Effectiveness of Web-Based Nutrition Education for Chronic Kidney Disease Patients

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Abstract: *Background*: In the early stages of chronic kidney disease (CKD), encouraging health behaviors can help prevent the progression of kidney disease leading to eventual kidney failure. The studies of health education using computer technology have been greatly developed, especially web-based nutrition education.

Objective: To determine the effectiveness of a nutrition education website for CKD patients.

Method: The design of this quasi-experimental research was a group pre-test/post-test. The participants were pre-dialysis CKD patients who were enrolled on the developed website www.banraktai.com. The participants were required to complete an eating behavior questionnaire and knowledge test. They accessed the website for eight weeks, and at week 8, they completed the eating behavior questionnaire and knowledge test again. The main outcomes were the changes in scores of nutrition knowledge and eating behavior that were compared between the baseline and after the intervention using the paired t-test. The correlation between nutrition knowledge scores and eating behavior scores was determined using Spearman's correlation coefficient.

Results: There were 44 participants that completed the study. The results showed that the participants had significant improvement in both knowledge scores and consumption behavior scores ($p < 0.001$ and $p = 0.041$, respectively). However, there was no correlation between the nutrition knowledge scores and the eating behavior scores.

Conclusions: Web-based nutrition education can improve knowledge scores but is not effective enough to encourage and motivate CKD patients to make eating behavior changes.

Keywords: Chronic kidney disease, web-based nutrition education, patient education, nutrition knowledge, eating behavior.

INTRODUCTION

Chronic kidney disease (CKD) is a major public health problem, of which the prevalence and rate of incidence in the past few years have been increasing in Thailand. In the early stages of CKD, encouraging health behaviors can help prevent the progression of kidney disease that leads to eventual kidney failure. Promoting positive behaviors, such as proper nutrition, physical activity, maintenance of optimal levels of blood sugar and lipid profile, are important methods for patients to slow down the loss of kidney function. Therefore, CKD patients should also have general knowledge of CKD and be aware of their individual risks [1]. However, according to several studies, only a small number of patients can appropriately answer the questions regarding basic etiology prognosis and treatment of CKD. Some patients and families are unable to remember medical information regarding how to prevent kidney failure. Most CKD patients neither know the stage of their kidney disease nor know how to slow the progression of the disease [1-5]. Consequently, poor nutrition and health care in CKD patients results in bad practice, and also causes negative health effects.

The use of technology has changed the way that patients learn about health and nutrition. There are many nutrition and health education studies available for patients using computer technology. According to Wedman's study [6], an interactive videodisc (IVD) on dietary restrictions for hemodialysis patients was developed. This study showed that most participants improved their health behaviors, including compliance with sodium restriction, fluid modification, and protein serving size reduction. In addition, McMahon *et al*. [7] has shown that diabetic participants who received web-based care management had a significantly lower glycosylated hemoglobin (HbA_{1C}) when compared to the baseline. Later, development of a computer-assisted instruction (CAI) program on dietary control was applied to prevent ischemic heart disease among people with high levels of risk. It was found that this intervention could significantly improve the participants' post-test knowledge scores [8]. In Thailand, the studies on health education using computer technology have been greatly developed. However, there are few developed tools that can efficiently be applied to

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patients to measure the effectiveness. This study aimed to determine the effectiveness of a nutrition education website for CKD patients. Nutrition knowledge and eating behavior were also evaluated.

METHODS

Study Design

The study was approved by the Ethics Review Committee for Research Involving Human Research Subjects, Health Sciences Group, Chulalongkorn University (ECCU) in June 23th, 2016 (approval number 132/2558). The design of this quasi-experimental research was a one group pre-test/post-test. The patients who were diagnosed as being pre-dialysis by a nephrologist for at least three months were enrolled in the study. The participants had to be literate in Thai and able to use a computer and the internet. They had to complete all the directions of the forms and use the internet at least one time weekly, or four times monthly. The participants who had some conditions such as liver disease, cancer, and pregnant and lactating were excluded from the study.

Research Instruments

The experimental instrument was the nutrition and health education website for CKD, www.banraktai.com, developed by Lamsaard *et al*. [9]. Its content is composed of four topics including basic etiology of kidney and CKD, nutrition, exercise, and medication regarding to early stages of CKD.

The data collection forms comprised four parts. First, the demographic data record included information on gender, age, weight, height, educational level, occupation, duration of illness, other diseases or comorbidity, previously receiving nutritional and health care information, and stage of CKD. Second, the one-day dietary record consisted of date, list of times, foods, ingredients and portion size, as well as some food models. Third, the eating behavior questionnaire consisted of nineteen selected items of appropriate food and drink and nine items of management of nutritional problems with a 4-point scale. Fourth, the knowledge test was developed with four topics including basic etiology of kidney and CKD, nutrition, exercise, and medication. Moreover, website satisfaction was assessed using a 5-point Likert scale (highly satisfied, satisfied, partially satisfied, not satisfied, and not at all satisfied). This form was divided into three parts: 1) content and information, 2) design and graphics, and 3) application and use.

Research Procedure

Implementation of the nutrition and health care website for CKD patients, www.banraktai.com (Thai version), was divided into three phases. The first phase (Baseline): The participants completed an electronic informed consent form on the website before registration. Personal information, one-day dietary records, the food-frequency questionnaire (FFQ), the eating behavior questionnaire, and the knowledge test were completed before the intervention. The second phase (1^{st} – 8^{th} week): The participants were followed up for eight weeks after they completed all of the forms. During those eight weeks, the participants accessed the education website and studied the content. Consultation on dietary and lifestyle modifications between the researchers and the participants was conducted and followed up via e-mail or the LINE application. The third phase (8^{th} week): The participants completed the one-day dietary record, FFQ and eating behavior questionnaire, knowledge test, and website satisfaction form.

Data Analysis

Demographic data and website feedback were analyzed using descriptive statistics, frequency and percentage. Knowledge and eating behavior scores were compared between baseline and after intervention using the paired *t*-test. Correlation of knowledge scores and behavior scores before and after intervention were determined using Spearman's correlation coefficient. Nutrient and caloric intakes from the one-day dietary records were calculated and analyzed using INMUCAL program version 3 [10]. The differences in average values between the baseline, the 4^{th} week and the 8^{th} week were analyzed by repeated measures analysis of variance.

RESULTS

Characteristics of Participants

There were 376 CKD patients who signed up for this study via electronic consent on the researchers' website. However, a total of only 44 patients (11.7%) met the criteria and their data were finally analyzed. The participants who filled in the record forms incompletely were then not included in the study. During the study, some participants were excluded from the study, due to unavailability or failure to complete the one-day dietary record. A flow diagram of the participants throughout the study is shown in Figure **1**.

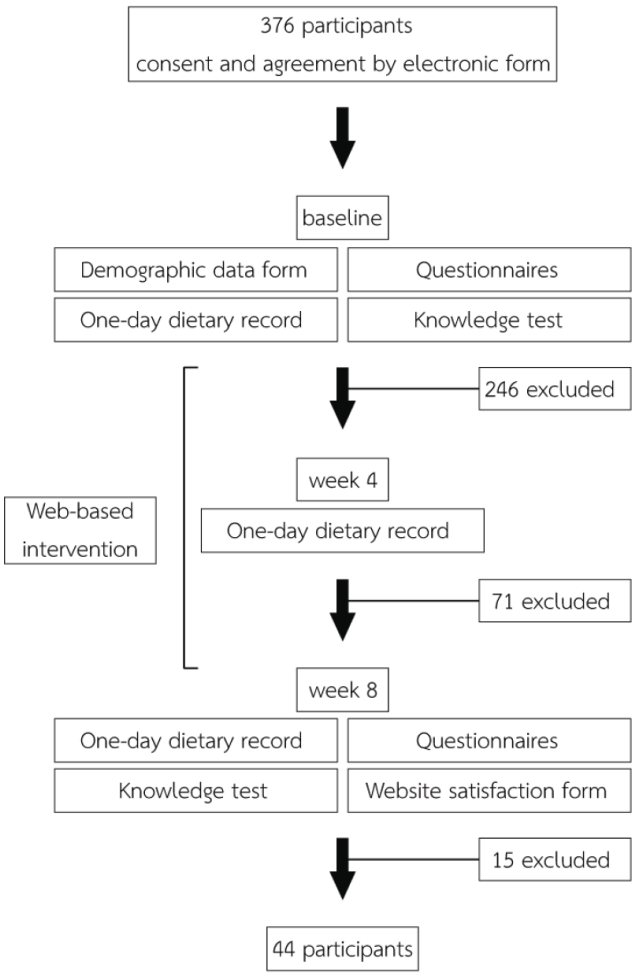

Figure 1: Flow diagram of participants throughout the study.

The demographic data is shown in Table **1**. Most of the participants were female and aged over 40 years, and the majority of them were pre-dialysis CKD patients at stage 3 and 4 for more than 1 year. Nearly half of the participants (43.2%) had comorbid hypertension, and 27.3% had comorbid diabetes. The average body mass index (BMI) was 23.7 ± 3.0 kg/m^2.

Table 1: Characteristics of Participants (n = 44)

Characteristics		Number (%)
Sex		
Male		13 (29.5)
Female		31 (70.5)
Age (years)		
20 - 29		6 (13.6)
30 - 39		12 (27.3)
40 - 49		16 (36.4)
50 - 59		10 (22.7)
Mean ± SD		41.7 ± 9.1
CKD stages		
Stage 3		29 (65.9)
Stage 4		15 (34.1)
Duration of CKD (months)		
6 – 12		8 (18.2)
> 12		36 (81.8)
Comorbid conditions		
Hypertension		19 (43.2)
Diabetes mellitus		12 (27.3)
Glomerulonephritis		4 (9.1)
Hyperlipidemia		4 (9.1)
Heart disease		2 (4.5)
Others		5 (11.4)
Nutritional status categorized by BMI (kg/m^2)		
< 18.5	Underweight	2 (4.5)
18.5 – 22.9	Normal	15 (34.1)
23.0 – 24.9	Overweight	8 (18.2)
> 25.0	Obesity	19 (43.2)
Mean ± SD		23.7 ± 3.0

Knowledge and Dietary Behavior

The total knowledge scores were significantly improved in the post-test when compared to the baseline, as shown in Table **2**. Eating behavior measures included the FFQ, eating behavior questionnaire and one-day dietary record. In comparison to the baseline, the food habit scores showed significant improvement, whereas the FFQ did not, as shown in Table **3**. This study showed low correlation (r = 0.369) between the nutrition knowledge scores and the total dietary behaviors, whereas the score after the intervention showed no correlation between the nutrition knowledge scores and dietary behaviors (Table **4**).

The comparisons of the mean values from the one-day dietary record performed at the beginning of the study, during and after the intervention were carried out. There were no significant changes in energy and macronutrient intakes as well as fiber intake (Table **5**). When compared to the recommended amount of daily intakes, most participants consumed lower energy, carbohydrates, and fat than the recommended amounts, whereas the intake of protein appeared to be higher than the recommended amount.

When considering the number of participants in each group classified by the amount of energy intake, it was shown that the number of participants with energy

Table 2: Mean Scores of Knowledge Test (n = 44)

Topic	Full marks	Knowledge score[1]		*p*-value[2]
		Pretest	Posttest	
Nutrition	10	6.41 ± 1.93	7.41 ± 1.80	< 0.001
Kidney and CKD	4	2.43 ± 0.66	2.80 ± 0.76	0.004
Exercise	3	2.70 ± 0.51	2.80 ± 0.41	0.317
Medication	3	2.36 ± 0.94	2.45 ± 0.55	0.317
Total	20	13.90 ± 2.46	15.46 ± 2.57	< 0.001

[1]Data are expressed as mean ± SD.
[2]*p*-value by Wilcoxon signed-ranks test with significant level at α=0.05.

Table 3: Score of Dietary Behaviors (n = 44)

Tools[1]	Pretest	Posttest	*p*-value[2]
Food-frequency questionnaire	49.23 ± 4.55	50.10 ± 3.40	0.066
Eating behavior questionnaire	18.77 ± 4.37	19.86 ± 2.45	0.047
Total	68.00 ± 8.04	69.95 ± 5.49	0.022

[1]Data are expressed as mean ± SD.
[2]*p*-value by paired t-test with significant level at α=0.05.

Table 4: Correlation between Nutrition Knowledge Score and Dietary Behavior Score Before and After the Intervention (n = 44)[1]

Nutrition knowledge score	FFQ	Dietary habits	Total
Pretest	0.369*	0.213	0.361*
Posttest	0.060	0.131	0.115

[1]Data are expressed as Spearman's rho.
*Correlation is significant at the 0.05 level.

Table 5: Calorie and Macronutrient Intakes of the Participants at Baseline, Week 4, and Week 8 of the Study (n = 44)

Energy and macronutrients[1]	Baseline	Week 4	Week 8	*p*-value[2]
Total energy				
kcal/day	1366.60 ± 256.23	1410.97 ± 201.07	1505.39 ± 333.25	0.051
Protein				
g/day	52.91 ± 18.09	53.33 ± 14.54	53.76 ± 15.06	0.971
kcal/day	211.64 ± 72.36	213.32 ± 58.16	215.04 ± 60.24	
Carbohydrate				
g/day	182.92 ± 46.50	199.31 ± 46.80	203.84 ± 50.95	0.098
kcal/day	731.68 ± 186.00	797.24 ± 187.20	815.36 ± 203.80	
Fat				
g/day	47.55 ± 16.38	45.82 ± 13.95	52.25 ± 20.24	0.218
kcal/day	427.95 ± 147.42	412.38 ± 125.55	470.25 ± 182.16	
Fiber				
g/day	7.38 ± 5.48	6.54 ± 3.96	5.59 ± 3.58	0.228

[1]Values are expressed as mean ± SD.
[2]*p*-value by repeated measures analysis of variance with significant level at α=0.05.

Table 6: Number of Participants Classified by Daily Energy and Macronutrient Intakes Compared with the Recommended Amount (n = 44)

Energy and Macronutrients	Number of participants (%)		
	Baseline	Week 4	Week 8
Energy			
Below recommended	37 (84.1)	33 (75.0)	29 (65.9)
On recommended	6 (13.6)	9 (20.5)	12 (27.3)
Above recommeded	1 (2.3)	2 (4.5)	3 (6.8)
χ^2 = 3.970, df = 4, *p*-value = 0.410			
Protein			
Below recommended	5 (11.4)	4 (9.1)	3 (6.8)
On recommended	8 (18.2)	14 (31.8)	14 (31.8)
Above recommeded	31 (70.4)	26 (59.1)	27 (61.4)
χ^2 = 3.000, df = 4, *p*-value = 0.558			
Carbohydrate			
Below recommended	32 (72.7)	33 (75.0)	32 (72.7)
On recommended	11 (25.0)	9 (20.5)	12 (27.3)
Above recommeded	1 (2.3)	2 (4.5)	0 (0.0)
χ^2 = 2.458, df = 4, *p*-value = 0.652			
Fat			
Below recommended	30 (68.2)	30 (68.2)	24 (54.5)
On recommended	6 (13.6)	8 (18.2)	8 (18.2)
Above recommeded	8 (18.2)	6 (13.6)	12 (27.3)
χ^2 = 3.375, df = 4, *p*-value = 0.497			

Total energy intake recommendation for CKD patients: 30 - 35 kcal/kg IBW/day [11].
Dietary protein intake for patient with CKD in pre-dialysis: 0.6 – 0.8 g/kg IBW/day [12].
Caloric intake from carbohydrate: 50 – 60% of total calorie intake [13].
Caloric intake from fat: 30 – 35% of total calorie intake [13].

Table 7: Mineral Intake of Participants at Baseline, Week 4, and Week 8 (n = 44)

Minerals	Amounts of mineral intake (mg/day)[1]			*p*-value[2]
	Baseline	Week 4	Week 8	
Sodium	2876.95 ± 1067.01	2384.93 ± 890.53	2318.83 ± 670.03	0.005
Phosphorus	617.32 ± 199.18	616.17 ± 123.49	604.03 ± 180.18	0.923
Calcium	458.38 ± 269.12	471.70 ± 281.80	478.46 ± 380.56	0.959
Potassium	1060.37 ± 400.77	935.11 ± 296.55	884.72 ± 324.28	0.069

[1]Values are expressed as mean ± SD.
[2]*p*-value by repeated measures analysis of variance with significant level at α=0.05.

intake under the recommended amount tended to decrease, whereas the number of participants whose energy intake was within the recommended amount was likely to rise, similar to the number of participants with regard to carbohydrate intake. However, there was no significant distinction (Table **6**). In addition, the intakes of some minerals were also observed. The results showed no significant changes in phosphorus, calcium, and potassium intakes between time periods, whereas the intake of sodium was significantly decreased, as shown in Table **7**.

Website Satisfaction

The website satisfaction was evaluated by a 5-point Likert scale format. The average scores of the parts of content/information, design/graphic, and application/ use were 4.13 ± 0.68, 3.93 ± 0.56, and 3.88 ± 0.85, respectively. The mean score of overall satisfaction was 3.98 ± 0.85.

DISCUSSION

Characteristics of Participants

In this study, the largest patient group (36.4%) was between 40 and 49 years old, the second largest was between 30 and 39 years old (27.3%), and the average age was 41.7 ± 9.1 years old. The generation associated with internet behavior might be a factor in this study [14], so the average age of the participants appeared to be in the range of 30 to 49 years old.

Twenty-nine (65.9%) patients with stage 3 CKD and 15 (34.1%) patients with stage 4 CKD were enrolled in this study. Generally, the symptoms are not clearly observable in CKD patient stages 1 and 2; hence, the patients had no awareness of their health care needs. A study among Thais reported that only 3.0% of the patients were well aware of their condition [15]. This supports the reason that early CKD patients were not found in this study. With regard to the comorbid conditions of CKD, this study showed that 43.2% of the participants had hypertension. Another complication found was diabetes (27.3%). This figure corresponds with the study on CKD prevalence in Thailand, which suggested that 45.8% of pre-dialysis CKD patients had hypertension and 8.2% had a diabetic condition [16]. It was suggested that hypertension is the most important risk factor for the development of chronic kidney disease in the Thai population, and that diabetes may cause damage to kidney function [17].

Regarding BMI, most participants appeared to be overweight and obese. This finding was consistent with the study of Wlodarek *et al*. [18], which reported that overweight and obese conditions were found in pre-dialysis patients. Moreover, several studies found that obesity is a risk factor among Asian CKD patients and CKD incidence is likely to increase in association with higher BMI, particularly in men [19, 20]. Moreover, one study among Japanese patients suggested that high BMI and prevalence of obesity were found to be higher in CKD patients than those in people without CKD [21].

Knowledge and Dietary Modification

Several studies found that CKD patients had gained a higher knowledge score after the intervention [22, 23] by both individual counseling and/or group counseling. Likewise, the results for computer-based or web-based education were the same [6, 8, 24]. The outcomes indicated a significant increase in knowledge scores after having studied through the website. This indicated that the efficiency of the content in the website could improve and facilitate self-learning for CKD patients with user-friendly text and accessible graphics. However, most patients had been diagnosed with CKD for over a year, and as a result, the website also facilitated their continuity in learning.

For dietary behavior, there was no change in the total score after the intervention compared with the baseline, whereas the average score of eating behavior showed a significant improvement. However, this study showed no correlation between the knowledge scores and eating behavior, which meant that higher nutrition knowledge scores did not correlate with a higher behavior scores. In conclusion, the content of the website may not provide sufficient motivation to influence the changes in dietary behavior as much as face-to-face intervention where social support and encouragement can be given directly [25]. Knowledge is essential to CKD patients, but knowledge alone may not influence the improvement of related behaviors [26].

Nutrient and Energy Intakes

The data from the one-day dietary records at baseline, during, and at the end of the study suggested that the participants had a daily total energy intake that was lower than the recommended amount. Likewise, carbohydrate and fat intakes were also lower than the recommended amounts, whereas protein intake appeared to be greater than the recommended amount. The results were similar to other studies in that most of the participants had energy intake lower than the recommended amount [18, 27, 28]. Quite possibly, this study was conducted on patients who had not undergone dialysis and the obvious symptoms had not yet appeared; hence, the patients did not have control of their protein intake.

Considering the intake of sodium, it is recommended that no more than 2,300 mg per day be ingested, based on the Dietary Approaches to Stop Hypertension (DASH diet). This study showed that sodium intake among the participants decreased. It is possible that the participants may have been recommended a diet with low sodium or avoidance of foods that are high in sodium contained on the website. For phosphorus, the majority of the participants had low intake of this mineral (800 - 1,000 mg per day) [12], contrary to protein intake, which appeared to be greater than the recommendation. People with higher protein consumption may have higher phosphorus intake because high-protein foods also contain phosphorus. One gram of protein contains 13 - 15 mg of phosphorus, and 30% to 70% of phosphorus is absorbed through the intestine, depending on the type of food [29]. It is possible that the participants tried to avoid some foods that are rich in phosphorus, such as beverages or snacks with chocolate, cola, beer, and pulses.

For calcium intake, most participants consumed calcium below the recommended level (800 - 1,500 mg per day) [12]. Low calcium intake is associated with increased risk of osteoporosis [30]. In terms of calcium

intake among Thai females, 97.2% had an average calcium intake of 265 mg per day [31], which is lower than the recommended amount of 800 mg per day (Thai RDIs). Additionally, most Thai foods are likely to contain low calcium content as the general meal does not include the consumption of much milk or dairy products, which are rich in calcium bioavailability [32]. Moreover, some participants may have to limit phosphorus and protein intake from dairy products, which probably results in lower calcium ingestion than the recommended amount. However, this study did not collect detailed information about the use of medications, dietary supplements or herbs during the intervention that may have an influence on such mineral intakes. Another mineral intake observed in this study was potassium. The study found that all participants consumed less than 3,500 mg of potassium per day, which was lower than the recommended amount of Thai RDIs, and even tended to decrease. Since potassium is found in plant-based foods, it is possible that the participants ate less than the optimum amounts of fruits and vegetables. According to the calculation results of mean fiber consumption, it was found that the average fiber intake of the participants was lower than the recommended amount (20 - 30 g per day) [18]. Presumably, the participants were missing out on fiber due to restrictions in high-potassium foodstuffs such as plant-based foods. Furthermore, most participants tended to consume incomplete meals (insufficient protein, carbohydrate, fruit and vegetable intake), which may lead to lower than recommended amounts of fiber and potassium intakes.

This study showed that online information enhanced learning in patients and influenced consumption behavior improvement. However, there was no effect on nutrient and caloric intakes. CKD varies from individual to individual and it is recommended that patients receive regular advice from health professionals. According to CKD interpersonal counseling intervention, the patients had improvement of nutrient intake when compared with the control group [33]. Likewise, other studies with face-to-face intervention resulted in the same outcome when compared to the internet-based group and the control group [7, 34]. Certainly, the face-to-face intervention has been proven to be the most effective method when compared to the other two groups. The interpersonal counseling intervention provides the most effective results in the improvement of consumption and other outcome variables. Medical personnel are able to specifically focus on nutritional issues with direct social support from verbal encouragement, which could not be provided through computer-based intervention. In addition, the CKD patients are likely to consult their health care professionals and to verify the information online. The internet is patients' alternative source for health information [35].

From the researchers' observation, the topic of nutrition had the highest number of views from website visitors (64.0%), followed by the topics of kidney and CKD, exercise, and medicine, respectively. Further investigation into the nutrition topics showed that the top three most visited were micronutrients, macronutrients, and fruits and vegetables. These results indicate that most participants are focused on nutrition, which may be due to nutrition being the main content of the website. Therefore, it was likely to draw the attention of the participants. However, this study collected the information based on click-counts only and as a result, this method was not able to indicate the time duration that visitors spent on each webpage and thus does not accurately reflect the actual use of the website. Aside from searching for information, the users also shared and exchanged contents, giving and receiving social support from peers [21]. Thus, it can be seen that the internet has become an alternative channel to share health care information and experiences.

CONCLUSION

This educational website for pre-dialysis CKD patients could improve both the knowledge and consumption behavior scores. The correlation between the knowledge scores and consumption scores was not found. After the intervention, there were no differences in daily energy intake and some nutrient intakes other than a significantly lower intake of sodium. Web-based nutrition education may not provide enough encouragement and motivation to the CKD patients to make changes to eating behaviors. However, this web-based nutrition education for CKD is a feasible alternative information source and may be beneficial for patients, caregivers and health professionals as a tool for improving health and slowing down the progression of CKD.

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