Nutrition and Food Sciences Research Vol 1, No 2, Oct-Dec 2014, pages: 11-18

Original Article

Relationship of Glycemic Control and Stages of Change for Fiber Intake in Type 2 Diabetic Patients: A Cross-sectional Study

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Received: September 2014 **Accepted:** November 2014

A B S T R A C T

Background and Objectives: Increased consumption of fiber in the diet of diabetic patients is usually recommended for better diabetes control. Trans-theoretical model of health behavior has had positive results in diabetes consultations on healthcare and adherence to healthy eating. The present study aimed to investigate the relationship between the stages of change based on fiber consumption and glycemic control in the patients with type 2 diabetes.

Materials and Methods: This study was conducted on126 individuals (aged 30-65 years) with type 2 diabetes selected from two diabetes care centers in Tehran, Iran. *"Stages of change questionnaire"* was completed, and dietary intake was determined by a three-day food record. Logistic regression was used to explore the relationship between the stages of change and glycemic control indices in these patients. P-value<0.05 was considered as statistically significant.

Results: The mean fiber intake in the patients with type 2 diabetes (10.62±3.19 g/kcal) was less than the minimum amount recommended by Dietary Reference Intake (DRI). Besides, most patients were in the maintenance (52%) and preparation (22.4%) stages. After adjustment for confounding factors, a positive significant relationship was observed between the blood glucose level and the action and maintenance stages. However, this relationship was contrary to the expected results. The largest part of fiber intake was related to fruits (~40%).

Conclusions: Trans-theoretical model seems to be efficient for distinguishing the readiness of the patients with type 2 diabetes for change in their fiber intake behavior. Nevertheless, no association was found between the stages and glycemic control indices.

Keywords: Stages of change, Dietary fiber, Type 2 diabetes

Introduction

Diabetes mellitus has become one of the great epidemics of our time. In 2014, around 387 million people had diabetes in the world, and by 2035 this will rise to 592 million. In Iran, more than 4.5 million people suffer from diabetes based on the latest International Diabetes Federation (IDF) Diabetes Atlas on 2014 (prevalence rate: 8.64%) (1). Diet plays a pivotal role in the therapeutic strategy to keep patients with diabetes in good glycemic control, and prevent micro- and macro-vascular complications. Thus, increasing the consumption of dietary fiber is an important recommendation for these patients' diets. Some studies have shown that high fiber intakes may improve glycemic control by improving the postprandial glycemic response and insulin concentrations, and also by increasing the sensitivity to insulin in diabetic subjects (2-4).

Dietary Reference Intakes (DRI) recommended consumption of 14 g dietary fiber per 1,000 kcal (or 25 g for adult women and 38 g for adult men) based on epidemiologic studies (5,6). However, several studies suggest a lower amount of intake (2, 7-10). In order to help individuals meet this recommendation, an overwhelming consensus among the health organizations advised increased consumption of fruits, vegetables, dried beans and peas, and whole grains (2).

In order to make a long-term behavior modification and to evaluate the behaviors efficiently, it is recommended to use the behavioral models and theories in studies and programs (11). It has also been shown that promoting healthy eating behaviors would be successful if the mediating factors are considered through appropriate models of health behavior change (12). One of the most

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common models of behavior change in health education is Trans-theoretical Model (TTM). It has been shown that this model was effective in predicting and improving the nutritional behaviors in diverse populations (13,14). TTM, first introduced by Procheska and De Clement (15), provides a framework for understanding the health-related behavior change. This model, also called "stages of change", assesses individuals' motivation to change unhealthy living habits, and has been used to tailor nutritional interventional studies. Stages of change describe a sequence of cognitive and behavioral steps until reaching the actual behavior changes (16). In this model, individuals are classified into five stages (pre-contemplation, contemplation, preparation, action, and maintenance) based on their current behavior and their readiness to change that behavior.

The growing literature applying TTM to dietary behaviors indicates that this model could be applied to the adults' dietary behaviors, such as fat intake, and consumption of dietary fiber, and consumption of fruits and vegetables (17,18). According to the literature, dietary intake and stages of change are correlated in predicted directions; that is, individuals in more advanced stages of change derive the lowest percentage of energy from fat, exhibit higher levels of fiber consumption, and eat more fruits and vegetables. The value of these data lies in the validation of the concept of stages of change as an important marker for the actual intake (19). Following the nutritional recommendations in a better way is related to an increase in the stages of change; TTM has also claimed that individuals have different needs of consulting and educational interventions based on their stages of change. The present research aims to compare the distribution of stages of change related to more fiber intake, and to determine the association between the stages and glycemic control indices in the patients with type 2 diabetes.

Materials and Methods

Subjects and procedure: In this cross-sectional study, 145 diabetic patients aged 30 to 65 years were randomly recruited from "Charity Foundation for Special Diseases" and "Iranian Diabetes Society" in Tehran, Iran. They were suffering from type2 diabetes for 3 years and more, and at least 3 months had passed from their attendance in the nutritional educational classes. They were able to read and write in Persian, and were willing to participate in the study. After a 12-14 hr overnight fasting and before taking any drug(s), 5 ml of blood sample was collected from each subject between 8 and 10 a.m. Afterwards, demographic information and stages of change questionnaires were completed, and the patients were taught how to record food by the kitchen utensils. They were then asked for a 3-day food record (2 weekdays and 1 weekend). One week to 10 days later, food records were collected, and the other questionnaires were completed in person. The participants who did not return their food records were withdrawn from the study.

The height was measured using a tape measure to the nearest 0.1 cm, while standing without shoes, with the back to the wall, feet together, and the head, shoulders and hips touching the wall. The weight was measured in light clothing using a Seca balance scale, with a measurement accuracy of 0.1 kg. Then their Body Mass Index (BMI) was calculated as weight/height^2 (kg/m^2). Besides, the data on physical activity were obtained using modified International Physical Activity Questionnaire (IPAQ), and expressed as metabolic equivalent h/day (MET-h/day). To measure the blood glucose, glucose oxidase kit based on colorimetric method was used (Pars Azmoon Inc, Iran). Glycosylated hemoglobin and total hemoglobin were separated by chromatography method by BioSystems kit (Spain), and the solvent adsorption was read at 415 nm. The serum insulin was measured by ELISA (Mercodia Inc, Sweden), and the insulin resistance was estimated by HOMA equation as follows:

Fasting plasma glucose (mmol/l) × Fasting serum insulin (mU/l) / 22.5

Nutritional assessment: Dietary fiber, carbohydrate, protein and energy intakes were assessed using the 3-day food records by the modified Nutritionist IV program for Persian food.

Stages of change: The stages of change in fiber intake were measured by a valid questionnaire. In doing so, the patients were asked to indicate which of the five statements best described their current dietary behavior: 1) "I currently do not eat enough high fiber foods and I am not thinking about starting" (pre-contemplation); 2) "I currently do not eat enough high fiber foods but I am thinking about starting" (contemplation); 3) "I currently do not eat enough high fiber foods but I plan to do so within the next month" (preparation); 4) "I currently eat enough high fiber foods but I have only begun to do so in the last 6 months" (action); and 5) "I currently eat enough high fiber foods and I have done so for longer than 6 months" (maintenance). Dietary fiber is not a tangible concept; therefore, the participants were informed about the foods rich in fiber (cereals, fruits, vegetables, and beans), and their recommended amounts before choosing the stages by brochures.

Statistical analysis: All the analyses were performed using the SPSS statistical software (v. 16). Normality has been checked for all variables and for variables which do not have normal distribution, the log transformed forms were used for further analyses. The data were expressed as mean ± SD or percentages. The variables were compared across the stages of change by one-way ANOVA with Tukey's post-hoc comparisons for quantitative variables, and Chi-square test for qualitative variables. Moreover,

logistic regression was used to determine the relationship between the stages of change and glycemic control indices. Overall, five models were constructed to examine the association between the stages of change and the risk of hyperglycemia in type 2 diabetes patients. Model I was unadjusted. Model II was adjusted for gender and duration of diabetes. Model III included the variables in Model II plus BMI. Model IV included the variables in Model III plus hypoglycemic drugs. Finally, model V was adjusted for all of the previous variables plus physical activity (MET.h/day) and energy intake (Kcal).

Ethics: The Ethics Committee of 'National Nutrition and Food Technology Research Institute' (Tehran-Iran) approved the study, and all participants gave their permission by signing an informed consent form.

Results

Out of the 145 type 2 diabetic patients who were invited to participate in the study, 126 (87%) completed the study. Among the study participants, 82 (65.1%) were male and 44 (34.9%) were female, 77.8% had high school or above degrees. Average of BMI was 29.22 ± 4.27, and it was not significantly different among the stages. The characteristics of the study patients are presented in Table 1.

Table 1. Characteristics of the studied diabetic patients

Characteristics of the patients		Mean±SD
Age (year)		53.5±6.02
The number of years stricken with diabetes		9.18±5.31
Body Mass Index (kg/m^2)		29.22±4.27
The amount of physical activity based on MET.h/day		32.84±3.75
		Number (N%)
Gender	Male	82 (65.1%)
	Female	44 (34.9%)
Employment status	Unemployed	3 (2.4%)
	3d grade job	15 (11.9%)
	2nd grade job	55 (43.7%)
	1st grade job	8 (6.3%)
	Retired	45 (35.7%)
Marital status	Married	117 (92.9%)
	Single	2 (1.6%)
	Widow/Divorced	7 (5.6%)
Education level	Elementary school	17 (13.5%)
	Guidance school	11 (8.7%)
	High school and diploma	62 (49.2%)
	University	36 (28.6%)
Smoking	Yes	23 (18.3%)
	No	103 (81.7%)
Medicines decreasing glucose Number of people taking medicine (%)	Metformin	108 (85.7%)
	Glibenclamide	91 (72.2%)
	Other medicines	32 (21.4%)

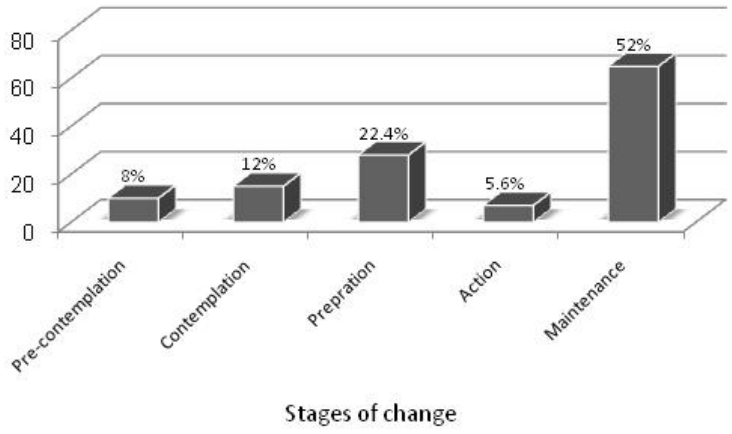


Fig1. Frequency of stage of change in fiber intake

The study results indicated that the participants were spread across the stages as shown in Fig 1. Accordingly, most of the participants (57.6%) were in the post-action stages (action and maintenance), and 42.4% were in the pre-action stages (pre-contemplation, contemplation, and preparation). Indeed, 10 participants did not intend to increase consumption of high-fiber foods (pre-contemplation), 28 were in the preparation stage, 10 were in the contemplation stage, 7 were in the action stage, and 66 perceived that they had been consuming high-fiber diets for more than 6 months (maintenance). The individuals in the action stage showed a significantly greater intake of fiber as compared to those in the pre-contemplation (P=0.013) and contemplation (P=0.012) stages. Besides, significant differences were observed between the stages of maintenance and pre-contemplation (P<0.0001), maintenance and contemplation (P<0.0001), preparation and action (P=0.009), and preparation and maintenance (P<0.0001) in terms of diet fiber. Also a significant difference was observed between the stages of preparation and maintenance regarding the calorie intake (P=0.003) (Table 2).

The study findings revealed no significant difference among the stages of change concerning the fasting blood glucose (FBG), glycosylated hemoglobin, serum insulin, and insulin resistance. Yet, the highest levels of FBG and insulin resistance were detected in the action stage, while the lowest level of glycosylated hemoglobin was observed in the pre-contemplation stage (Table 2).

Logistic regression analysis (5 regression models) was used to determine the relationship between the glycemic control indices and the stages of change. In order to increase the number of samples existing in the stages and decreasing the random error, the stages of pre-contemplation and contemplation, as well as the stages of action and maintenance were combined. The results demonstrated a significant relationship between the level of FBG and the stages of change both before and after adjusting the confounding variables. Moreover, the risk of high FBG was significantly higher in the stages of action and maintenance compared to the pre-contemplation stage (P=0.019). It is also worth mentioning that this association was independent from known hyperglycemia (Table 3).

Table 2. Glycemic control indices and fiber intake in the stages of change* (Mean±SD)

	Pre-contemplation n=10	Contemplation n=15	Preparation n=28	Action n=7	Maintenance n=66	P-value
FBG (mg/dl)	145.70±42.78	161.20±47.72	145.34±51.87	185.28±65.42	169.21±58.48	0.202
HbAlc (%)	8.94±1.85	9.79±2.39	9.44±2.21	9.69±3.37	9.13±2.43	0.827
Serum insulin (mU/L)	5.36±4.86	4.34±2.78	5.63±3.28	6.78±4.25	5.81±3.40	0.555
Insulin resistance (HOMA IR)	1.91±1.69	1.66±1.02	1.98±1.25	3.16±2.87	2.35±1.29	0.134
Fiber intake[1] (g/kcal)	8.14±2.36	8.67±2.47	9.45±3.09	11.99±4.39	11.80±2.79	<0.0001
Calorie intake[2] (kcal)	2062.80±538.11	2046.60±605.04	1926.71±464.78	2238.43±509.36	2396.68±603.07	0.004
Cereal fiber[3] (g)	5.15±1.58	5.27±2.59	4.49±2.15	5.16±2.04	6.14±2.31	0.027
Fruit fiber[4] (g)	4.28±2.91	4.69±2.83	5.93±3.05	10.39±4.96	10.54±5.64	<0.001
Fresh fruit fiber [5] (g)	3.89±2.99	3.95±2.84	4.79±2.80	9.44±4.67	9.13±4.71	<0.001
Vegetable fiber [6] (g)	4.05±1.75	5.62±1.91	4.88±2.57	4.96±2.76	6.68±2.87	0.005
Non-starch vegetable fiber [7] (g)	3.77±1.83	4.84±1.61	4.52±2.63	4.68±2.76	6.19±2.93	0.011
Beans fiber (g)	1.86±1.78	0.75±0.86	1.18±1.31	2.01±1.86	1.93±1.79	0.058

*Analysis of Variance (ANOVA)
1- Significant difference between pre-contemplation and maintenance (P=0.003), contemplation and maintenance (P=0.002), and preparation and maintenance (P=0.004)
2- Significant difference between preparation and maintenance (P=0.003)
3 -Significant difference between preparation and maintenance (P=0.013)
4- Significant difference between pre-contemplation and maintenance (P=0.001), contemplation and maintenance (P<0.001), and preparation and maintenance (P<0.001)
5- Significant difference between pre-contemplation and action (P=0.048), pre-contemplation and maintenance (P=0.002), contemplation and action (P=0.029), contemplation and maintenance (P<0.001), and preparation and maintenance (P<0.001)
6- Significant difference between pre-contemplation and maintenance (P=0.031) and preparation and maintenance (P=0.024)
7- Significant difference between preparation and maintenance (P=0.048)

Table 3. The relationship of glycemic control indices and fiber intakes with the stages of change (odds ratio: 95% CI)*

		P	A/M	P Trend
FBG (mg/dl)	Model I	0.84 (0.27-2.63)	2.64 (1.03-6.77)	0.019
	Model II	0.85 (0.27-2.70)	2.66 (1.02-6.59)	0.021
	Model III	0.85 (0.26-2.71)	2.66 (1.03-6.90)	0.022
	Model IV	0.87 (0.24-3.21)	3.37 (1.16-9.71)	0.012
	Model V	0.88 (0.23-3.28)	3.06 (0.99-9.40)	0.041
HbA1c (%)	Model I	0.92 (0.31-2.71)	0.92 (0.37-2.29)	0.984
	Model II	0.82 (0.27-2.47)	0.91 (0.36-2.28)	0.942
	Model III	0.79 (0.26-2.40)	0.92 (0.36-2.33)	0.918
	Model IV	0.69 (0.21-2.34)	0.79 (0.29-2.14)	0.838
	Model V	0.67 (0.19-2.27)	0.63 (0.22-1.82)	0.687
Serum insulin (mU/L)	Model I	2.45 (0.79-7.5)	2.8 (1.07-7.35)	0.105
	Model II	1.97 (0.60-6.41)	3.2 (1.15-8.8)	0.078
	Model III	1.8 (0.51-6.44)	3.6 (1.25-10.52)	0.047
	Model IV	1.3 (0.35-5.12)	2.7 (0.89-8.23)	0.146
	Model V	1.3 (0.35-5.11)	2.7 (0.86-8.62)	0.176
Insulin resistance (HOMA IR)	Model I	0.43 (0.04-5.01)	1.24 (0.24-6.42)	0.619
	Model II	0.33 (0.03-4.04)	1.23 (0.23-6.52)	0.492
	Model III	0.27 (0.02-3.71)	1.25 (0.24-6.58)	0.435
	Model IV	0.09 (0.003-2.40)	0.87 (0.15-5.11)	0.286
	Model V	0.09 (0.003-2.40)	0.87 (0.13-5.70)	0.290
Cereal fiber (g)	Model I	0.36 (0.11-1.15)	1.61(0.64-4.01)	0.011
	Model II	0.42 (0.13-1.41)	1.79(0.69-4.65)	0.019
	Model III	0.42 (0.13-1.41)	1.79(0.69-4.67)	0.019
	Model IV	0.41(0.12-1.39)	1.83(0.70-4.76)	0.017
	Model V	0.39(0.11-1.44)	1.02(0.35-2.99)	0.218
Fruit fiber (g)	Model I	2.05(0.62-6.74)	10.24(3.53-29.78)	<0.001
	Model II	1.80(0.53-6.16)	10.89(3.63-32.68)	<0.001
	Model III	1.90(0.55-6.57)	10.95(3.63-33.05)	<0.001
	Model IV	1.91(0.55-6.69)	10.83(3.58-32.82)	<0.001
	Model V	1.96(0.54-7.09)	10.44(3.18-34.33)	<0.001
Vegetable fiber (g)	Model I	0.99(0.32-3.04)	2.64(1.03-6.77)	0.033
	Model II	0.89(0.28-2.79)	2.62(1.01-6.78)	0.027
	Model III	0.82(0.26-2.64)	2.67(1.03-6.96)	0.020
	Model IV	0.83(0.26-2.65)	2.65(1.02-6.89)	0.023
	Model V	0.85(0.26-2.75)	2.20(0.81-5.98)	0.110
Non-starch vegetable fiber (g)	Model I	0.99(0.32-3.04)	2.64(1.03-6.77)	0.033
	Model II	0.89(0.28-2.79)	2.65(1.02-6.87)	0.025
	Model III	0.85(0.27-2.68)	2.69(1.03-6.97)	0.021
	Model IV	0.86(0.27-2.73)	2.65(1.02-6.89)	0.025
	Model V	0.87(0.28-2.85)	2.60(0.95-7.12)	0.053
Bean fiber (g)	Model I	2.05(0.62-6.74)	5.28(1.88-14.85)	0.003
	Model II	2.16(0.64-7.23)	5.22(1.84-14.80)	0.004
	Model III	2.41(0.70-8.28)	5.31(1.85-15.27)	0.005
	Model IV	2.41(0.70-8.27)	5.35(1.86-15.38)	0.005
	Model V	2.49(0.72-8.59)	2.49(0.72-8.59)	0.015

* Logistic regression analysis
PC and C groups were combined and considered as base group.
PC: Pre-contemplation, C: Contemplation, P: Preparation, A: Action, M: Maintenance
Model I: Unadjusted model
Model II: Adjusted for age, gender, and the duration of diabetes
Model III: Variables included in Model 2 plus body mass index
Model IV: Variables included in Model 3 plus hypoglycemic drugs
Model V: Variables included in Model 4 plus physical activity (MET.h/day) and energy intake (Kcal)
*The stages of action and maintenance had a significant relationship with FBG both before and after entering the confounders into the model.

Discussion

In this study, the mean intake of fiber in the patients with type 2 diabetes (10.62±3.19 g/kcal) was both less than the minimum amount recommended by DRI, and the "Evidence-based Recommendations" for diabetes (15–25 g/1000 kcal) (4). Other researchers have also shown low intake of dietary fiber in different groups in Iran (20-23). In the current study, the patients' fiber intake ranged from 8 to 48 grams.

Most of the participants (57.6%) were in the post-action stages (action and maintenance) and 42.4% were in the pre-action stages. Previous studies on the stages of change of increasing fruit and vegetable intake, decreasing fat intake, and following a healthy diet achieved different results regarding the individuals' distribution in the stages of behavior change. Vallis et al. conducted a study on diabetic patients based on this model, and showed that 60.2% of the participants were in the pre-action stages for healthy diet (low-fat diet and taking vegetables) and

37.6% were in the action and maintenance stages (24). Kavookjian also used TTM for diabetes diet adherence and revealed that two thirds of the patients were in the pre-action stages (25). Since dietary fiber is a subjective concept, it was defined to the participants, and high fiber foods (cereals, fruits, vegetables, and beans), as well as the recommended consumption of each were explained to them before choosing the stages. Nevertheless, it might not have been enough for some of them to choose the suitable stage because although the model could truly separate the pre-action stages from the maintenance stage, the mean intake of fiber was not very high in the maintenance stage (11.80±2.79 g).

Unexpectedly, increase of fiber intake through the stages of change did not make any improvement in the type 2 diabetic patients' glycemic control in the present research. Lack of any significant relationship between fiber intake and glycemic control indices in our study can explain not observing any significant relationship between the stages of change and glycemic control indices. In addition, our results showed no significant change in the outcome measures by considering the dietary fiber intake based on gram per day during the sensitivity analysis. Yet, many other factors, such as stress and quality of life, can also affect the glycemic status besides diet; however, they were not taken into account in this study. Up to now, a few studies have been conducted on the relationship between the constructs of the model and the glycemic control indices. A research on diabetic patients showed a significant difference among the stages of change for diet adherence regarding the mean HbAlc, which was lower in the maintenance stage compared to the pre-contemplation stage (26).

To date, controversial results have been obtained concerning the effect of fiber on glycemic control indices. Some researchers have reported different effects of dietary fiber on insulin sensitivity (27), glucose control (7, 28,29), and HbAlc level (28-30); all of these studies were performed in short run. For instance, Pereira et al. measured insulin sensitivity in obese, hyperinsulinemic patients, and showed that whole cereal diet improved post-prandial insulin sensitivity (31); Weicker employed the same method (as Pereira et al.) but observed no such effects on insulin sensitivity after a three-day high-fiber food intake (27). Similarly, Jenkins et al. (29) reported no improvement in the glycemic control indices after using high-fiber diet in diabetic patients for 3 months. A twenty-year cohort study performed in 7 countries also showed no relationship between diet fiber, glucose intolerance and diabetes (32).

In the present study, unlike our expectations, FBG was higher in the last stages compared to the first ones. Thus, it seems that the individuals with higher blood glucose need higher amounts of fiber intake. It might also be attributed to over-reporting; i.e., the individuals with higher blood glucose might have reported higher amounts of fruits, vegetables, and high-fiber foods intake. The largest proportion of fiber intake in our population was related to fruits (39.13%); cereal fiber formed about 25.78% of the dietary fiber, and legumes comprised only 7.54% of the total dietary fiber (data not shown). Besides, fruit fiber was significantly higher in the action and maintenance stages as compared to the pre-action stages. Also a weak positive correlation was observed between FBG and fruit ($r=0.18$, $P=0.04$) and fresh fruit ($r=0.2$, $P=0.02$) intake, but not other foods. These outcomes indicate that extra fruit consumption in the action and maintenance stages could have a role in increasing the blood glucose in these stages. Although increased fruit intake have benefits to prevent chronic diseases such as diabetes or its complications and metabolic syndrome (33,34), some studies have shown that in comparison to fruits, grain and vegetable fiber had better effects on chronic diseases prevention and glycemic control indices (35-37). Moreover, based on the researches conducted on fruits, only those with low Glycemic Index (GI) contributed independently and significantly to predicting changes in HbA1c level (38).

Conclusion

In the present study, most of the patients were in the maintenance (52%) and preparation (22.4%) stages. Unexpectedly, the results showed a significant relationship between FBG and action and maintenance stages after adjusting the confounding variables. However, no significant relationship was found between HbA1c level and insulin resistance, and the stages of change. Furthermore, TTM seemed to be efficient and appropriate for distinguishing the type 2 diabetic patients' readiness for behavioral change with regard to fiber intake; however, it had no associations with the glycemic control indices.

This study had a cross-sectional design and, consequently, did not show the cause and effect relationships. In addition, future studies are suggested to make use of a knowledge questionnaire besides determining the stages of change. Moreover, fiber resources are suggested to consider separately with regard to their glycemic indexes.

Acknowledgement

This study was extracted from an M.Sc. thesis entitled "Association of Trans-theoretical Model (TTM) Constructs with Fiber Intake and Glycemic Control in Patients with Type 2 Diabetes of Tehran Diabetes Centers" approved by the National Nutrition and Food Technology Research Institute of Iran**.** Hereby, the authors are grateful for the financial and administrative supports of this institute and the patients who participated in the

study, as well as the kind assistance of Iranian Diabetes Society and the Charity Foundation for Special Diseases. Thanks also go to Mrs. A. Keivanshekouh at the Research Improvement Center of Shiraz University of Medical Sciences for improving the use of English in the manuscript.

Financial disclosure

The authors declared no financial interest.

Funding/Support

National Nutrition and Food Technology Research Institute

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