Effects of Carbohydrate Counting on Glycemic Control in Type 1 Diabetes Patients: Clinical Experience in Thailand

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Background: *Carbohydrate counting has been shown to improve glycemic control in patients with Type 1 diabetes (T1D). However, the data in Asians are lacking.*
Objective: *To explore the effects of carbohydrate counting in T1D patients in Thailand.*
Material and Method: *The present study was a retrospective medical charts review of adult T1D patients attending carbohydrate counting clinic at Ramathibodi Hospital, Bangkok. Hemoglobin A1c (HbA1c), weight, and total daily insulin dose (TDD) were collected. Patients' self-reported hypoglycemia and satisfaction were assessed using questionnaires.*
Results: *Seventy-eight patients were included in this study. HbA1c significantly decreased from the baseline of 8.5±1.8% to 8.0±1.8% at 3-month (mean difference (MD) -0.5%, p = 0.004), 8.1±1.7% at 6-month (MD -0.5%, p = 0.006), 8.1±1.7% at 9-month (MD -0.5%, p = 0.003), and 8.1±1.8% at 12-month (MD -0.5% (p = 0.004). Compared to baseline, weight, and TDD did not change significantly at 6-month (58.7±11.1 kg vs. 57.9±11.8 kg, p = 0.17; and 44.6±23.8 units/day vs. 42.3±22.5 units/day, p = 0.17). Patients reported that hypoglycemia decreased (p<0.001) while freedom in eating and confidence in diabetes self-care increased (p<0.001).*
Conclusion: *Carbohydrate counting in Thailand significantly improved glycemic control with no increase in hypoglycemia, along with increased satisfaction in T1D patients.*

Keywords: *Carbohydrate counting, Type 1 diabetes, Glycemic control, Hypoglycemia*

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Optimal glycemic control in patients with diabetes is associated with reduction in long-term complications, especially microvascular complications[1,2]. Carbohydrate is the primary macronutrient which directly affects postprandial glucose levels. Monitoring carbohydrate intake is one of the tools in achieving glycemic control[3]. It is recommended that patients with Type 1 diabetes should receive an intensive flexible insulin therapy that matches premeal insulin dosing with carbohydrate intake, along with an implementation of corrective insulin dosing[3]. For those on fixed insulin dosing, consistent carbohydrate intake can result in improved glycemic control and a reduction in hypoglycemia[3].

The concept of carbohydrate counting is not new and there have been many studies exploring the effectiveness of this approach in patients with Type 1 diabetes, both observational and randomized-controlled studies, mostly conducted in Western countries. The most recent meta-analysis of seven randomized controlled studies (599 adults and 104 children) demonstrated a non-significant improvement in hemoglobin A1c (HbA1c) level by 0.4%, compared to usual care[4]. However, when focusing on five studies with parallel design only, the reduction was statistically significant (0.6%)[4]. A recent systematic review of 21 observational studies found that all but one demonstrated at least a trend towards HbA1c improvement up to 1.2%, along with no increase in severe and non-severe hypoglycemia[5].

Although carbohydrate counting is considered a standard for Type 1 diabetes, it has not been used widely in Asian countries including Thailand. This could be due to several reasons. The incidence of Type 1 diabetes in Asian countries is relatively low compared to Western nations. For example, the incidence in Thailand, although increasing, is still

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very low, 1.65/100,000/year from a survey in 1991 to 1995[6], while it was 27.4/100,000/year in the United States in 2009, and 64.2/100,000/year in Finland in 2005[7,8]. This could be associated with less attention/familiarity and health care resources directed toward Type 1 diabetes. Findings in China, an Asian country, where there is relatively low incidence of Type 1 diabetes (3.1/100,000/year)[9], showed that fewer than half of the patients reported ever meeting with a dietician, and only 12% ever used carbohydrate counting techniques. Thai food is known for its complexity, with each meal containing multiple dishes and having at least three and up to five fundamental taste senses (sour, sweet, salty, bitter, and spicy)[10]. Moreover, Bangkok was ranked as one of the cities with the best street food in the world[11]. Unfortunately, these foods, including the variety of desserts, do not have standard nutritional labels, and have widely varied nutritional contents. In addition, tropical fruits are also available all year round. These factors could make it difficult to apply the carbohydrate counting technique, and some do not believe that this could be done with acceptable accuracy.

The purpose of this retrospective study was to review the efficacy of carbohydrate counting technique on glycemic control, insulin requirement, and body weight in Type 1 diabetes patients at an academic medical center in Bangkok. In addition, self-reported hypoglycemia and patients' satisfaction were collected. We hypothesize that, carbohydrate counting technique is possible with Thai food using local food database and multidisciplinary team approach (dieticians, nurses, and endocrinologists), and will result in improved glycemic control and patients' satisfaction, with no increase in hypoglycemia.

Material and Method

This was a retrospective chart review study between October 2013 and August 2015 involving non-pregnant adults with Type 1 diabetes who attended the carbohydrate counting clinic at the Division of Endocrinology, Faculty of Medicine, Ramathibodi Hospital. The protocol was approved by the Ethics Committee, Faculty of Medicine Ramathibodi Hospital (ID 04-57-24), and in compliance with the provisions of the Declaration of Helsinki in 1995. Participants who answered questionnaires gave written or oral informed consent.

The carbohydrate counting clinic, established in October 2013, is a multidisciplinary clinic with a team of an endocrinologist, dieticians, and diabetes nurses, and accepts referrals from other endocrinologists. The purpose was to educate the patients regarding carbohydrate counting and flexible insulin dosing for those with Type 1 diabetes. The first visit involved teaching the patients about carbohydrate containing food groups (one carb = 15 grams of carbohydrate) utilizing slide sets, food models, packaged food (for label readings), and practicing scooping one portion of cooked rice, as this is one of the staple foods in Thailand. The patients were given booklets, developed by a registered dietician (Kongsomboonvech D) and an endocrinologist (Reutrakul S), listing carbohydrate contents of common Thai food, with picture illustrations. Carbohydrate contents of Thai food as well as fruits were verified using Inmucal-Nutrients, a database developed by Institute of Nutrition, Mahidol University, Bangkok[12]. Because Thai food is typically a mixed dish, the patients were also taught how to account for all carbohydrate content in a meal, including hidden sugars typically found in many types of sauces. For western food, we used "Carbohydrate Counting for People with Diabetes, 3rd Edition, International Diabetes Center, Park Nicolet, MN, U.S.A." as a guide[13]. The nurse reviewed injection techniques, ketone testing, and hypoglycemia treatments at the end of the session. Fig. 1 illustrates tools utilized in the clinic and examples of Thai food.

The patients typically came back for a follow-up within 1 to 2 weeks after completing daily food record and performing self-monitoring of blood glucoses. The log was reviewed by the dietician. After determining that the patients could accurately count carbohydrates (typically within 15 grams), they were prescribed insulin to carbohydrate ratios and pre-meal insulin correction scale to be used for meal time insulin. Specifically, the insulin to carbohydrate ratio was calculated using the 450 or 500 rule (450 or 500 divided by total daily insulin dose is the amount in grams of carbohydrates covered by one unit of rapid acting insulin), along with the information from home glucose monitoring[14]. The insulin correction scale was calculated using the 1,800 rule (1,800 divided by total daily insulin dose is the reduction in glucose level (mg/dL) from one unit of rapid acting insulin)[14]. Follow-ups were made to ensure that the regimen was appropriate and adjustments were made as necessary. For some of the patients, a consistent carbohydrate intake along with insulin correction scale was recommended if flexible insulin dosing was deemed too complicated.

Eligible participants for the present study included those with Type 1 diabetes who attended the

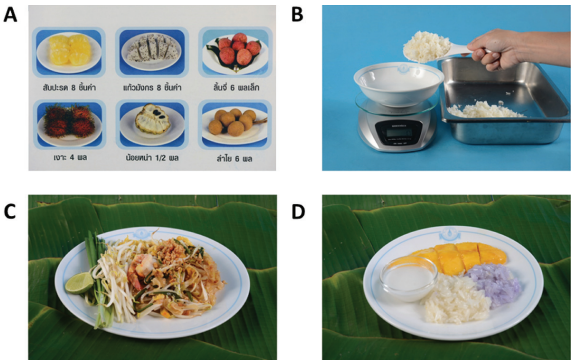

Fig. 1 Examples of tools utilized in the clinic and some Thai food. A) Carbohydrate counting booklet displaying Thai fruits containing 15 grams of carbohydrate (pineapple, dragon fruit, lychee, rambutan, custard apple, and longan). Reproduced with permission from Dr. Surat Komindr, Faculty of Medicine Ramathibodi Hospital. B) Rice scooping practice using ladle and scale. C) Pad Thai containing 48 grams of carbohydrate (1 cup of noodle = 30 grams, 2 teaspoons of white sugar = 9 grams, 2 teaspoons of tamarind juice = 9 grams; non-carbohydrate ingredients are egg, shrimp, peanuts, green onion, lime, bean sprout, and oil). D) Mango and sticky rice with coconut milk containing 54 grams of carbohydrate (1/2 cup of sticky rice = 30 grams, 2 teaspoons of white sugar = 9 grams, half of a ripe mango = 15 grams; non-carbohydrate ingredient is coconut milk).

clinic, and had a baseline and at least one HbA1c value during the 12-month follow-up period. Medical records were reviewed for baseline characteristics including age, sex, weight, height, insulin regimen and dosing. Baseline HbA1c was obtained from an average of HbA1c values in the preceding 12 months prior to attending the clinic. Follow-up HbA1c values at 3-, 6-, 9-, and 12-month after the first visit, and body weight and insulin dose at 6-month were obtained from the medical records.

We attempted to contact all patients and could reach a subset of the participants (n = 43). They were asked to answer a set of questionnaires six months or after from the time of the first visit. The questions ask the participants to compare the following before and after attending the clinic: 1) how many times you experienced severe hypoglycemia (loss of conscious or requiring help from others) in the three-month period?, 2) on the average, how many times per week you experienced non-severe hypoglycemia?, 3) how much do you feel that your diabetes is under control?, 4) how much freedom do you feel in choosing your food?, 5) how anxious or concern are you overall regarding your diabetes?, and 6) how confident are you regarding diabetes self-care?. Questions #3 to 6 were on a scale of 1 to 5, with 5 being the most. Lastly, they were asked to rate an overall satisfaction of the clinic, on a scale of 1 to 10, with 10 being the most satisfied (Appendix).

Statistical analysis

Data were presented as mean ± SD, median (interquartile range, IQR), or frequency and percentages. Paired t-tests were used to compare differences in HbA1c levels, insulin requirement, and body weight before and after the participants enrolled in the clinic. Related-sample Wilcoxon Signed Ranks were used to analyze questionnaire results before and after the clinic's enrollment. The analyzes were performed using SPSS 18.0 (Chicago, IL).

Results

Seventy-eight patients were included in the study. Their baseline characteristics are shown in Table 1. Baseline HbA1c levels, took from an average of 3.5 readings within the 12-month period before attending the clinic, reflected poorly controlled diabetes. The average number of clinic visits was 5.4 times over the 12-month period. The majority of the patients were on a basal-bolus insulin regimen. Of the three patients on insulin pump, one had learned

Table 1. Baseline characteristics of the patients

	Type 1 diabetes (n = 78)
Age (years)	40.2±16.7
Male	26 (33.3)
Body weight (kg)	58.6±11.1
BMI (kg/m^2)	23.0±3.9
Insulin type	
Basal bolus	63 (80.8)
NPH and rapid/short acting insulin	12 (15.4)
Insulin pump	3 (3.8)
Total daily insulin (units)	43.9±24.6
Number of visits per 12 month period	5.4±3.2
Number of HbA1c measurements in the 12 months prior to the first visit	3.5±1.3
Average HbA1c in the 12 months prior to the first visit (%)	8.5±1.8

BMI = body mass index; NPH = neutral protamine hagedorn; HbA1c = hemoglobin A1c
Data are expressed as median (IQR) or n (%)

carbohydrate counting previously but was not using it, one was dosing insulin based on caloric intake, and the other had not learned it before.

Changes in glycemic control, insulin dose and weight

There was a significant and persistent HbA1c reduction at 3-, 6-, 9-, and 12-month after attending the first visit, with a mean difference of -0.5% (95% CI -0.9, -0.2), -0.5% (95% CI -0.8, -0.1), -0.5% (95% CI -0.9, -0.2), and -0.5% (95% CI -0.9, -0.2), respectively (Table 2). At 6-month follow-up, compared to baseline, there were no significant changes in weight (baseline 58.7±11.1 kg vs. 6-month 57.9±11.8 kg, n = 76, p = 0.17) or insulin requirement (baseline 44.6±23.8 units/day vs. 6-month 42.3±22.5 units/day, n = 77, p = 0.17).

Questionnaire results

Forty-three participants answered questionnaires. The results are shown in Table 3. Self-reported severe and mild hypoglycemia decreased. The participants reported feeling that their diabetes was under a better control, having more freedom in choosing food items, more confident with diabetes self-care, and less concern about the disease. Overall, participants indicated high satisfaction with the clinic with a median score of 9 (of 10).

Discussion

In this retrospective study, we reported for the first time the effects of carbohydrate counting on glycemic control, insulin requirement, weight, and patients' satisfaction in adults with Type 1 diabetes in a non-western country. There was a significant improvement in HbA1c levels, up to 12 months, without an increase in self-reported hypoglycemia. This demonstrated a feasibility of this approach, with an adaptation to local cultures, in a resource-limited setting.

Adults with Type 1 diabetes in the current study achieved a significant HbA1c reduction of 0.5% which was sustained at 12 months. This effect size is comparable to several studies in adults on similar follow-up period, such as those using the Dose Adjustment for Normalized Eating (DAFNE) program. The DAFNE is an established 5-day comprehensive diabetes education program for Type 1 diabetes patients, including carbohydrate counting and flexible insulin dosing skill, in several countries including the UK and Australia. In their randomized controlled study for six months in the UK, the mean HbA1c was significantly lower in the intervention compared to the controlled arm (8.4% vs. 9.4%)[15]. Subsequent studies employing this technique in a routine care setting, without a control group, in adult patients in the UK

Table 2. Changes in HbA1c levels during a follow-up period

Follow-up visit	n	Baseline HbA1c (%)	Follow-up HbA1c (%)	Mean difference (%)	95% CI	*p*-value
3 months	71	8.5±1.8	8.0±1.8	-0.5	-0.9, -0.2	0.004
6 months	71	8.6±1.8	8.1±1.7	-0.5	-0.8, -0.1	0.006
9 months	65	8.6±1.8	8.1±1.7	-0.5	-0.9, -0.2	0.003
12 month	55	8.6±1.8	8.1±1.8	-0.5	-0.9, -0.2	0.004

Table 3. Results of questionnaire surveys (n = 43)

	Before	After	*p*-value
Mild hypoglycemia (times/week)†	1 (0 to 3)	1 (0 to 2)	<0.001
Severe hypoglycemia (times/3 months)†	0 (0 to 1)	0 (0 to 0)	0.008
Feel that diabetes is under control†	2 (2 to 3)	4 (3 to 4)	<0.001
Freedom in choosing food items†	3 (2 to 4)	4 (4 to 5)	<0.001
Concern about diabetes†	4 (3 to 5)	3 (2 to 4)	0.001
Confidence in diabetes self-care†	2 (2 to 3)	4 (4 to 5)	<0.001
Overall satisfaction‡		9 (8 to 10)	

Data are expressed as median (IQR)
† On the scale of 1 to 5, with 5 being the most
‡ On the scale of 1 to 10, with 10 being the most

and Australia for 12 months found a significant HbA1c reduction of 0.2 to 0.5%[16,17]. This effect was sustained in a longer follow-up study of 38 to 44 months with a HbA1c reduction of 0.4%[18]. However, not all studies reported a significant improvement in glycemic control[19,20]. A recent meta-analysis of randomized controlled studies revealed a statistically significant HbA1c reduction of 0.6% when focusing on studies with parallel design only[4]. Therefore, although not entirely consistent, carbohydrate counting with flexible insulin dosing appears to offer glycemic benefits to those with Type 1 diabetes.

In the current study, glycemic improvement was achieved without an increase in weight or insulin requirement. This could be due to more proper insulin distribution using flexible dosing regimen, and possibly improved dietary pattern due to more awareness although this was not formally measured in the present study. In addition, self-reported mild and severe hypoglycemia decreased after the program's participation. This data should be interpreted with caution as it was done on a recall basis and no confirmation of glucoses was performed. However, it was likely that at least hypoglycemia did not increase. This is in agreement with previous studies as a recent systematic review found that none of the 13 studies reported an increase in severe hypoglycemia, with several found a significant reduction[5]. For non-severe hypoglycemia, four of five studies found either no change or reduction after carbohydrate counting[5]. In addition, participants in the current study also reported increased freedom of eating, as a result of flexible insulin regimen, and feeling that their diabetes was under a better control, along with less concern and more confident in their diabetes self-care. Although a standard quality of life questionnaire was not utilized, the results reflect an overall improvement in empowerment and diabetes-related quality of life. This was supported by a high rate of overall satisfaction of the program. The finding is similar to previous data as improved psychological well-being and reduction in diabetes-related distress have been reported in several studies using DAFNE program[21,22].

There were several learned lessons from this clinic. The separate setting from the usual endocrinology clinic, while possibly posing inconveniences for patients in making additional visits, allowed us to have a dedicated time specifically for needed patients and use a multidisciplinary approach in a real-time basis. This helped us overcome a usually crowded environment of a clinic in a governmental hospital with limited resource setting. Using a local food database, which included food from all regions of Thailand, along with Western food data, was the key in dealing with diverse eating patterns in Thailand. Many times, a best estimate approach has been used to deal with food without labels, along with post-prandial glucose levels monitoring to help with insulin dosing in the future. Some participants have used a chat application on their smart phone to send the pictures of their food to the dieticians in order to help with carbohydrate counting accuracy, although this was not a systemic approach. There have been a few studies already documenting the benefits of technology, especially smart phone-based, in helping with carbohydrate counting and flexible insulin dosing in Type 1 diabetes patients. This included an automated bolus calculator[19] as well as an application that helped the accuracy of carbohydrate counting using photographs of the meals[23]. Developing this tool using a local food database and language should be the next step in helping Thai patients in their diabetes care.

There are several limitations in the present study. This was not a randomized controlled trial (RCT) as we did not feel that performing such a study, with a control group, was appropriate given benefits of this approach documented in the literature. The goal of this study was rather to proof the feasibility of this technique in Thailand. As this study was not an RCT, the number of participants was not pre-calculated. However, the current study yielded a power of test of 63% in detecting a mean difference in HbA1c of 0.5% at 3-month. It is possible that the improvement in glycemic control and patients' satisfaction could be a result form a combination of factors, including carbohydrate counting, frequent visits as well as diabetes education in this setting. In addition, the assessment of hypoglycemia was on a recall basis without documentation, which could be prone to errors. We did not have a systematic collection of home monitoring blood glucose levels, which should be helpful. This information, along with a possible use of a continuous glucose monitoring, will be considered as outcomes in the future. The standard quality of life or anxiety/depression scale also was not used. Nonetheless, the questionnaire results reflected the direction of the patients' perception towards this approach. Lastly, despite using this program, the HbA1c levels still reflected inadequately controlled diabetes. This could be due to the inadequacy of carbohydrate counting alone as other approaches such as the use food insulin index[24], considerations of

glycemic load[25], and fat/protein intake[26] may better improve premeal insulin dosing and reduce postprandial glucose levels. In addition, the accuracy of carbohydrate counting has been a question in several studies[27,28]. For example, in one study, only 23% of youths could accurately estimate carbohydrate within 10 grams of the actual content[27].

Conclusion

In summary, carbohydrate counting training significantly improved glycemic control and patients' satisfaction without an increase in hypoglycemia in patients with Type 1 diabetes in Thailand.

What is already known on this topic?

The American Diabetes Association recommends carbohydrate counting as a part of standard care for patients with Type 1 diabetes. It is used to calculate premeal insulin dosing, usually with short acting insulin analogs, to allow flexible insulin dosing. As these patients lack endogenous insulin secretion, matching exogenous insulin to food intake and blood glucose levels is the key to optimize glycemic control. A meta-analysis of studies conducted in western countries revealed that this method resulted in a significant HbA1c reduction of 0.6%[4].

The incidence of Type 1 diabetes in Asian population is much lower than of that reported in the western countries, and carbohydrate counting has not been used widely. Asian food often lacks labels and can contain a variety of ingredients despite being the same type of food, making carbohydrate counting more complicated. To date, the effects of carbohydrate counting in Asian Type 1 diabetes patients have not been reported.

What this study adds?

This study demonstrated that carbohydrate counting technique is feasible for Type 1 diabetes patients in Thailand. Multidisciplinary team approach is one of the keys to success. The magnitude of HbA1c reduction is sustained at 12 months, and comparable to studies conducted in western countries[4]. This was achieved with no increase in self-reported hypoglycemia. In addition, patients' satisfaction is high. Overall, the results suggest that this method should be applied to Type 1 diabetes patients in Thailand.

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Potential conflicts of interest

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Appendix. Questionnaire

ขอให้ท่านนึกทบทวน และตอบคำถามต่อไปนี้ตามความรู้สึกของท่าน ก่อน และหลังการเข้าคลินิกนับคาร์โบไฮเดรต (1 = น้อยที่สุด, 5 = มากที่สุด)

	ก่อนเข้าโปรแกรม					หลังเข้าโปรแกรม				
ท่านมีอาการน้ำตาลต่ำ กี่ครั้งต่อสัปดาห์										
ท่านมีอาการน้ำตาลต่ำรุนแรง กี่ครั้ง ในช่วงสามเดือน (หมดสติ ต้องการความช่วยเหลือจากผู้อื่น)										
การควบคุมเบาหวานของท่าน ดีเพียงใด	1	2	3	4	5	1	2	3	4	5
ความพอใจในการมีอิสระการเลือกรับประทานอาหารที่ท่านต้องการ	1	2	3	4	5	1	2	3	4	5
ความกังวลโดยรวมที่ท่านมีต่อโรคเบาหวาน	1	2	3	4	5	1	2	3	4	5
ความมั่นใจในการดูแลตนเองเกี่ยวกับเบาหวาน	1	2	3	4	5	1	2	3	4	5

ท่านมีความพอใจในการเข้าโปรแกรมนับคาร์โบไฮเดรตเพียงใด

1	2	3	4	5	6	7	8	9	10

ผลของการนับคาร์โบไฮเดรตต่อการควบคุมระดับน้ำตาลในผู้ป่วยเบาหวานชนิดที่ 1: ประสบการณ์ทางคลินิกในประเทศไทย

จินดาพร ไชยโคตร, สุภาพร สมหวัง, อมรรัตน์ หทัยเดชะดุษฎี, ฉัตรวรา อารีวุฒิ, สุนีย์ แซ่ตั้ง, น้ำเพชร สายบัวทอง, รัตนาภรณ์ จีระวัฒนะ, กนกพร พาบัว, สิริมนต์ ริ้วตระกูล

ภูมิหลัง: *มีหลักฐานว่าการนับคาร์โบไฮเดรตในผู้ป่วยเบาหวานประเภทที่ 1 นั้นสามารถช่วยให้การควบคุมเบาหวานดีขึ้น อย่างไรก็ตาม การศึกษาในชาวเอเชียยังมีน้อยมาก*

วัตถุประสงค์: *เพื่อศึกษาผลของการนับคาร์โบไฮเดรตในผู้ป่วยเบาหวานชนิดที่ 1 ในประเทศไทย*

วัสดุและวิธีการ: *เก็บข้อมูลจากเวชระเบียนย้อนหลังในผู้ป่วยที่เข้ารับการรักษาที่คลินิกนับคาร์โบไฮเดรตที่โรงพยาบาลรามาธิบดี กรุงเทพมหานคร โดยเก็บข้อมูลระดับน้ำตาลสะสม น้ำหนัก และจำนวนอินซูลินที่ใช้ต่อวัน รวมทั้งประเมินผลการเกิดภาวะน้ำตาลต่ำและความพอใจของผู้ป่วยโดยใช้แบบสอบถาม*

ผลการศึกษา: *มีผู้ป่วยเบาหวานทั้งหมดจำนวน 78 ราย พบว่า ระดับน้ำตาลสะสมลดลงอย่างมีนัยสำคัญทางสถิติจากก่อนเข้าร่วมโครงการ 8.5±1.8% เป็น 8.0±1.8% ที่ 3 เดือน (ค่าความแตกต่างเฉลี่ย -0.5%, p = 0.004), 8.1±1.7% ที่ 6 เดือน (ค่าความแตกต่างเฉลี่ย -0.46%, p = 0.006), 8.1±1.7% ที่ 9 เดือน (ค่าความแตกต่างเฉลี่ย -0.46%, p = 0.004) และ 8.1±1.8% ที่ 12 เดือน (ค่าความแตกต่างเฉลี่ย -0.5%, p = 0.004) เมื่อเทียบกับก่อนเข้าโครงการ พบว่า น้ำหนักและขนาดอินซูลินที่ใช้ ที่ 6 เดือน ไม่เปลี่ยนแปลงอย่างมีนัยสำคัญทางสถิติ (น้ำหนักเฉลี่ย 58.7±11.1 กิโลกรัม เทียบกับ 57.9±11.8 กิโลกรัม, p = 0.17; ขนาดอินซูลิน 44.6±23.8 ยูนิตต่อวัน เทียบกับ 42.3±22.5 ยูนิตต่อวัน, p = 0.17) ผลจากแบบสอบถาม พบว่า ผู้ป่วยรายงานว่ามีภาวะระดับน้ำตาลต่ำลดลง (p<0.001) ในขณะที่ความมีอิสระในการเลือกรับประทานอาหารเพิ่มขึ้น และรู้สึกมั่นใจในการดูแลตนเองเกี่ยวกับเบาหวานมากขึ้น (p<0.001)*

สรุป: *การนับคาร์โบไฮเดรตในผู้ป่วยเบาหวานชนิดที่ 1 ในประเทศไทยช่วยให้การควบคุมระดับน้ำตาลดีขึ้น โดยไม่เพิ่มภาวะระดับน้ำตาลต่ำ และผู้ป่วยมีความพอใจในการดูแลตัวเองมากขึ้น*