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ORIGINAL ARTICLE

Comparison of the Effect Yoga, Almond Consumption, the Harris-Benedict Formula Diabetic Diet and Their Combination on Blood Sugar Level in Women with Type 2 Diabetes in Damghan, Iran

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ABSTRACT

Background: Type 2 diabetes is one of the most common chronic diseases with a prevalence increasing due to overweight and obesity. Lifestyle modification (diet and exercise) can beneficially affect blood sugar level and anthropometric parameters. The main purpose of this present study was to examine the effects of yoga exercises, almond consumption, and adherence to a healthy diet separately or together on blood sugar level and anthropometric parameters in diabetic women.

Methods: In a clinical trial conducted for 8 weeks in Damghan, Iran on women with type 2 diabetes who were between 30 and 50 years old; 50 diabetic women were included in the study and were divided into five groups of ten participants (control, yoga, almond, diet, and combined).

Results: It was shown that the yoga, almonds, Harris-Benedict formula diabetic diet, and combined group (diet, yoga, and almonds) experienced a decrease in mean body mass index, waist circumference, and fasting blood glucose (FBS) level in comparison with the control group. In addition, individuals who strictly followed the prescribed diet were the only group to show a significant difference for hemoglobin A1c (HbA1c) level (p=0.037).

Conclusion: Yoga, almond, and the healthy diet, each alone or in combination could improve the body composition and FBS level in diabetic women. The diet alone was not able to improve HbA1c level effectively.

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Introduction

The high prevalence of diabetes is strongly related to overweight, obesity, and lack of physical activity. Diabetes is a major cause of cardiovascular diseases, lower-limb amputation, renal failure, and blindness, and is a leading cause of death among individuals in developed and developing countries (1). As a result, diabetes directly and indirectly creates a heavy socioeconomic burden on national healthcare systems representing. It was shown that more than 8 percent and 10 percent of total healthcare, respectively in Iran and USA is due to diabetes (2, 3). This disease is largely predictable and preventable (4). Increases in fasting blood

sugar (FBS), hemoglobin A1C, body weight, and body mass index (BMI) are related to an increased risk of developing type 2 diabetes and are often used in statistical analysis for predicting the risk of developing it (5). Additionally to medication therapy, type 2 diabetes and its risk factors can be effectively prevented or delayed by lifestyle modification (especially by a change in physical activity and diet). The increase in exercise (walking, running, cycling, yoga, etc.) and changes in diet are key components of the management of diabetes (6).

It has been shown that yoga can play an important role in risk modification for hypertension, cardiovascular diseases, and diabetes (7). In addition, people who do yoga have improved their lipid profile compared to the control group (8). In another study on diabetic people, it was shown that after intervention with yoga, the level of total cholesterol, triglycerides, and low density lipoprotein-cholesterol (LDL-C) decreased (9). On the other hand, the effect of yoga compared to walking could control weight loss and improve the blood sugar level in diabetics (10). A strong connection was noticed between nut consumption and reduced risk of cardiovascular diseases and diabetes (11). Accordingly, the Dietary Guidelines for Americans recommended nuts as a good food source for heart health as nuts are rich sources of fiber, unsaturated fats, proteins, and minerals (11).

On the other hand, nut consumption was demonstrated to be associated with a reduction in the risk of diabetes, inflammation, insulin resistance, and oxidative stress (12). Accordingly, the American Diabetes Association recommends that nuts to be included in the diet of a diabetic as a healthy food item (13). One of the most consumed tree nuts is almond, which is an excellent source of α-tocopherol, monounsaturated fats, dietary fibers, magnesium, copper, arginine, polyphenols, and plant sterols. Therefore, it is recommended as a cardioprotective in the diet of people with cardiovascular diseases (14). Jenkins et al. found that almonds could reduce the blood sugar level (14, 15). So this study compared the effect yoga, almond consumption, and the Harris-Benedict formula diabetic diet on blood sugar level in women with type 2 diabetes.

Materials and Methods

A clinical trial that was conducted for 8 weeks in Damghan City, Iran on 50 women with type 2 diabetes who were between 30 and 50 years old. The participants completed the health questionnaire and medical history forms before entering the study. The diabetic women were divided into five equal groups of to compare the effect yoga, almond consumption, and the Harris-Benedict formula diabetic diet on blood sugar level. A summary of the entry and selection of participants in this clinical trial was shown in Figure 1. The yoga training program was conducted under the supervision of a yoga instructor. About 45 minutes of moderate-intensity yoga was performed every morning for 8 weeks. These exercises were performed in 3 ways as breathing exercise for 10 minutes, stretching exercise for 20 minutes, and concentration exercise for 15 minutes.

The subjects of almond consumption group were asked to replace 10% of their daily calorie intake with 1 ounce (equivalent to 28.34 grams) of almonds, which was about 23 almonds so that the total daily calorie intake remained constant. For this purpose, by using 3 days of 24-hour food recall that was taken at the beginning of the research, as well as weight and height, BMI, and physical activity, the average total daily calorie intake of each person was calculated. The people of this group were told to consume almonds in the evening meal around 4 to 5 pm and to report any problems.

Based on the height, weight, BMI, activity, and disease history of the subjects in Harris-Benedict formula diet group, a dietary plan was set that included 3 main meals and 3 snacks. The amount of calories needed by the subjects was measured based on the Harris-Benedict formula. The amount of carbohydrates, fat, and protein in the diet (based on the Mediterranean diet) was presented by a nutrition and diet therapy expert and was implemented by the subjects of this group. This dietary plan was set based on the food pyramid and compliance with diversity and balance, and to prove the correctness and accurate implementation of this dietary plan, the subjects completed the dietary recall questionnaire every 15 days. The nutrition expert checked these questionnaires with the food plan provided to reduce the percentage of the subjects' errors and served as a reminder.

Subjects in the yoga, almond, the defined diet and the combination group followed the plan provided by the nutritionist. The subjects of control group did not implement any of the above items (yoga, almond, diet). They were asked to continue the normal life as before. Height was measured by a wall-mounted stadiometer to the nearest 0.5 cm without shoes, heels together touching the wall; while looking straight forward. Body weight was measured using a Hamilton scale to the nearest 100 g in minimal clothing without shoes. Waist circumference was measured at a point midway between the iliac crest and the lower rib margin with a non-elastic tape to the nearest 0.5 cm.

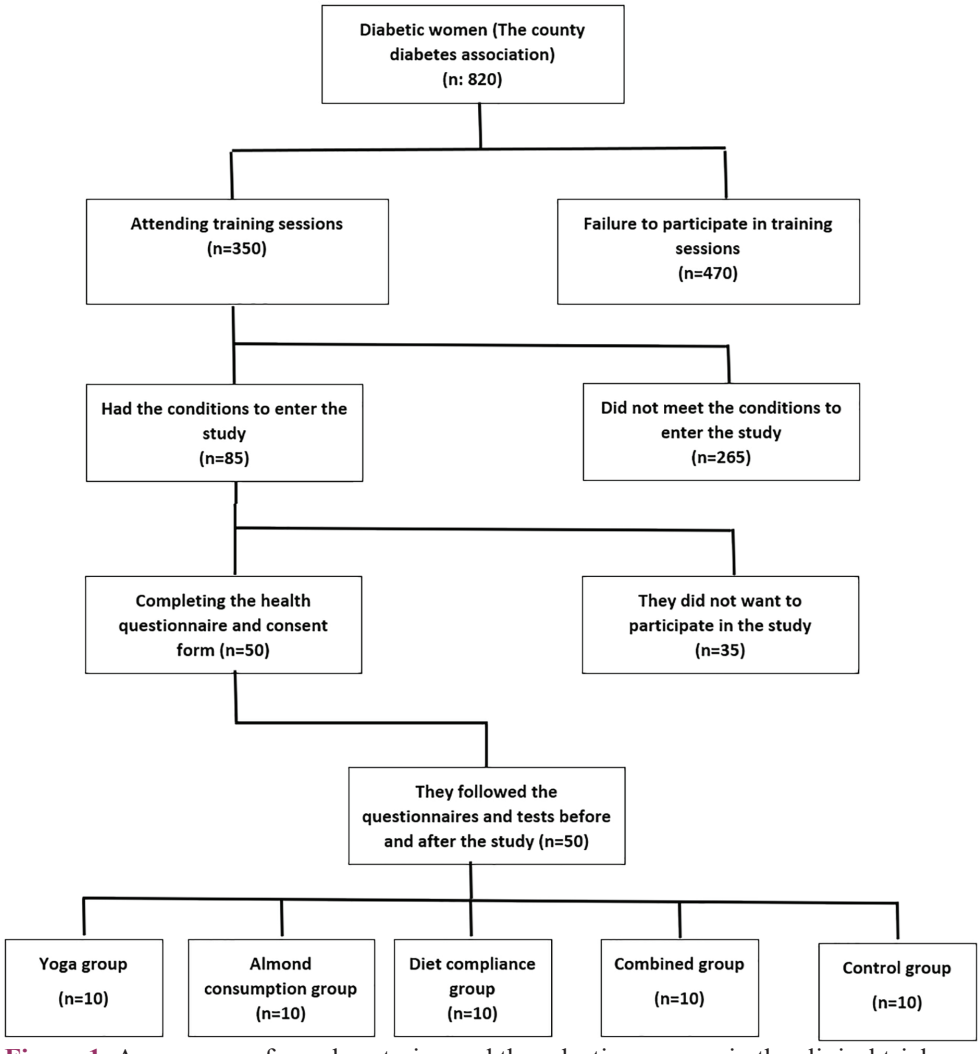

Figure 1: A summary of people entering and the selection process in the clinical trial.

All anthropometric measurements were performed by a trained expert staff. BMI was calculated by body weight (kg) divided by height squared (m^2). Fasting serum glucose and HbA1c were measured from blood samples drawn after 8-12 hours of overnight fasting. All samples were assessed by standard methods at the Biochemistry Laboratory of the Islamic Azad University, Damghan, Iran. Data were analyzed using SPSS software (version 22, Chicago, IL, USA). The one-way ANOVA was used to compare the groups. The paired samples t-test was employed to compare variables within groups at the beginning and end (pre- and post-test) of the study. Independent t-test was utilized to compare the intervention groups with the control group. A $p<0.05$ was considered statistically significant.

Results

Table 1 displays the key characteristics of the study population of different groups. The results of the analysis of ANOVA did not indicate to any significant differences between the groups, except for age ($p=0.025$) and weight ($p=0.003$). Notably, the mixed intervention group consisted of the oldest participants, with an average age of 45.40±3.75 years. Additionally, the mean weight of participants in the yoga group was 91.20±5.03 kg, which exceeded the average weight of individuals in the other groups. Table 2 presents a comparison of the changes in key variables within the groups from the baseline to the end of the study. The results did not illustrate any significant changes in the control groups, except for waist circumference ($p=0.004$). Conversely, all participants who received the intervention demonstrated significant improvements in BMI, waist circumference, FBS, and HbA1c at the end of the study compared to the initial measurements.

Table 3 presents a comparison of the average changes in variables between all intervention groups in comparison to the control group. The study findings indicated that the yoga group experienced a decrease in mean BMI, waist circumference, and FBS level, but no significant difference was observed for HbA1c level ($p=0.161$) in comparison with the control group. Similarly, the consumption of almonds and the combination therapy involving

Table 1: Comparison baseline parameters between groups.

Variable	Group						*P* value
	All	Control	Yoga	Almond	Diet	Mix	
Number	50	10	10	10	10	10	
Age	41.02±6.34	39.60±6.29	42.30±6.06	36.60±5.48	41.20±7.15	45.40±3.75	0.025
Height	159.48±3.03	158.10±2.33	160.10±2.51	160.70±3.71	159.20±3.42	159.30±2.90	0.386
Weight	82.18±9.20	83.30±10.37	91.20±5.03	76.70±6.60	79.10±10.38	80.60±6.22	0.003
TG	192.90±19.95	200.10±21.79	191.50±19.87	190.80±16.01	186.00±17.62	196.10±24.51	0.588
SBP	12.24±0.66	12.00±0.82	12.40±0.52	12.20±0.42	12.30±0.95	12.30±0.48	0.727
DBP	7.40±0.78	7.20±0.63	7.60±0.97	7.20±0.42	7.50±0.97	7.50±0.85	0.699

**P* value resulted from One-way ANOVA test. Abbreviations: TG: Triglyceride; SBP: Systolic blood pressure; DBP: Ddiastolic blood pressure.

Table 2: Comparison of outcomes within groups before and after interventions.

Variable	Group	Before Intervention	After intervention	*P* value*
		Mean±SD	Mean±SD	
BMI	Control	33.31±4.02	32.85±4.05	0.074
	Yoga	35.61±2.38	34.36±2.27	<0.001
	Almond	29.69±2.31	28.53±2.29	<0.001
	Diet	31.12±3.06	29.62±3.19	<0.001
	Mix	31.73±1.80	30.66±2.01	<0.001
WC	Control	93.50±13.17	91.70±12.89	0.004
	Yoga	94.90±6.35	90.40±6.70	<0.001
	Almond	81.10±5.97	77.50±5.95	<0.001
	Diet	86.00±11.97	82.40±11.18	<0.001
	Mix	86.20±5.69	82.50±6.75	0.001
FBS	Control	165.00±31.71	162.00±31.02	0.313
	Yoga	181.50±42.56	143.00±29.83	0.001
	Almond	164.00±41.50	124.50±39.05	<0.001
	Diet	181.50±41.23	136.00±33.40	<0.001
	Mix	179.50±39.61	141.00±37.62	0.001
HbA1c	Control	7.55±0.86	7.10±0.91	0.103
	Yoga	8.16±1.16	7.28±0.77	<0.001
	Almond	7.85±1.29	6.62±0.58	0.004
	Diet	8.08±0.76	6.98±0.81	<0.001
	Mix	7.80±1.00	6.91±0.55	0.005

**P*-value resulted from Paired-sample t-test. Abbreviations: BMI: Body mass index; WC: Waist circumference; FBS: Fasting blood sugar; HbA1c: Hemoglobin A1c.

Table 3: Comparison of outcomes between groups.

Variable	Control	Yoga		Almond		Diet		Mix		*P*
	Mean±SD	Mean±SD	*P* value[a]	Mean±SD	*P* value[a]	Mean±SD	*P* value[a]	Mean±SD	*P* value[a]	value[b]
BMI	-0.47±0.73	-1.25±0.55	0.015	-1.16±0.58	0.031	-1.50±0.34	0.001	-1.06±0.59	0.060	0.004
WC	-1.80±1.47	-4.50±1.43	0.001	-0.3.60±1.17	0.007	-3.60±1.95	0.032	-3.70±2.21	0.037	0.016
FBS	-3.00±0.55	-38.50±25.39	0.002	-39.50±18.92	<0.001	-45.50±26.92	0.001	-38.50±23.10	0.001	<0.001
HbA1c	-0.45±0.78	-0.88±0.48	0.161	-1.23±1.03	0.075	-1.10±0.42	0.037	-0.89±0.76	0.220	0.181

[a]*P* value resulted from independent t-test in comparison with control group. [b]*P* value resulted from One-way ANOVA test. Abbreviations: BMI: Body mass index; WC: Waist circumference; FBS: Fasting blood sugar; HbA1c: Hemoglobin A1c.

yoga, almonds, and defined diet exhibited similar effects. Notably, participants who strictly followed the prescribed diet were the only group to demonstrate a significant difference in HbA1c level (p=0.037) in addition to BMI, waist circumference, and FBS level when compared to the control group. The results of the ANOVA test confirmed a significant difference between groups in BMI (p=0.004), waist circumference (p=0.016), and FBS level (p<0.001), but not for HbA1c level (p=0.181).

Discussion

This study assessed the effects of yoga, almond consumption, and the defined diet individually or simultaneously on glycemic levels and anthropometric parameters of diabetic women. Our study showed that all interventions (yoga, almond, diet, and combined groups) improved BMI, waist circumference, FBS, and HbA1c levels at the end of the study when compared to the initial measurements. Our findings showed that yoga, almonds, and the defined diet reduced BMI when compared to the control group, but this effect was not observed in the combined intervention. Also, all the intervention groups experienced a significant reduction in the waist circumference and FBS level in comparison to the control group. However, among the interventions, only our defined diet caused a significant decrease in HbA1c level.

A study was conducted for three months and examined the effect of almonds denoted to a significant weight loss in the almond group that is in the alignment with our finding (16). An almond-enriched low-calorie diet that was consumed as eighty-four grams/day of almonds has resulted in a reduction in waist circumference and BMI (17). A meta-analysis showed that almonds did not have a significant effect on BMI and waist circumference (18). One study compared biscuit snacks and almond snacks and did not notice any significant difference in weight and waist circumference (19). Various reasons have been mentioned for the effect of almonds on BMI and blood sugar level, which is mostly due to its diverse ingredients. They are low in sodium and rich in unique nutrients and bioactive components like vitamins, monounsaturated fatty acids, polyunsaturated fatty acids, minerals such as potassium, magnesium, and calcium, polyphenolic compounds, antioxidants, and plant sterols and stanols (20).

A previous study revealed a high content of important polyphenols such as protocatechuic acid, catechin, and chromogenic acid in almond hulls (21). The highest content was hydrolyzable tannins, proanthocyanidins, phenolic acids, aldehydes, flavonoids (non-isoflavone), lignans, isoflavones, and stilbenes (22). These properties and compounds found in almonds have been considered as potential beneficial effects on obesity and blood sugar level (20). Another reason for the effect of almonds is the effect of satiety caused by their fiber and protein (23). On the other hand, the effect of almonds on the intestinal microbiome has also been mentioned, which is related to the control of obesity and blood sugar level (24).

A few randomized control trial studies have explicitly focused on the effect of yoga intervention in diabetes individuals. In line with our study, recent systematic reviews demonstrated that yoga intervention was beneficial in patients with type 2 diabetes as well as in overweight or obese persons or in those with cardiovascular risk constellations (25, 26). The twelve-week intervention of yoga had positive effects on anthropometric indices (Body weight, BMI, and waist circumference) in women with abdominal obesity (27). While lessons of yoga for amateurs are associated with little intense training, they do not meet the recommendations for exercises in diabetes and cardiovascular diseases (28), and an intensive yoga training can lead to higher consumption of energy (28) and thus contribute to weight control and weight loss (29). It was shown that body weight reduction of 3 kg of body weight, or 22500 kcal happened in yoga. The average energy expenditure in yoga was shown to be 2.2-3.2 kcal/minute (28). According to the recommendations of the yoga exercise, it should be between 63 and 92 hours (30), while the average training time in our study was less than 45 hours. These findings demonstrate the importance of exercise in health status of people (31, 32).

Based on our findings, the combined intervention (mix) revealed a greater effect on waist circumference, but diet alone had a better effect on FBS and HbA1c levels. Akbarian *et al.* indicated that 8 weeks of yoga training, consumption of almonds, and a proper diet could significantly affect sexual function (33). A lifestyle change program, incorporating either a separate or a combined diet or exercise resulted in a significant reduction in weight and improvement in anthropometric indices (34). Another study showed that an energy-restricted Mediterranean diet with physical activity was effective in decreasing adiposity and improving cardiovascular risk factors in individuals with or at risk for diabetes (35). Salas-Salvadó *et al.*'s study showed that the Mediterranean diet supplemented with nuts could improve weight in metabolic syndrome (36).

It was shown that a Mediterranean diet with nut supplements improved blood sugar level and metabolic syndrome even without weight loss (37). The Mediterranean diet with nuts without calorie restriction was beneficial for reversing metabolic syndrome suggesting that its components, principally nuts, had positive effects on blood sugar level and insulin resistance, systemic oxidation, and related chronic inflammation (38, 39). Besides nuts, the high content of vegetables and fresh fruits of the Mediterranean diet, together with a high intake of antioxidant vitamins, and phenolic compounds and moderate consumption of wine improved insulin

resistance (36). A Mediterranean diet with nuts was shown to reduce obesity and blood sugar level due to the presence of fibers, increased thermogenesis, fat malabsorption, and lower adiposity (40). There were several limitations in the present study that we have addressed. Individuals in our study were women; therefore, our findings may not be generalized to men. The sample size in this study was small, which could affect the results. We used the food recall questionnaire to measure people's food intake, which is dependent on memory, so an error may have occurred in evaluating their nutrition.

Conclusion

The present study indicated that yoga, almond consumption, and Harris-Benedict formula diabetic diet alone or in combination could improve the BMI, waist circumference, and FBS level among diabetic women. The diet alone was also effective to improve the HbA1c level. It seems, more studies with a larger sample size are needed.

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Authors' Contribution

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Conflict of Interest

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