Original

Fiber-focused Nutrition Counseling Through Nutrition Software Improved HbA1c of Vietnamese Type 2 Diabetes Mellitus Patients

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ABSTRACT ***Background and purpose:*** Type 2 diabetes mellitus **(**T2DM**)**, which is an individual health challenge requiring ongoing management, has been rapidly increasing**.** The major factor affecting the rate of Vietnamese T2DM is reported by some studies as low fiber intake**.** In this situation, dietitian need to help T2DM patients to change their dietary habits, in order to control their blood glucose**.** However, in Vietnam, the number of dietitians is very limited**.** Calorie Smile Vietnam version (CSV) is a nutrition support software which can be a solution for dietitians, who can monitor and advise many people at the same time and also work at from any time and place**.** Such a tool will be extremely useful in Vietnam**.** Therefore, we wanted to determine the effect of fiber-focused nutrition counseling thourgh the nutrition software on improving HbA1c of Vietnamese T2DM patients. ***Method*****:** Sixty outpatients with T2DM were recruited at a hospital for a 3-month randomized controlled trial study. We formed 30 pairs matched by HbA1c, sex, age, BMI, and years of diabetes, and divided them randomly into an Intervention and a Control group. Both groups were instructed to use the CSV software. All the nutrition surveys and nutrition counseling were carried out using CSV. The Control group had a 3-consecutive-day nutrition survey at baseline and final and received 1-time nutrition counseling at baseline. The Intervention group had 3-consecutive-day nutrition survey and counseling 5 times. The counseling was focused on increasing fiber intake from vegetables and fruits. The target was 2 bowls of vegetables/meal; the appropriate amount of fruit/day. In addition, subjects were also counseled about food choices. At baseline and final, anthropometric measurements and blood withdrawal were conducted. ***Result:*** After 3 months, the intervention group had increased fiber intake (from 6.4 ± 2.5 to 8.3 ± 3.0 g/day, $p<0.0001$), while the control group had no change. As a result, HbA1c was significantly improved in the Intervention group (from 8.16 ± 0.75% to 7.79 ± 0.85%, $p<0.05$) compared with the Control group (from 8.05 ± 0.77% to 8.39 ± 1.33%). There was a negative correlation between change in fiber intake and change in HbA1c. ***Conclusion:*** Real time nutrition counseling for T2DM patients using the CSV software was effective for improving fiber intake and HbA1c.

Keywords: Nutrition Software, education, dietary fiber, - \Type 2 DM, Vietnam

BACKGROUND

Diabetes mellitus is a chronic metabolic disease characterized by elevated levels of blood glucose thatoccur either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces (1). Diabetes of all types can lead to complications in many parts of the body and can increase the overall risk of dying prematurely. According to the World Health Organization (WHO), globally, in 2014 there were about 422 million people with diabetes; in 2016, an estimated 1.6 million deaths were directly caused by diabetes and another 2.2 million deaths were attributable to high blood glucose in 2012 10 years. In 2002, the proportion was 2.7%, but by 2012, it was up to 5.4% (2). In 2015, it was estimated that 5.6% of people had diabetes and about 53,458 deaths were attributed to diabetes (3). The diabetes-related expenditures in Viet Nam are on average 163 USD per patient per year, more than the average monthly salary of 150 USD in Viet Nam (4).

Nowadays, in a period of economic development and transformation of nutrition and food security, the traditional diet of Vietnamese, which was high-carbohydrate, low-fat and high-fiber, has been changed to a high-carbohydrate, high-fat, and low-fiber diet. This is a major factor affecting the rate of type 2 diabetes mellitus (T2DM) in Vietnam. If T2DM patients do not have a proper diet, they cannot control their blood glucose, so they may suffer from serious complications whereby the economic burden also becomes extremely high. Dietary management for diabetic patients has been

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shown to improve blood glucose control and reduce the risk of complications. Despite that, there are various barriers for patients to obtaining the proper dietary management. These include lack of dietitians, lack of time for dietitians to provide patients with continuing education and sometimes lack of patients′ access to dietitians because patients do not have the time or money to come to the hospital.

In this situation, a solution to support patients in dietary management is very necessary. There is a need for a tool that can overcome the barriers. Systems and software to support nutritional counseling become imperative but in Vietnam, they are not available. Thus, a Japanese computer company and some Vietnamese nutrition experts have developed nutrition software for Vietnamese, called Calorie Smile Vietnam version (CSV) (5). Such a tool will be extremely useful in Vietnam where the number of dietitians is very limited. However, there has been no study to prove its effectiveness with Vietnamese people. Therefore, we wanted to determine the effect of nutrition counseling through CSV software on improving HbA1c in T2DM patients.

METHODS

Design of Calorie Smile Vietnam version (CSV)

CSV is a nutrition software which has installed in it Vietnamese language (5), and has been integrated with the Vietnam food composition table (6), the nutrition value of 500 common dishes from the Hanoi area (7) and the nutrition value of common street food from the Ho Chi Minh city (8). This software offers dietitians a new way to conveniently exchange information with their patients.

CSV is designed to connect dietitians and patients through the internet, from anywhere and at any time. So, the dietitians can adjust the time and place of work and the patients can get nutrition advice without going to the hospital.

CSV includes 6 functions:

1. Questionnaire: The dietitian can create a detailed questionnaire about patients′ everyday dietary habits and ask the patients to complete it. The patients can use their smartphones to fill in the questionnaire and return it to the dietitian. Based on this data, the dietitian drafts an action plan to monitor the patients′ daily progress.
2. Data transferring: Patient data such as meal photos, biochemical indices, anthropometric indicators, and physical activity indicators submitted by the patient to the software will be transferred to the account of the dietitian as well as being shown on the patient's page.
3. Daily progress: The patient′s daily progress can be traced at a glance. Patient data are shown in tables and charts, making it easy for the dietitian to check.
4. Meal analysis: Based on the patient′s meal photos, the dietitian can make a detailed nutritional analysis and send back to the patient. CSV is integrated with data about common dishes in Vietnam, so the meal can be analyzed quickly. In addition, if the patient's dishes are different from the available dishes, change can be made to meal ingredients and portions.
5. Nutritional advice: After analyzing, the dietitian sends the patients nutritional advice to boost their motivation. Patients can also reply to the dietitian, so that the communication is carried out smoothly.
6. Group counseling: A team of dietitians can work together to advise one user. This function is very convenient for learning and sharing experiences among dietitians, as well as transferring information on patients in the same group.

Study design:

This was a 3-month randomized controlled trial performed between October 2018 and April 2019 at Vietnam-Cuba Friendship Hospital. T2DM patients who had HbA1c>7%, were using oral drugs for management of T2DM, had no severe complications, had no intervention by dietetics professionals for T2DM, were using smart-phones and were able to access the internet and weren′t pregnant at the time of recruitment for the study. After screening data at the hospital, and through phone contact and meeting in person, 60 subjects who agreed to participate in this study were enrolled. Sixty patients who were pair matched by HbA1c, age group, years with T2DM, BMI, and gender then were randomly divided into 2 groups, 30 in the Control Group and 30 in the Intervention Group. During the intervention, drug dosage was not changed in either the Control or the Intervention Group.

Study methods:

Subjects visited us twice, at baseline and final. At baseline, all the subjects received CSV software instruction.

Nutrition survey:

A 3-consecutive-day nutrition survey by the photographic method was conduct at week 1 and week 12 through CSV software for all subjects. For the intervention group, subjects would have 4 more sessions of nutrition survey in weeks 3, 6, 10, and 12. Energy and nutrient intakes were calculated.

* Patients were instructed to take photos of food:
  - Patients were asked what type of bowls, plates that they use.
  - At meals, patients took photos of all the food with the proper amounts that they intended to eat in separate bowls/plates and took pictures from 2 angles: straight and tilted.
  - After the meal, patients would take pictures of the food left over.

Dietary counselling:

All the counselling was given through CSV software by 5 Bachelors of Nutrition who had graduated from Hanoi Medical University. Subjects in the intervention group had counseling 5 times, after the nutrition survey in week 1, and in weeks 3, 6, 10, and 12. Subjects in the control group continued their treatment regimen and did not receive any counselling from this study during the intervention period.

Counselling method:

The counseling was focused on increasing fiber intake and food choices.

We instructed patients to gradually increase vegetables, using certain measuring tools such as rice bowls to measure the amount of vegetables at each meal and we set goals for patients at each consultation. For example, for the first consultation, we set a goal of 2/3

of a bowl of vegetables/meal, at the second consultation we would check and raise the target to 1 bowl of vegetables/meal, the 3rd consultation targeted 1.5 bowls of vegetables/meal, the 4th consultation targeted 2 bowls of vegetables/ meal and then subjects maintained this amount. We also advised them to choose seasonal vegetables and to combine various kinds of vegetable in one meal. We checked their progress through photos of the food they ate and constantly monitored, motivated, and reminded them to try to achieve their goals.

Besides vegetables, we encouraged patients to eat more fruits, gave them a list of fruits they should eat and fruits they should avoid or eat only occasionally if they craved them and we also showed them the amount they could eat each time. For example, Guava is a low-sugar, high-fiber fruit so we recommended that they could eat 1/2-1 guava/day.

Blood test

Intravenous fasting blood samples were taken in the morning at baseline and final. HbA1c was analyzed.

Anthropometric measurement

Weight, height, and body fat percentage were measured twice, at the baseline and final and the average value was calculated for each individual. Body weight and height were measured in light clothing and without shoes. Body mass index (BMI) was computed as the ratio of weight (kg) per height squared (m^2). Body weight and percent body fat were measured by a digital weight scale (OMRON HBF-354IT) with accuracy to 0.1kg and 0.1%. Body height were measured by a portable stadiometer (Seca 213) with accuracy to 0.01cm.

Statistical analysis

Quantitative variables were checked for normal distribution and compared by the paired and unpaired Student *t*-test. P-values of less than 0.05 were considered statistically significant for all the analyses. The above statistical procedures were performed using Microsoft Excel 2013.

RESULTS

Baseline characteristics of the 60 subjects are shown in Table 1. Characteristics were similar between the 2 groups. The overall study population was predominantly female (66%), average age was 59.2 years (SD = 9.4), and average HbAc1 8.0% (SD = 0.7). After 3 months, there were 2 dropout patients in the Intervention Group.

Table 2 shows the change in HbA1c from baseline to final by study group. HbA1c values declined significantly in the Intervention Group ($p<0.05$), while in the Control Group, it increased but not significantly.

Table 1: Baseline characteristics of the subjects

	Intervention Group (n=30)	**Control Group (n=30)**
HbA1c (%)	8.17±0.73	8.05±0.77
Age (years)	57.8±9.0	60.6±8.2
Year with diabetes	6.0±4.3	6.5±5.9
Sex		
Female	20	20
Male	10	10
Body mass index (kg/m^2)		
<18.5	0	0
18.5-24.9	20	20
≥25	10	10
P values obtained from unpaired *t*-test between intervention and control groups		

Table 2: Comparison of biochemical parameters at baseline and final of Intervention and Control Group

	Intervention Group (n=28)		**Control Group (n=30)**	
	Baseline	Final	Baseline	Final
HbA1c (%)	8.16±0.75	7.79±0.85*	8.05±0.77	8.39±1.33
*Significantly different from baseline to final within the group by paired *t*-test; $p<0.05$				

Table 3 shows the comparison of vegetable and fruit intake at baseline and final of Intervention and Control Groups. With the Intervention Group, the intake increased significantly. Energy and nutrient intakes of both groups at baseline and final data within the group did not differ except for fiber (Table 4). As a result, after 3 months, there were no changes in the physical characteristics of both groups (Table 5). Relationship between changes in fiber intake and change in HbA1C is shown in figure 1. HbA1C decreased as fiber intake increased.

Table 3: Comparison of vegetable and fruit intake at baseline and final of Intervention and Control Group

	Intervention Group (n=28)		**Control Group (n=30)**	
	Baseline	Final	Baseline	Final
Vegetable and fruit intake (g)	234.4±129.9	326.2±173.2*	160.9±118.2	187.4±132.4

*Significantly different from baseline to final within the group by paired *t*-test; p<0.05

Table 4: Energy and nutrient intakes at baseline and final of Intervention and Control Group

	Intervention Group (n=28)		**Control Group (n=30)**	
	Baseline	Final	Baseline	Final
Energy (kcal/day)	1399±294	1377±234	1398±315	1378±296
Protein (%E)	19.1±4.4	18.0±3.2	17.6±2.6	16.9±2.6
Protein (g/day)	66.4±18.3	62.6±16.9	61.5±15.7	58.9±17.1
Fat (%E)	26.3±6.2	24.9±3.1	24.7±4.3	25.5±3.8
Fat (g/day)	41.3±13.1	38.1±8.7	38.4±11.0	39.1±10.6
Carbohydrate(%E)	54.7±8.2	57.1±4.4	57.7±5.5	57.6±4.9
Carbohydrate (g/day)	190.4±47.5	195.7±32.7	201.5±50.6	197.6±45.2
Fiber (g/day)	6.4±2.5	8.3±3.0***	5.5±1.8	5.9±2.1

*** Significantly different from baseline to final within the group by paired *t*-test (p<0.0001)

Table 5: Comparison of physical characteristics at baseline and final of Intervention and Control Group

	Intervention Group (n=28)		**Control Group (n=30)**	
	Baseline	Final	Baseline	Final
Weight (kg)	61.2 ± 10.4	60.9 ± 10.4	60.6 ± 8.2	60.5 ± 8.12
BMI (kg/m2)	24.4 ± 3.6	24.4 ± 3.6	24.5 ± 2.6	24.5 ± 2.7
Body fat (%)	31.8 ± 4.8	31.4 ± 4.9	31.2 ± 4.7	30.6 ± 4.9

P values obtained from paired t-test between baseline and final within the group

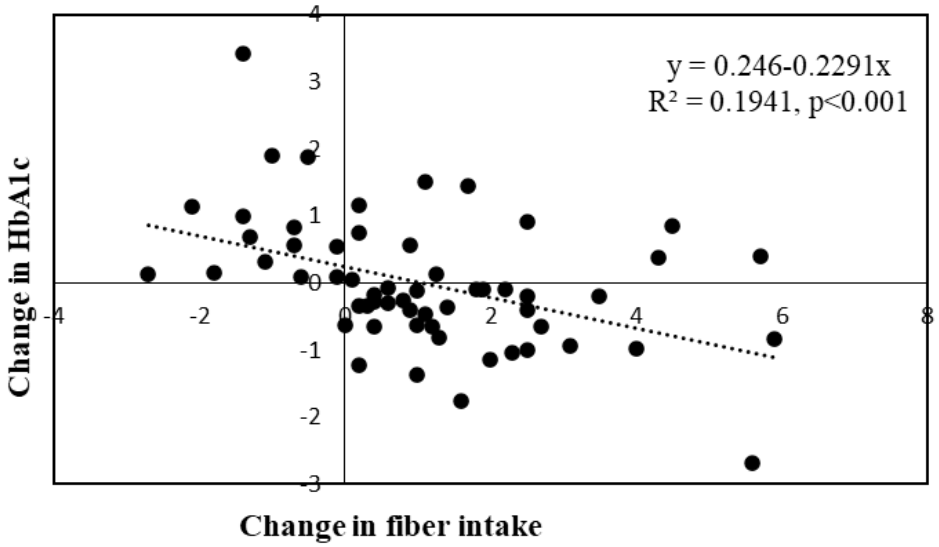

Figure 1: Relationship between change in fiber intake and change in HbA1c

Table 6 presents the comparison of nutrition education received by the 2 groups in 3 months. At baseline, all patients said that they had consulted with their general practitioner and referred to the internet about diet for diabetics, but they had only very basic knowledge. They had followed it for a short time, but no one pushed them, so they quickly returned to their old habits and ate what they liked. Subjects expected to get counseling from dietitians and to be monitored on diet and to receive timely advice. In the 3 months of the study, the control group received nutrition education only 3 times with very basic information from a general doctor at the hospital without analysis of their diet, while the intervention group were able to receive intensive nutrition education suited to their diet 5 times and received it at home.

Table 6: Comparison of nutrition education received by the 2 groups in 3 months.

	Intervention group	**Control group**
Number of nutrition counseling/3 month	5 times	3 times
Counselor	Dietitian	General doctor
Place	At home	At hospital
Time	At week 1,3,6,12 of the study	When coming to hospital to for re-examination and to receive drug
Content	Detailed advice according to the analyzed diet information Diet goal: - Fiber: 10g/1000Kcal, Vegetable and fruit: 400-500g/day - Energy: 30-35 kcal/ kg of ideal body weight/ day - Carbohydrate: 55-65% of total energy, coordination between low glycemic load foods and high glycemic load foods. - Protein: 1 -1.25g/kg of ideal body weight/day - Fat: 20-25% of total energy	Only received advice: ″Your blood glucose is too high; you should reduce the energy and carbohydrate intake; increase the vegetable intake″ without analyzing their diet.

DISCUSSION

This study found that nutrition counseling through nutrition software was effective in lowering HbA1c, and improving dietary pattern, especially fiber intake, in a community population of adults with diabetes over a 3-month period.

In order for patient to change their eating habits, it is essential to set individual specific goals at each consultation, and to provide feedback, follow-up, and motivation for the patient. If patients are motivated regularly and given timely advice, they will be able to adopt good lifestyle behaviors, and easily control their blood sugar well. In this study, these tasks were facilitated by the CSV software and patients did not have to go to the hospital, which saved them a lot of time. Both dietitians and patients can easily exchange data at any time of the day, wherever they may be. This is more efficient than making face-to-face appointments that can be missed due to busy schedules. Dietitians and patients can stay in constant contact to help patients reach their targets. Moreover, thanks to the analytical features available on CSV software, dietitians could analyze patients′ meal photos quickly; therefore, at the same time, they could analyze for more patients. After the 3 months of study, it was rewarding to note that patients in the intervention group referred to dietitians for diabetes nutrition counseling. Their behaviors were likewise improved, paralleling and likely influencing positive clinical outcomes. In addition, there were only 2 dropout patients, indicating that CSV is easy to use, convenient and had supported patients particularly well.

After the intervention, the HbA1c of the intervention group decreased by 0.38% ($p < 0.05$) while the control group increased by 0.34% ($p > 0.05$). During the 3 months, no patient had changed medication, indicating regular monitoring and nutrition counseling were effective. In order to reduce HbA1c, it is very important to properly evaluate the current diet and to develop an appropriate nutrition plan for patients. After the first nutrition survey, we found that most subjects in the study were consuming a moderate energy level of 1300-1400 kcal with a reasonable ratio of protein: lipid: carbohydrate, but the food choices and distribution of meals were not yet appropriate. In particular, the amount of fiber consumed was very low. The low fiber consumption may explain why the subjects′ BMI was not high (about 24.4-24.5 kg/m2) even though T2DM patients worldwide are usually obese. Therefore, if we continue to require patients who have already reduced energy intake to reduce energy intake more, it may not be effective and may often lead to low compliance. Instead, counseling on how to change the pattern of eating, food choices and recommendations to eat more fiber can bring greater compliance for participants. With this counselling method, after the study, in the

intervention group, vegetable consumption increased from 234 to 326 g/day and fiber consumption increased statistically, from 6.4 ± 2.5 to 8.3 ± 3.0g/day, while the control group did not change. Moreover, the variety of vegetables also increased. At baseline, almost all intervention patients ate just one kind of vegetable at many meals. This may have made them lose their appetite and they did not want to eat more vegetables. We tried to tell them to choose seasonal vegetables and combine various kinds of vegetable in 1 meal so the dishes will become more delicious and eye-catching. We also encouraged patients to change the kind of vegetable frequently, so they did not get bored. Hence, from 1 kind of vegetable/meal at baseline, they could change to 2-3 kinds of vegetables/meal at the end of the study.

Fiber is important for everyone and especially for people with diabetes. Dietary fiber can increase the viscosity of diets and cause a delay in digestion and the absorption of sugar into the bloodstream. The positive effects of fiber or vegetables on blood glucose control have been shown by many studies. The last two studies on diabetics in Vietnam have shown similar results (9,10). A study of Okara in which the intervention group consumed about 6 g of fiber from Okara per day for 2 weeks showed that when dietary fiber intake increased from 6.9 to 12.6 g ($p<0.01$), fasting blood glucose and fructosamine dropped from 6.3 to 5.4 mmol/L ($p<0.05$) and from 319 to 301 μmol/L ($p<0.05$), respectively. Another study showed that when vegetable intakes increased from 200-300g to 300g and 450g in the control and intervention group, respectively, the fructosamine concentration in the intervention group decreased significantly ($P<0.05$) but not in the control group ($P>0.05$). Other studies in various countries used a variety of grams of fiber per day in their interventions, comprising a large range, from as little as an additional 4 g/d to as much as 40 g/d; the mean increase in fiber was approximately 18 g/d to achieve an overall reduction in HbA1c by fiber of 0.26% (95% CI, 0.02–0.51) more than the reduction from a placebo (11). However, in this study, only a small quantity of fiber increase (2g) was effective in controlling blood glucose. It may be due to the fact that the recent intake of Vietnamese is very low, only 6g/day, so an increase of 2 grams means a 1/3 increase over recent intake.

Although we observed positive results for the application of CSV in supporting nutrition counseling in our current research, several obstacles need to be overcome before this software can be implemented. At typical Vietnamese meals, all dishes except individual bowls of rice are communal, so it is necessary to establish common measurement methods to be able to calculate the patient's diet accurately. Besides, Vietnamese people are not familiar with taking photos of meals as well as posting photos and receiving advice through the software. In this study, we had to contact patients regularly to remind them but in reality, with the workload of doctors and nutritionists, they would not be able to do so. This limitation can be overcome by developing an automated reminder system based on the patient's data.

This study had 3 months of intervention; but with T2DM patients, to improve glycemic control, maintaining long-term control is required. Therefore, further study should have a longer time for intervention and follow-up.

CONCLUSION

In summary, by using nutrition counseling through nutrition software for 3 months, fiber intake was increased about 2g/day, were effective in decreasing HbA1c of Vietnamese T2DM patients.

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