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Research Article

A Health Education Intervention to Increase Fiber Intake: A Randomized Clinical Trial

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Abstract The intake level of fiber, a nutrient with a vast number of health benefits, falls behind the recommendations nationwide. The impact of nutrition education on improving daily intake has thus been investigated and shown to be effective in enhancing the intake of specific fiber-rich foods. Not much has been done to probe the effect of education on enhancing fiber intake with emphasis on all sources of dietary fiber. Thus, we conducted a randomized controlled trial to determine if a multi-component intervention—the Full Plate Diet— that places emphasis on fiber-rich foods, impacts the dietary fiber intake to a level that exceeds the recommendations of the Institute of Medicine. Thirty-five subjects (7 males and 28 females) were randomly assigned to either the intervention group (n=20), which received the nutrition/health education or to the control group (n=15) which did not receive the education. A collective analysis of the two groups' dietary intake was divided into three time points; April, May, and June. The recalled intake of dietary fiber and food groups considered to be rich sources of dietary fiber as well as macronutrients were averaged for each of these time points for each treatment group. For the purpose of comparing changes in intake of dietary fiber across the 3 time points and between the intervention and control groups, a linear mixed-model was used. The delta changes between the various time points were computed by subtracting the final time point minus the initial time point. Results showed that fiber intake increased significantly by 9.3 grams from the first time-point (April) to the second time-point (May) (95% CI 2.2, 16.4). The intake of legumes significantly improved by 0.36 (95% CI: 0.01, 0.7) and by 0.65 (95% CI: 0.3, 1.0) servings in the intervention group between baseline and the second and third-time (June) points, respectively, but did not change in the control group. Short-term education with emphasis on fiber intake from various food sources could improve the daily fiber intake. Longer follow-up investigations should also be conducted to assess whether or not health education could significantly improve the level of fiber on a long-term basis.

Keywords *Fiber; randomized controlled trial; education; legumes*

1. Introduction

With the increase in the prevalence of nutrition-related health issues, it is important to adopt dietary patterns that foster protective benefits (Mu et al., 2017). Patterns that have an abundance of fruits, vegetables, and whole grains have been linked with a reduced risk of several chronic diseases (Boeing et al., 2012). These foods contain a variety of macro and micro- nutrients that work independently and synergistically (Kakoti et al., 2015; Ros et al., 2018) to render positive outcomes (Liu, 2013). One main macronutrient is dietary fiber. Existing evidence strongly suggests the protective role of dietary fiber against cancer (Kunzmann et al., 2015), coronary heart disease (Wu et al., 2015), hypertension (Khan et al., 2018), hyperlipidemia (Surampudi et al., 2016), and diabetes (Wang et al., 2016). According to the Institute of Medicine, 25 and 38 g of fiber daily are recommended for females and males, respectively (Trumbo et al., 2002). However, during the past two decades, the fiber intake of Americans did not improve and still fell behind these recommendations with an average of 15-16 g daily (King et al., 2012, McGill and Devareddy, 2015). It is thus imperative to improve the intake level of the public to attain its health benefits and attenuate risks of various chronic diseases (Kunzmann et al., 2015; Wu et al., 2015; Khan et al., 2018; Surampudi et al., 2016; Wang et al., 2016). One strategy that has been proven to be effective in improving the dietary behavior of individuals is nutrition education. Literature strongly suggests the importance of nutrition education in improving the intake of fiber-rich foods such as fruits and vegetables and attenuating the consumption of saturated fats and refined carbohydrates (Anderson et al., 2001; Ha and Caine-Bish, 2009; Liu et al., 2009). Ha and Caine-Bish (2009) showed that an intervention based on a general nutrition course led to an increase in the intake of fruits and vegetables resulting in an increase in fiber intake and a decrease in consumption of energy-dense foods.

For a nutrition intervention to be successful, however, it should consist of multiple components and not solely basic nutrition information. It should assess readiness for change, attitudes, beliefs, social norms, and behavioral and environmental factors (Pollard et al., 2009). Resnicow et al. (2001) showed that a multi-component intervention with emphasis on motivational interviewing led to a significant increase in intake of fruits and vegetables.

Even though much research has been conducted to assess the impact of nutrition education on improving dietary habits of individuals, most were focused on enhancing the intake of specific foods such as fruits and vegetables (Anderson et al., 2001; Ha and Caine-Bish, 2009; Liu et al., 2009; Resnicow et al., 2001). Not much has been done to probe the effect of education on enhancing fiber intake with emphasis on all sources of dietary fiber. Most of the existing studies also targeted children (Jarpe-Ratner et al., 2016) or young adults (Welch et al., 1987) and excluded older individuals who might be at greater risk for various health problems (Shanmugasundaram et al., 2010).

Thus, we conducted a multi-component intervention—the Full Plate Diet—among middle-aged adults to determine if emphasis on fiber-rich foods impacts the dietary fiber intake to a level that exceeds the recommendations of the Institute of Medicine.

2. Methods

2.1. Study Design and Participants

The Full Plate Diet (FPD) study is a 10-week randomized controlled trial with a parallel design composed of an intervention and a control arm. The aim of the study was to determine the impact of nutrition education on dietary fiber intake. We also compared the effect of nutrition education on intake of various fiber-rich foods (fruits, vegetables, legumes, whole grains, and seeds) and of

major macronutrients (carbohydrates, proteins, total fats, and solid fats). Recruitment was conducted from January to March 2018 at and around the city of Loma Linda through an advertisement in the local newspaper, flyers sent to local churches, and flyers provided to clients of the Loma Linda University Drayson Center. Drayson Center is a wellness center that promotes through various fitness and other lifestyle activities, physical, emotional, and social wholeness.

Subjects were included if they were 21 to 65 years old, had a body mass index (BMI) between 25 and 35 kg/m^2, did not have a debilitating disease, and have not participated previously in the Full Plate Diet program. Thirty-five subjects (7 males and 28 females) participated in the study. The study participants were randomly assigned to either the intervention group (n=20), which received nutrition/health education focused on eating a diet rich in dietary fiber or to the control group (n=15).

The intervention group was also advised to increase their daily fiber intake to reach the goal of 40 grams. The control group did not receive the nutrition education nor any dietary advice but was offered a separate one-time stress management session mid-way through the 10 weeks; after the termination of the study, the control group was offered the complete nutrition intervention. All subjects were advised to continue following their habitual diet.

All subjects provided written and oral informed consent to participate. The study protocol was approved by the Loma Linda University Institutional Review Board (LLU-IRB # 5170138).

2.2. Assessment of Dietary Intake

To assess the dietary intake specifically of dietary fiber and its food sources, subjects had to complete 24-hour dietary recalls once every 2 weeks between April 1 to June 24, 2018. Dietary intake data for 24-hour recalls were collected and analyzed using the Automated Self-Administered 24-hour (ASA24) Dietary Assessment Tool, version 2016 developed by the National Cancer Institute, Bethesda, MD (https://epi.grants.cancer.gov/asa24). The subjects were trained to self-report their intake using the ASA24 online and those that had difficulty or had slow internet connection at home were encouraged to do their recalls at the study site.

To ensure compliance to the protocol for the intervention group, participants were provided a dietary fiber intake report sheet, which comprised a list of fiber-rich foods and their corresponding amounts of fiber per serving. Subjects had to report the high-fiber foods they consumed on a weekly basis throughout the 10-week intervention period.

2.3. Nutrition Education Intervention

The nutrition education intervention was conducted through educational classes once a week for 10 weeks at the Loma Linda University Drayson Center, a wellness center that promotes physical, emotional, and social wholeness through various fitness, sports, and other activities. The main goal was to help participants adopt the Full Plate Diet by gradually increasing their daily fiber intake to 40 g.

The intervention was formed from multiple components including a nutrition course provided through 10 lectures each having a 2-hour duration. The nutrition education did not place emphasis on the restriction of calorie intake, but was focused on the ways to enhance meals by increasing dietary fiber intake, emphasizing the importance of consuming foods with high nutrient density, and promoting various lifestyle modification tools, such as physical activity, that decrease the risk of chronic diseases.

The classes included direct teaching using PowerPoint presentations and interactive in-class and outdoor learning activities, such as visiting local markets to learn how to shop for high-fiber items and powering up menus with fiber-rich foods. The classes also included food demonstrations on recipes for dietary fiber-rich meals to educate and show the participants on how to prepare and cook these meals. Multiple assessments were administered to examine the subjects' readiness for change, attitudes, and barriers, and to assess their progress in knowledge and lifestyle modification.

The series of classes conducted were titled "Intro to Full Plate Diet", "Measuring Body Composition and Setting Goals", "Power Up/Portion Control", "Benefits and Types of Fiber", "Nutrition Fact Label/ Shopping", "Exercise Nutrition", "Dr. Bean", "Emotional Eating", "Eating Out", and "Chronic Disease Prevention". The program helped participants set lifestyle, dietary, and behavior goals and defined the steps required to achieve beneficial outcomes.

2.4. Sample Size Estimation

To estimate the sample size, an effect size of 0.857 was attained from literature and derived from Carmody et al. (2008) to compute and compare the minimal differences in the changes of dietary fiber from baseline to post-intervention between the control and intervention groups that are of clinical importance. G*Power 3.1 was utilized for the power analysis calculations taking into account 80% power and allowing for a type I (α) error of 5%. This study needed a minimum of 8 subjects/per group or a total sample of 16 subjects after taking into account a potential 20% drop-out rate. In order to increase power however, we included 35 subjects (15 in the control and 20 in the intervention).

2.5. Statistical Analysis

Data were analyzed using SPSS version 25 (IBM SPSS, Inc., Armonk, NY) with a level of significance set at $\alpha = 0.05$. Data are presented as either mean ± SD or median (interquartile range) based on the distribution of the variables. Demographic characteristics of the participants were determined using descriptive analyses; Chi-square analysis was used to compare demographic distributions of the control and intervention groups and *t*-test to determine mean differences for scale level variables.

Considering that behavior change takes time, a collective analysis of the two groups' dietary intake was divided into three time points. Dietary intake reported during the month of April was designated as time point 1 (baseline), dietary intake during the month of May was considered time point 2, and intake during the month of June as time point 3. The recalled intake of dietary fiber and food groups considered to be rich sources of dietary fiber (fruits, vegetables, whole grains, legumes, and seeds) as well as macronutrients were averaged for each of these time points for the two groups.

For the purpose of comparing changes in intake of dietary fiber across the 3 time points and between the intervention and control groups, a linear mixed-model was used. All of the dietary variables satisfied the normality assumptions. The delta changes between the various time points were computed by subtracting the final time point minus the initial time point.

The associated 95% confidence intervals were displayed to assess the level of precision of the time factor. A p-value was generated and presented to assess the level of between-group differences in the dietary fiber intake and in the intake of the various food groups and macronutrients.

3. Results

Table 1 displays the characteristics of the FPD participants. The control and intervention groups did not differ significantly in any of the characteristics except moderate physical activity where the control group exercised significantly more. The average age was 53 years and the baseline weight was 85 kg. At baseline, the majority of the population were females, non-smokers, employed for wages, had a 4-year college degree, did not consume alcohol, and did not have any cardiovascular disease risk factor.

Table 2 compares the fiber intake at baseline and during the second and third time-points between the intervention and control groups. In the intervention group, fiber intake increased significantly by 9.3 grams from the first time-point (baseline, T1) to the second (T2) (95% CI 2.2, 16.4) and the fiber intake difference (T2 – T1) comparing the intervention to the control group was significant (p=0.01). No significant changes in fiber intake were observed between the second and third time-points. A significant increase of 11.4 g was also observed in the intervention group between baseline and the third-time point (T3) (95% CI 3.7, 19.1) with the fiber intake difference (T3 – T1) comparing the intervention to the control group was even more significant (p=0.003). The control group had no significant changes in fiber intake between baseline and the second or the third time-points.

Table 3 compares the changes in the intake of various food groups between the control and intervention. The intake of fruits improved non-significantly by 0.43 serving in the intervention group but non-significantly decreased in the control group by 0.69 serving between baseline and the second-time point. These changes, however, were significantly different between the two groups (p = 0.03). No significant changes were observed between the second and third time-points in either group. Moreover, nonsignificant improvements were observed in the intervention group, but not in the control group, between baseline and the second and third time points when it came to total vegetables and whole grains. The intake of legumes, however, significantly improved by 0.36 (95% CI: 0.01, 0.7) and by 0.65 (95% CI: 0.3, 1.0) servings in the intervention group between baseline and the second and third-time points, respectively, but did not change in the control group. No changes were observed for the intake of seeds in either group.

Table 4 compares the changes in the macronutrients intake between the 2 groups. Total energy intake (Kcal) did not significantly change across the three time-points. The intake of carbohydrates non-significantly increased from 234.9g at baseline to 243.1g at the second time-point and to 248.4g at the third time-point in the intervention group. The carbohydrate intake non-significantly decreased by 7.7g between baseline and the third time-point in the control group. Protein intake non-significantly increased between baseline and third time-points in both groups. The intake of total fat non-significantly decreased from 78.4g at baseline to 74.3g at the second time-point to 70.1g at the third time-point in the intervention group. The intake of solid fats decreased in the intervention group non-significantly by 8.3g from baseline to the third time-point. The level of fat and solids fats did not change significantly in the control group between baseline, and the second and third time points.

Table 1: *Characteristics of the Full Plate Diet Study at Baseline (Control n=15; Intervention n=20)*

Variable	Control[a] (n=15)	Intervention[a] (n=20)	*p*-value[b]
Age, years	53.5 ± 9.6	53.2 ± 11.6	0.92
Marital Status			0.26
Single	0	15	
Married	93	75	
Divorced	7	10	
Gender			0.67
Male	13	25	
Female	87	75	
Education			0.84
High School or less	6.7	0	
High School graduate/ GED	6.7	10	
Some college	6.7	5	
2-year college	13.3	25	
4-year college	40	40	
Graduate degree	26.6	20	
Current Employment Status			0.25
Employed for wages	46.7	75	
Self-employed	26.7	5	
Home-maker	6.7	5	
Retired	20	15	
Income			0.34
$ 29,000 or less	40	25	
$30,000 – 59,999	13.3	40	
$60,000- $89,000	33.3	20	
$90,000 or more	13.3	15	
Vigorous physical activity, freq/week			0.33
Less than once per week	6.7	25	
1-2 times per week	26.7	30	
3-4 times per week	40	40	
5 times per week	13.3	0	
6 or more times per week	13.3	8.6	
Moderate physical activity, mins/d	43.6 ± 29.7	26.0 ± 18.1	0.003
Vigorous physical activity, mins/d	42.7 ± 33.6	23.6 ± 22.1	0.1
Smoking Status			
Non-smoker	100	100	0.99
Alcohol Intake			0.74
Yes	46.7	40.0	
No	53.3	60.0	
CVD Risk Factors at Baseline[c]			0.33
No	49	60	

[a] Data displayed as percentages for nominal/categorical variables and as mean ± standard deviation for scale variables

[b] P value generated through Chi-square for nominal or categorical variables and independent t-test for scale variables

[c] Has heart disease and/or one of its risk factors such as diabetes, hypertension, or high cholesterol

Table 2: *Within Group and Between-Group Differences of Fiber Intake for the Full Plate Diet study participants (n=35)*

	T1 (95% CI)	T2 (95% CI)	T3 (95% CI)	[a]Δ (T2- T1) (95% CI)	[d]P Value	[b]Δ (T3-T1) (95% CI)	[d]P Value	[c]Δ (T3-T2) (95% CI)	P Value
Fiber g (Control)	26.6 (22.1, 31.2)	24.4 (20.7, 28.2)	23.6 (19.2, 28.0)	-2.2 (-10.1, 5.7)	0.01*	-3.00 (-11.5, 5.5)	0.003*	-0.8 (-8.6, 6.9)	0.5
Fiber g (Intervention)	31.0 (26.2, 35.8)	40.3 (36.3, 44.3)	42.37 (37.6, 47.2)	9.31 (2.22, 16.4)*		11.38 (3.7, 19.1)*		2.08 (-5.0, 9.2)	

T1, time point 1, baseline or April; T2, time point 2, May; T3, time point 3, June
[a] Differences of means in fiber intake between May and April with 95% confidence interval to test for significance between time points
[b] Differences of means in fiber intake between April and June
[c] Differences of means in fiber intake between May and June
[d] P value to test significance for the differences between the control and intervention groups
* statistical significance

Table 3: *Within Group and Between-Group Differences of Food Groups for the Full Plate Diet Study Participants (n=35)*

	T1 (95% CI)	T2 (95% CI)	T3 (95% CI)	[a] Δ (T2- T1) (95% CI)	[d] P Value	[b] Δ (T3-T1) (95% CI)	P Value	[c] Δ (T3-T2) (95% CI)	P Value
Total Fruits servings (Control)	1.9 (1.3, 2.5)	1.2 (0.7, 1.7)	1.3 (0.7, 1.8)	-0.7 (-1.7, 0.3)	0.03*	-0.7 (-1.7, 0.4)	0.08	0.03 (-0.9, 0.4)	0.85
Total Fruits servings (Intervention)	1.4 (0.9, 2)	1.9 (1.42, 2.3)	1.8 (1.3, 2.3)	0.4 (-0.4, 1.3)		0.4 (-0.6, 1.3)		-0.1 (-0.9, 0.8)	
Total Vegetables servings (Control)	3.1 (2.2, 3.7)	3.2 (2.7, 3.7)	3.0 (2.4, 3.6)	0.1 (-0.9, 1.1)	0.52	-0.03 (-1.1, 1.0)	0.66	-0.1 (-1.1, 0.8)	0.86
Total Vegetables servings (Intervention)	3.0 (2.4, 3.5)	3.4 (3.0, 4.0)	3.2 (2.6, 3.7)	0.5 (-0.4, 1.3)		0.2 (-0.7, 1.2)		-0.2 (-1.1, 0.6)	
Legumes servings (control)	0.3 (0.01, 0.5)	0.2 (-0.01, 0.4)	0.3 (0.02, 0.5)	-0.1 (-0.5, 0.3)	0.06	0.001 (-0.4, 0.4)	0.007*	0.1 (-0.3, 0.5)	0.29
Legumes servings (intervention)	0.4 (0.2, 0.6)	0.8 (0.6, 1)	1.1 (0.8, 1.3)	0.4 (0.01, 0.7)*		0.7 (0.3, 1.0)*		0.3 (-0.1, 0.7)	
Whole grains servings (control)	1.1 (0.4, 1.8)	1.0 (0.4, 1.6)	1.1 (0.4, 1.8)	-0.04 (-1.2, 1.1)	0.17	-0.002 (-1.2, 1.2)	0.32	0.04 (-1.1, 1.2)	0.75
Whole grains serving (intervention)	1.7 (1.1, 2.4)	2.6 (2.1, 3.1)	2.4 (1.8, 3.1)	0.8 (-0.2, 1.9)		0.7 (-0.4, 1.8)		-0.2 (-1.9, 0.9)	
Seeds (control)	1.4 (0.5, 2.4)	1.5 (0.7, 2.3)	1.1 (0.2, 2.0)	0.1 (-1.5, 1.6)	0.40	-0.3 (-2.0, 1.3)	0.49	-0.4 (-1.9, 1.1)	0.92
Seeds (intervention)	2.1 (1.2, 3.0)	2.9 (2.2, 3.6)	2.4 (1.5, 3.3)	0.8 (-0.6, 2.2)		0.3 (-1.2, 1.8)		-0.5 (1.9, 0.9)	

T1, baseline or April; T2, May; T3, June

[a] Differences of means of intake between May and April with 95% confidence interval to test for significance between time points

[b] Differences of means of intake between June and April

[c] Differences of means of intake between June and May

[d] P value to test significance for the differences between the control and intervention groups

* statistical significance

Table 4: *Within Group and Between-Group Differences of Energy and Macronutrients for the Full Plate Diet Study Participants (n=35)*

	T1 (95% CI)	T2 (95% CI)	T3 (95% CI)	[a]Δ (T2- T1) (95% CI)	[d]P Value	[b]Δ (T3-T1) (95% CI)	P Value	[c]Δ (T3-T2) (95% CI)	P Value
Energy Kcal (Control)	1676.5 (1408.5, 1944.5)	1953.9 (1731.9, 2175.8)	1792.5 (1535.0, 2050.0)	277.3 (-147.6, 277.3)	0.53	115.9 (-338, 569.8)	0.45	-161.4 (-576.5, 253.8)	0.70
Energy Kcal (Intervention)	1830 (1590.3, 2069.7)	1941.4 (1747.8, 2135)	1753.6 (1509.8, 1997.4)	111.4 (-264.9, 487.7)		-76.4 (-494.0, 341.2)		-187.8 (-568.0, 192.4)	
Carbohydrates g (Control)	213.8 (193.7, 233.9)	200.5 (183.9, 217.2)	206.2 (186.9, 225.5)	-13.3 (-45.2, 18.7)	0.23	-7.7 (-41.8, 26.5)	0.27	5.6 (-25.6, 36.8)	0.99
Carbohydrates g (Intervention)	234.9 (216.9, 252.9)	243.1 (228.4, 257.7)	248.4 (230.4, 266.4)	8.2 (-20.2, 36.6)		13.5 (-17.6, 44.6)		5.3 (-23.1, 33.7)	
Protein g (control)	73.8 (64.4, 83.1)	80.9 (73.2, 88.6)	82.8 (73.9, 91.8)	7.2 (-7.6, 22)	0.87	9.1 (-6.7, 24.9)	0.50	1.9 (-12.6, 16.4)	0.57
Protein g (Intervention)	63.7 (55.3, 72)	69.4 (62.6, 76.2)	66.8 (58.5, 75.1)	5.8 (-7.4, 19)		3.1 (-11.3, 17.6)		-2.7 (-15.8, 10.5)	
Total fat g (control)	78.7 (71.0, 86.3)	79.4 (73.1, 85.7)	74.3 (67.0, 81.7)	0.7 (-11.4, 12.9)	0.47	-4.3 (-17.3, 8.6)	0.59	-5.1 (-16.9, 6.8)	0.89
Total fat g (Intervention)	78.4 (71.6, 85.3)	74.3 (68.8, 79.8)	70.1 (63.2, 77.1)	-4.1 (-14.9, 6.6)		-8.3 (-20.2, 3.6)		-4.2 (-15.0, 6.7)	
Solid Fats g (Control)	24.7 (18.2, 31.3)	24.9 (19.5, 30.3)	27.0 (20.7, 33.2)	0.2 (-10.2, 10.6)	0.14	2.3 (-8.8, 13.4)	0.23	2.1 (-8.0, 12.3)	0.86
Solid Fats g (Intervention)	24.9 (19.0, 30.7)	16.6 (11.8, 21.3)	19.7 (13.9, 25.6)	-8.3 (-17.6, 0.9)		-5.17 (-15.3, 5)		3.2 (-6.1, 12.4)	

T1, baseline or April; T2, May; T3, June

[a] Differences of means between May and April with 95% confidence interval to test for significance between time points

[b] Differences of means between June and April

[c] Differences of means between June and May

[d] P value to test significance for the differences between the control and intervention groups

4. Discussion

The aim of our study was to investigate how a 10-week nutrition education program impacts the daily fiber intake in a group of middle-aged individuals. We found that fiber intake improved along with the intake of legumes and fruits. An increase was observed for vegetable and whole grain intake which did not reach significance. This could be related to the strong emphasis placed on the intake of beans and other legumes in our program.

Very little research has been done to investigate the effect of nutrition education on fiber intake; most studies assessed the association between education and the intake of various food-groups such as fruits and vegetables. The results of the few investigations that measured the change in dietary fiber intake specifically lack consistency. Pimentel et al. (2010) showed that nutrition education that emphasized on the intake of whole grains, fruits, and vegetables failed to improve the dietary fiber intake in Brazilian adults. A few studies have displayed the effectiveness of nutrition education in improving total fiber or fruit and vegetable intake in children (Jarpe-Ratner et al., 2016) and young adults (Welch et al., 1987); not much has been conducted to assess the impact on middle-aged individuals who might be susceptible for morbidity and mortality from various chronic diseases. Our investigation circumvented these gaps by directly measuring dietary fiber as one of the main outcomes and including a middle-aged population.

Literature suggests that the success of the intervention programs in changing dietary habits and increasing daily fiber consumption is tied to their design (Bensley et al., 2011, Carmody et al., 2008, Jarpe-Ratner et al., 2016). Congruent with our findings, programs that included more than the element of direct education have been shown to be much more effective in reaching the dietary change goals. Bensley et al. (2011) showed that follow-up counseling is essential to ensure the success of nutrition education interventions in increasing fruit and vegetable intake, whether traditional or internet-based. Including interactive learning such as cooking demonstration also seems to produce more promising results than basic nutrition education programs. Studies document that culinary education improves attitudes regarding healthy cooking (Levy and Auld, 2004), time spent cooking (Eisenberg et al., 2013), and healthy food intake (Levy and Auld, 2004, Eisenberg et al., 2013). Carmody et al. (2008) showed in a study conducted on men with prostate cancer that a nutrition education program comprised of dietary and cooking classes with mindfulness practice and an emphasis on plant-based foods and fish, led to an increase in fiber intake from 20.4 g at baseline to 28.4 g after. The effect of cooking on behavior change is also prominent in younger populations. Jarpe-Ratner et al. (2016) showed that students in grades 3–8 from low-income communities who experienced Cooking and Nutrition Education Program improved their cooking-self efficacy and vegetable consumption score. Moreover, parallel to our findings, investigations that not only focused on the benefits and sources of fiber but also on how to introduce these foods into the daily meals, succeeded in achieving the dietary goals. Wagner et al. (2016) showed in a study involving overweight and obese adults (average age of 45 years) that nutrition education that emphasized on means of incorporating fruits and vegetables into meal plans improved their intake level.

Our investigation has various advantages. It showed that a multi-component intervention program, even though of short duration, was able to improve the dietary fiber intake of a young and middle-aged population mostly free of chronic diseases. It is one of the few that aimed to increase fiber intake to a level exceeding that recommended by the Institute of Medicine (Trumbo et al., 2002).

However, our study has various limitations. Dietary analysis was done at the group level instead of at individual level when determining how dietary fiber intake changed over time since a single 24-hr recall is not an accurate estimate of an individual's usual dietary intake. Moreover, dietary

intake was self-reported using an interactive web-based 24-hr recall software (ASA24). The nature of the method used may have introduced recall bias and self-reporting is also susceptible to reporting bias, both of which may have reduced the accuracy in the estimates of dietary fiber intake. Whereas participants were trained in the use of the ASA24 software when reporting their dietary intake, some encountered difficulties in using the software. Nevertheless, those who faced difficulties or had slow internet connection at home were encouraged to do their recalls at the study site. Since the study was short-term, it is also not known whether the increase in dietary fiber intake is sustainable long-term.

Conclusion

A multi-component nutrition education intervention of short duration could potentially raise dietary fiber intake along with the intake of legumes and fruits in a group of middle-aged individuals. More research should be conducted to validate the estimation of fiber intake from dietary recalls with a more objective tool such as food records to improve the validity of assessment. Longer follow-up investigations should also be conducted to assess whether or not health education could significantly improve the level of fiber on a long-term basis.

Conflict of Interest Disclosure

None of the authors declared any conflict of interest.

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A complete description of the Full Plate Diet Clinical Trial (number is 03232970) is available on http://www.ClinicalTrials.gov, as required by U.S law.

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