission) is one of the policies to alleviate the burden of diabetes introduced by Thailand Ministry of Public Health and The Diabetes Association of Thailand.[4] DM Remission program offers concepts and protocols to achieve diabetes remission called the Remission Service. All-level hospitals nationwide could apply the service to fit their own healthcare system context. In DM Remission program, lifestyle medicine is the main care modality with the limited additional use of diabetes drugs.

In addition to pharmacological treatment, lifestyle modification plays a major role in glycemic control in diabetic patients. This behavioral change could be achieved through health literacy. The United Nations Educational Scientific and Cultural Organization (UNESCO) suggests that health literacy is crucial in controlling non-communicable disease especially in areas with limited medical care and information access and The United Nations Sustainable Development Goals (SDGs) emphasizes the chronic disease burden through community health promotion.[5-7] Healthcare based on lifestyle modification shows effective glycemic control.[8]

In Thailand, DM Remission program with the lifestyle medicine uses 6 domains for behavioral modification in diabetic patients including 1) appropriate body weight control, 2) proper mobility and regular exercise, 3) stress management and good mental health, 4) quality sleep, 5) avoid poisonous substances, and 6) good relationship.[4] Lifestyle medicine is applied to suit local areas with specific context (e.g., culture and lifestyles) for primary healthcare. Learning activities in DM Remission program included class lecture, training, role model, experience sharing, empowerment[9] through home follow-up, and periodical evaluation by multidisciplinary team (i.e., physicians, nurses, physical therapists, psychologist/psychotherapists, and dietitians) and village heath volunteers and sub-district health promoting hospital healthcare providers.

Healthcare based on lifestyle medicine offered effective LDL reduction in Thai patients.[10] However, outcomes of DM Remission program by other institutions at the time of the preparation of our present study were not known. The study of outcomes of DM Remission program at community hospitals was of great need.

Type 2 diabetes is a complicated metabolic disease associated with insulin resistance and pancreatic beta-cell impairment. Glycemic control and complication prevention are the goal. Higher body mass index (BMI) is associated with more insulin resistance and poorer glycemic control as shown in international studies[11] and a study in Thailand.[12] Not only for direct glycemic control, but lifestyle modification is also for BMI reduction which could potentially further alleviate insulin resistance and a better glycemic control. Therefore, DM Remission program could be expected to positively improve BMI and glycemic control reflected by 1) Capillary plasma glucose level measured by Dextrostix® or DTX method and 2) HbA1c level.

Banna Hospital and Ongkharak Hospital, district-level community hospitals with 90 and 60 beds, respectively in Nakhonnayok province, Thailand prepared implementing the DM Remission program lifestyle since late 2023. These two district-level community hospitals had networks of sub-district health promoting hospitals. Since the time of planning to implement and conduct research on DM Remission program in Banna Hospital and Ongkharak Hospital around late 2023, there has been no studies to demonstrate the benefits of the DM Remission program in Thailand. Therefore, this present study aimed to test benefits of DM Remission program in reducing BMI and improving glycemic control (i.e., reducing CPG and HbA1c) at the community hospital level. In addition, the relationships between BMI and glycemic control (i.e., HbA1c) were shown in previous studies.[11-13] However, these studies were observational, not interventional in design. Therefore, we also aimed to examine relationships between BMI and glycemic control (i.e., HbA1c and CPG) in this interventional study.

For **specific objectives,** this present quasi-experimental study aimed to 1) compare CPG, HbA1c and BMI measures before and after the DM Remission program and 2) test the associations of BMI as independent variable and glycemic control measures (i.e., CPG and HbA1c levels) as dependent variables after the DM Remission program. The associations were adjusted for age, sex and study setting (i.e., Banna Hospital and Ongkharak Hospital). Higher HbA1c were found in men and those age 30 – 49 years old.[13,14] Study setting (i.e., Banna Hospital and Ongkharak Hospital) was adjusted for since patients of these two hospitals might have different patient's demographic characteristics. Accordingly, it was **hypothesized** that CPG, HbA1c and BMI before and after the DM Remission program were not different and BMI was not associated with CPG or HbA1c after the program. The tests of associations of BMI

with HbA1c and CPG after the program assumed that BMI and HbA1c measures need considerable time for change (except for CPG). The measures from the same time point should be used for association test.

Methods

In this quasi-experimental research, all participating patients were trained with the DM Remission learning/training activities with the one-group pretest-posttest design. Study population was all patients who were diagnosed with type 2 diabetes up to the year 2024 and taken care of at Banna Hospital (N = 3,280)[15] and Ongkharak Hospital (N = 2,151)[16] (total of 5,431 patients). Study sample was those in the study population who were selected through multi-stage stratified random sampling on sub-district. Individual patients were then selected with purposive sampling. To be eligible, participants had to be 18 years or older, have HbA1c more than 6.5%, and be able to participate at least 80% of the study conduct time. However, those who had severe illnesses (e.g., end-stage renal disease and severe heart disease) and were unable to meet the 80% participation time were excluded. Data of those who withdrew were not included for analysis.

For sample size, it was estimated based on the findings from a previous study where HbA1c after the educational program in 45 diabetic patients decreased 9.46 $\pm$ 2.64% to 8.43 $\pm$ 1.50%.[17] With a type I error = 5% (two-sided) and a power of 80% for paired t test, 37 participants were required. For linear regression analysis, with a small effect size assumed (0.20), a type I error of 5% (two-sided), a power of 80%, and 4 independent variables (i.e., BMI, sex, age, and hospital), 304 participants were needed.[18]

Research instruments

The instruments were the experimental intervention (i.e., DM Remission program) and the form to collect the participants' demographic characteristics, BMI (kg/m^2), CPG (mg/dL) (measured by Dextrostix® or DTX method) and HbA1c (%).

The experimental intervention

Before the first participant learning session, the researcher and DM Remission multidisciplinary team (i.e., physicians, nurses, physical therapists, psychologist/ psychotherapists, and dietitians) trained village heath volunteers and sub-district health promoting hospital healthcare providers about lifestyle medicine and DM Remission program. These village heath volunteers and sub-district health promoting hospital healthcare providers were trained to advise participants in their community on technical aspects of lifestyle modification. For example, advising participants on what food or drink should be consumed when asked and assisting the participants in carbohydrate consumption counting. The interaction between participants and village heath volunteers and sub-district health promoting hospital healthcare providers could be done in-person or online using LINE application as convenient for the participants.

The preparation of the DM Remission program started in November 2023. After the ethical protection was approved, recruitment and experimental conduct was initiated in August 2024. The researcher made appointments for the participants for the 3 training sessions. In each session, DM Remission multidisciplinary team members (i.e., physician, nurse, public health officers, physical therapist, psychotherapist, and dietitian) taught and trained the participants with their respective expertise. In sessions 2 and 3, in addition to teaching and training, multidisciplinary team also offered consultation and advice, specifically by identifying, solving and preventing problems with options suitable for specific patients.

The **first session** took one day. Six domains of Lifestyle Medicine were taught (i.e., 1) appropriate body weight control, 2) proper mobility and regular exercise, 3) stress management and good mental health, 4) quality sleep, 5) avoid poisonous substances, and 6) good relationship) with practical examples given to promote motivation to control blood sugar (3 hours). In the afternoon, the two-hour training was done with rotation to six bases of health status evaluation, exercise, food selection, carbohydrate consumption counting, quality sleep, and medication therapy. With a large number of participants, four training days were scheduled for four groups (70 – 80 participants per group). The first session for the first group was conducted in August 2024 while that of the fourth group was in February 2025.

The researcher collected demographic and clinical characteristics of the participants. CPG (measured by DTX method) and HbA1c levels were the latest visit from the electronic medical records before the study. BMI was

calculated based on the weight on the session day. Participants were also asked to complete behavior-related and health literacy questionnaires for the program, but the results are not presented in this research article.

The **second session** was carried out about a month from the first one. In this one-day session, participants were taught and practically trained with effective carbohydrate consumption reduction and intermittent fasting (IF), meal replacement, blenderized diet and grain beverage preparations, simple exercise for blood glucose control, and mindfulness training. Blood sugar level target was reminded, discussion session allowed participants to share problems and obstacles in modifying their behaviors with each other and the multidisciplinary team for identifying problems and seeking options for solving and preventing such problems. CPG, HbA1c and BMI levels were measured on the same day.

The **third session** was held about two months from the second one, or a total of three months from the first one. Participants were encouraged to share their experiences in self-care and lifestyle modification for the care of diabetes and hypertension among themselves and the multidisciplinary team. Problems and obstacles in modifying their behaviors with each other and the multidisciplinary team for identifying problems and seeking options for solving and preventing such problems. CPG, HbA1c and BMI levels were measured on the same day.

Participants ethical protection

The study was approved by the Ethics Committee for Human Research of the Provincial Office of Health Administration of Nakhonnayok (approval number: NPHO 2024-023).

Data analysis

Descriptive statistics including mean with standard deviation and frequency with percentage were used to summarize demographic and clinical characteristics and CPG, HbA1c and BMI levels before (month 0) and after the study (month 3 or third session). Comparisons of CPG and HbA1c before and after the study were done using paired t test because both variables were normally distributed. Preliminary associations of BMI with CPG and HbA1c levels after the study were tested using Pearson's correlation analysis because BMI, CPG and HbA1c were normally distributed. If BMI was significantly associated with either CPG or HbA1c, linear regression analysis on HbA1c/CPG (dependent variable variable) with BMI, sex, age, and hospital (independent variables) was conducted. With stepwise regression, insignificant independent variables were removed for consecutive analysis. Predictive power of the remaining independent variables on variance of the dependent variable was determined by R^2. Statistical significance was set a type I error of 5%. All statistical analyses were conducted using SPSS version 20.

Results

Of the 352 participants, most were from Banna Hospital (n = 302 or 85.80%), were women (58.81%), were in their 50 – 59 years of age (39.49%) followed by 40 – 49 (24.15%) and were with co-morbidity (65.91%) especially hypertension (28.41%) (Table 1).

Table 1 Demographic and clinical characteristics of the participants (N = 352).

Characteristics	N	%
Hospital		
Banna Hospital	302	85.80
Ongkharak Hospital	50	14.20
Sex		
Men	145	41.19
Women	207	58.81
Age (years)		
< 40	48	13.64
40 – 49	85	24.15
50 – 59	139	39.49
60 or older	80	22.73
Co-morbidity		
No	120	34.09
Yes	232	65.91
Hypertension	100	28.41
Hyperlipidemia	90	25.57
Hypertension, hyperlipidemia and diabetes	42	11.93

At the end of the study (i.e., month 3), CPG and HbA1c levels decreased from those before the study significantly both when data of the two hospitals combined (CPG: 144.23 to 139.90 mg/dL, P-value = 0.035; HbA1c: 8.11% to 7.06%, P-value < 0.001, respectively) and separated except for CPG at Banna Hospital (for Banna Hospital, CPG: 143.78 to 140.67 mg/dL, P-value 0.161; HbA1c: 7.90% to 7.04%, P-value < 0.001; for Ongkharak Hospital, CPG: 147.10 to 135.22 mg/dl, P-value = 0.0345; HbA1c: 9.38% to 7.14%, P-value < 0.0014). For BMI, the decrease from the start to the end of the study was statistically significant when data from the two hospitals were combined (27.43 to 26.87 mg/m^2, P-value < 0.001). The decrease of BMI of Banna Hospital was significant (27.33 to 26.71 mg/m^2, P-value <

0.001); while the one of Ongkharak Hospital was not (Table 2).

Table 2 Comparisons of CPG, HbA1c and BMI before and after the study (N = 352).

	Mean (SD)		T test	P-value
	Before	After		
CPG (mg/dL)				
All (n = 352)	144.26 (40.90)	139.90 (40.21)	2.12	0.035
Banna Hospital (n = 302)	143.78 (42.50)	140.67 (40.90)	1.40	0.161
Ongkharak Hospital (n = 50)	147.10 (29.64)	135.22 (35.75)	2.18	0.034
HbA1c (%)				
All (n = 352)	8.11 (1.94)	7.06 (1.51)	12.50	< 0.001
Banna Hospital (n = 302)	7.90 (1.90)	7.04 (1.56)	9.68	< 0.001
Ongkharak Hospital (n = 50)	9.38 (1.72)	7.14 (1.17)	12.17	< 0.001
BMI (kg/m^2)				
All (n = 352)	27.43 (4.81)	26.87 (4.66)	7.70	< 0.001
Banna Hospital (n = 302)	27.33 (4.81)	26.71 (4.59)	7.52	< 0.001
Ongkharak Hospital (n = 50)	28.03 (4.82)	27.84 (4.99)	1.85	0.071

At the end of the study, it was found that BMI was significantly, positively correlated with HbA1c (r = 0.118, P-value = 0.027) but not with CPG (r = 0.096, P-value 0.071). Therefore, linear regression analysis was done only for BMI and HbA1c. Among, BMI, sex, age, and hospital, only BMI was positively associated with HbA1c wit statistical significance (β = 0.12, P-value 0.031) (Table 3). The four independent variables together explained only 0.5% of the variance of the dependent variable (i.e., HbA1c) (R^2 = 0.005). The ANOVA test of this linear regression analysis was statistically insignificant ($F_{4,347}$ = 1.40, P-value = 0.232). Once sex, age and hospital variables were dropped, further regression analysis showed that BMI was significantly, positively associated with HbA1c (β = 0.12, P-value 0.027) with significant ANOVA test ($F_{4,350}$ = 4. 92, P-value = 0.0.027). Yet only 1.0% of variance of HbA1c was explained by BMI (R^2 = 0.01) (Table 3).

Table 3 Associations of HbA1c with BMI, sex, gender, and hospital by linear regression (N = 352).

	B	SE	Beta	T test	P-value
HbA1c (after the study)					
BMI (after the study	0.04	0.02	0.12	2.16	**0.031**
Age	-0.01	0.01	-0.04	-0.80	0.422
$Sex_{Women/Men}$	-0.03	0.17	-0.01	-0.18	0.860
$Hospital_{Ongkharak/Banna}$	0.09	0.24	0.02	0.39	0.697
$F_{4,347}$ = 1.40, P-value = 0.232, R^2 = 0.005.					
HbA1c (after the study)					
BMI (after the study)	0.04	0.02	0.12	2.22	**0.027**
$F_{4,347}$ = 4.92, P-value = 0.027, R^2 = 0.01.					

Discussions and Conclusion

In this study on the benefits of the 3-month DM Remission program on glycemic control and BMI at Banna Hospital and Ongkharak Hospital, Nakhonnayok province, Thailand, it showed that average CPG and HbA1c levels significantly decreased at the end of the study when the participants from the two hospitals combined (Banna Hospital and Ongkharak Hospital) and separated except for CPG of Banna Hospital. BMI levels also decreased significantly when data from the two hospitals combined and separated except for those from Ongkharak Hospital.

These findings suggest effectiveness of the DM Remission program in improving health behavior based on the six DM Remission concepts of 1) appropriate body weight control, 2) proper mobility and regular exercise, 3) stress management and good mental health, 4) quality sleep, 5) avoid poisonous substances, and 6) good relationship. These concepts were applied in learning and training to be specific context of given patients with the help of multidisciplinary team members aiming at empowering the continuous systematic improvement.

The change of HbA1c from 7.90% to 7.04% at Banna Hospital and 9.38% to 7.14% at Ongkharak Hospital suggests that this robust biological measure was improved by the 3-month lifestyle modification program. It needs a moderate duration, i.e., 2 - 3 months, for any changes to affect HbA1c. This shows the effectiveness of the DM Remission program in improving intermediate-to-long term glycemic control rather than the easily fluctuating fasting plasma glucose measure like CPG. The change in HbA1c also reflects physiological changes which was the reduction of BMI from 27.43 to 26.87 kg/m^2. At the end of the study, HbA1c was significantly, positively correlated with BMI (correlation coefficient = 0.118, P-value = 0.027; β = 0.12, P-value = 0.027, linear regression). Our findings are consistent with latest studies in Thailand where lifestyle modification program improve glycemic control.[19,20]

With a high BMI, glycemic control becomes more difficult. This high BMI is associated with more insulin resistance. Such resistance is associated with a higher level of visceral fat which makes glucose uptake to the cell less effective. According to DeFronzo (2004), poor insulin resistance is a major factor of type 2 diabetes.[21] A study shows that a reductio of 10 kg or more allows for at least

50% of type 2 diabetic patients to progress to remission without the use of medications. [22] The reduction of fat in the liver and pancreas could improve insulin secretion and subsequently glycemic control.[23]

Obesity and overweight play a major role in increasing insulin resistance and the risk of cardiovascular disease in diabetic patients.[24] Liver fat reduction could improve metabolism and decrease HbA1c significantly.[25] Strict carbohydrate control using ketogenic diet alleviate the need for glucose-lowering drugs and a better glycemic control.[26] Our findings are consistent with international studies that wholistic lifestyle modification, DM Remission program not only improved blood glucose and BMI significantly, but also offered potential for the remission. The program could be applied for community-based intervention for continuous seamless diabetic care and ultimately better quality of life.[1,2] Our promising results support the premise of The American Diabetes Association and The International Diabetes Federation (IDF, 2021) that promotes health behavioral modification such as low carbohydrate consumption, dietary calorie control, regular aerobic exercise, quality sleep, and effective stress management.[1,2]

Our findings showed that HbA1c was associated with sex and age where more HbA1c was in men and higher age but with no statistical significance. The direction of the association was consistent with previous studies[13,14] but unlike these studies, our study found no statistical significance. The no significant association between HbA1c and sex could be that our participants were mostly old cases of diabetes which were usually with high age and most were women. It has been known that old diabetes cases usually are more difficult to control blood glucose. A previous study shows that diabetic patients who have been diagnosed with type 2 diabetes for more than 10 years have high HbA1c levels.[12] Therefore, a relatively low variability of HbA1c, age and sex in our study might be the reason for no significant associations.

Our findings and conduct suggest that the 3-month DM Remission program could be beneficial for type 2 diabetic patients and could be implemented in community hospitals, and potentially hospitals with different levels of care service. However, this study has certain limitations. Since this was a one-group pretest-posttest study, the results could be biased with overestimated benefits of the DM Remission program. The benefits could be offered by the routine care of physicians. Therefore, future studies with control group offered by routine care should be conducted. In addition, modification in medication regimens should also be examined in future studies. Since only two community hospitals were included in the study, generalization to settings with different healthcare service context could be somewhat limited. Future studies should extend to hospitals with different levels of services and demographics of the patients. Studies with longer intervention and follow-up period should be conducted to examine long-term and/or sustainable benefits of DM Remission's lifestyle modifications. More wholistic outcomes of the intervention such as remission rate, quality of life, stress, sleep and healthy eating index should be examined in future studies.

In conclusion, the 3-month DM Remission program at Banna Hospital and Ongkharak Hospital resulted in better glycemic control and improved BMI. At the end of the study, BMI was significantly associated with HbA1c. The program should be implemented in more hospitals and tested for sustainable benefits.

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