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ORIGINAL ARTICLE

The Effect of Eight Weeks of Mediterranean Diet and High-Intensity Interval Training on Body Composition in Obese and Overweight Premenopausal Women

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ABSTRACT

Background: One of the most important strategies aimed to reduce obesity and the adverse health effects is lifestyle modifications consisted of a balanced diet and increased physical activity. This study evaluated the effect of eight weeks of Mediterranean diet (MD) and high-intensity interval training (HIIT) on body composition in obese and overweight premenopausal women.

Methods: Forty-seven participants aged 34.43±7.22 years old were assigned into 4 groups of MD, HIIT, MD+HIIT, and control group. The interventions consisted of instructions to follow MD without calorie restriction and/or HIIT exercises on cycle ergometer were carried out for 8 weeks as 3 sessions per week. Body composition and anthropometric measurements were determined after 8 weeks.

Results: Weight loss and decrease in waist circumference and body mass index (BMI) were significant in MD and MD+HIIT groups. Body fat mass (BFM) and skeletal muscle mass (SMM) decreased only in MD+HIIT group. HIIT group showed no significant changes in weight, BMI, BFM, SMM, and waist circumference. Moreover, all intervention groups showed a significant decrease in visceral fat level.

Conclusion: MD was shown to lead to more changes in body composition and anthropometry measurements, except for SMM. However, adding HIIT to MD could increase weight and fat loss and reduce waist circumference. So combination of MD and HIIT can be recommended when weight and fat loss and reduction of waist circumference are targeted.

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Introduction

Midlife obesity is a serious problem in the world. A recent study indicated that 97.9% of Iranian midlife women indicated more than average waist to hip ratio (WHR) (1). So, management of obesity can be one of important issues. A previous finding has showed that dietary interventions combined with exercise is more effective than either of these two

alone in improving body composition in peri- and post-menopausal women (2). High-intensity interval training (HIIT) and Mediterranean diet (MD) are types of interventions that have been demonstrated to reduce body weight in prostate cancer patients (3). MD is a dietary regimen defined by an adequate using of vegetables, fruits, whole grains, and legumes, while substituting consumption of saturated animal fats by unsaturated vegetable fats and increasing consumption of bioactive compounds. Because of its pleasant taste and chronic maintainability, the MD, particularly if it is hypocaloric, and combined with exercise, has been found to induce weight loss in obese individuals. It has been found that higher adherence to the MD is related to decreased risk for obesity (4), even, the MD diet has been found as comparable with pharmacological treatments regarding decreasing the risk of obesity (5).

Specifically, a cross-sectional study in 481 postmenopausal women found that a great adherence to the MD was negatively associated with body weight, waist circumference, and waist-to-height ratio (6). However, adherence to every diet including MD needs patience for a long time. Adherence to diet, weight loss and weight-loss satisfaction are associated with weight-loss maintenance (7). In addition, some studies have found that during long or short time, combining diet with exercise enhances weight loss and increases its maintenance (8). There are various exercise recommendations regarding mode, intensity, duration and frequency to improve body compositions (9, 10). HIIT is a type of exercise which has been recommended recently. A recent finding displayed that the HIIT programs are more effective than moderated intensity training in reducing abdominal/visceral fat mass (11). HIIT has been found as a more effective and time-efficient method that can replace traditional exercise modes in improving body composition (12). According to another study, 12 weeks of HIIT improved indices of body composition in healthy young and older participants (13). Considering the effects of MD and HIIT on body composition, it was hypothesized that HIIT combined with MD can induce synergistic effects and need shorter duration to improve body composition. So, the purpose of this study was to assess and compare the effects of MD and HIIT separately, or in combination on body composition of obese or overweight women.

Materials and Methods

In this controlled trial (trial registration: IRCT20130424013107N4), the effectiveness of 8 weeks of MD and HIIT on body composition and anthropometric parameters in overweight and obese women was assessed. This study was approved by the Research Ethics Committee of Shiraz University (approval ID: IR.US.REC.1401.009) and was conducted between June and September 2022. All participants signed informed consent before participation in the study. Totally, 47 women aged 18 to 50 years were recruited from a diet therapy clinic in Shiraz, southern Iran. After an announcement among volunteers, women with a body mass index (BMI) greater than 23 kg/m^2 (classified as overweight and obese according to the BMI classification for South Asian population) (14) voluntarily participated in this study. Inclusion criteria were BMI greater than 23 kg/m^2, being healthy or not suffering diseases which could affect physical activity or body composition and weight gain including hypo- or hyper-thyroidism; metabolic diseases, endocrine disorders, not using contraceptives, and not experiencing a recent dietary change (<1 month). Exclusion criteria were not participating in exercise training program for at most three sessions or not observing MD according to participants' reports. A physician examined and approved participants' health to take part in the study. From 47 participants who met inclusion criteria, a total of 12 subjects withdrew from the study or were excluded because of non-compliance with the intended intervention program and 35 subjects were included in the final analysis (Figure 1). Participants were randomly allocated to 4 groups as MD, HIIT program, MD combined with HIIT (MD+HIIT), and control group. Due to the nature of the interventions, it was not possible to blind the participants and supervisors involved in the study.

Participants of HIIT and HIIT+MD performed HIIT program on a stationary bike at the Shiraz university gym, for 3 sessions a week, in nonconsecutive days, during 8 weeks (24 sessions). Each session lasted for 20 minutes which was consisted of 5 min warm-up at self-selected speed, 4-6 bouts of 1-min efforts at 90-95% of peak heart rate (HR peak) interspersed with 1 min of passive recovery, and 3-min of cooling down. The HIIT protocol followed the recommendations of a previous study (15).

In HIIT group, participants were instructed to maintain their usual diet. The participants in MD program and MD+HIIT groups were instructed to follow the principal aspects of MD without caloric restriction which included consumption of 1 serving of olive oil per main meals (breakfast, lunch, dinner), more than 2 servings of vegetables per main meals, 1-2 servings of fruits per main meals, 1-2 servings of unrefined cereals per main meals, less than 2

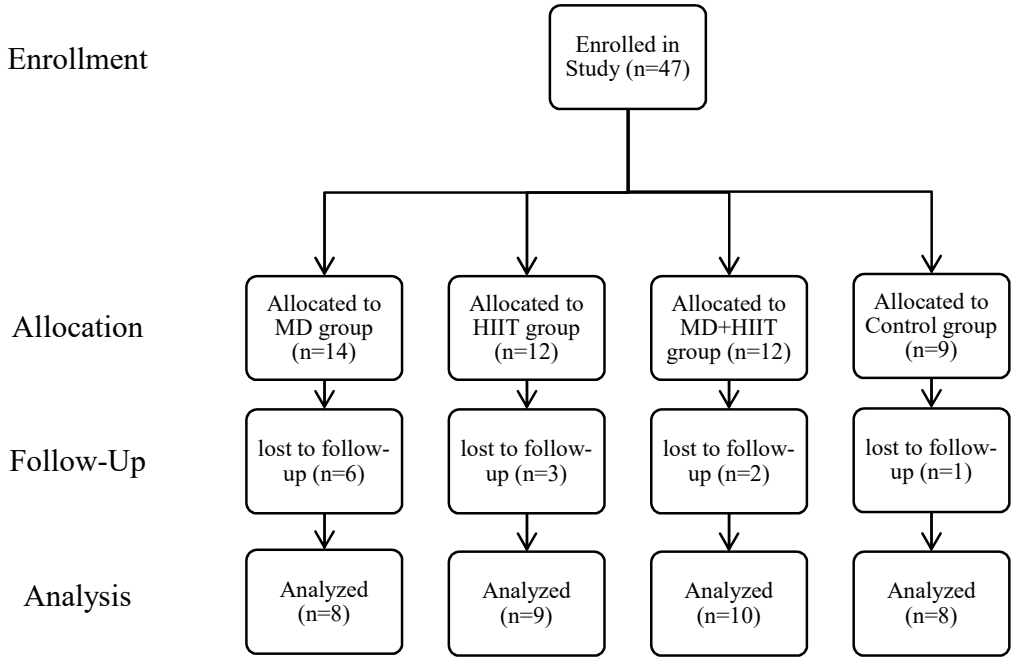

Figure 1: Process of allocating participants to the study groups.

servings of potato per week, 1-2 servings of nuts per day, 2 servings of dairy products per day, more than 2 servings of legumes per week, more than 2 servings of fish per week, less than 2 servings of red meat per week, less than 2 servings of sweets per weeks, 2-4 servings of eggs per week, 2 servings of poultry meat per week, and 1-2 glass of fermented beverages per day.

Body composition indices were measured 2-7 days before and after the intervention program. Height was measured (without shoes) using Seca 206 Roll-up measuring tape. Waist circumference was measured halfway between the last rib and the iliac crest by using an anthropometric tape. The hip circumference was taken horizontally in the maximum extension of the gluteus (larger posterior protrusion). WHR was calculated as the ratio of waist (cm) to hip (cm). Weight, BMI, body fat mass (BFM), skeletal muscle mass (SMM), and visceral fat level (VFL) were determined by electrical conduction instruments (Body Impedance Analyze; BIA) using InBody 230 body composition analyzer (Cerritos, CA, USA). Before measurements, participants were asked to remove any metal objects, refrain intense physical activity in the last 24-48 hours, avoid alcohol consumption in the last 24 hours and stop food and excessive intake of liquids before at least 4 hours of assessments. At the end of interventions period, all evaluations except height were repeated. These examinations were carried out at the same phase of the menstrual cycle (follicular phase), the same time of day (9-10 am) and by the same examiner (to avoid inter-examiner variability), who was previously trained and experienced in these types of measurements and was blinded to group allocations.

Based on assigned intervention, participants were advised to maintain their nutritional or physical activity habits, or both throughout the study. To quantify the dietary intake and physical activity, we used dietary recalls and the International Physical Activity Questionnaire (IPAQ) in the beginning, and the 4th and 8th week of the study. A 24-hour recall involved asking subjects to recall and describe quantity and quality of all the food and drink consumed in the previous 24 hours (non-holiday day), which was performed through interview. Both of IPAQ and dietary recall were utilzed to detect any change in physical activity and diet respectively.

The adherence to MD was evaluated in all groups before, 1 month, and 2 months after initiating the trial. Mediterranean diet adherence was assessed with the Mediterranean Dietary Serving Score (MDSS) based on the latest update of the MD pyramid, using the recommended consumption frequency of foods and food groups per meal/day, and per week. The MDSS involved 14 items with scores ranging from 0 to 24, however since fermented alcoholic beverages were not regularly consumed by any of our participants, this item was eliminated from our analysis and the overall score was calculated out of 23. Participants with scores below 17 (less than 75%) were excluded from the final analysis.

Data were assessed using Statistical Package for the Social Sciences (version 20.0; SPSS Inc., Chicago, IL) and GraphPad Prism (version 9.0.0 for Windows,

GraphPad Software, San Diego, California USA). The variables were presented as mean±standard deviation (SD) for each measurement. Paired samples t-tests were used to compare pre- and post- values of anthropometry measures within each group. One-way analysis of variance (ANOVA) was utilized to compare pretests and the changes between groups. In the case of significant findings, Tukey follow-up test was used to compare paired groups. A *p* value less than 0.05 was considered statistically significant.

Results

Baseline subjects' characteristics along with a comparison of baseline values between groups were presented in Table 1. Mean±SD of age, weight, and BMI of participants were 35.43 (7.22) years, 70.28 (7.46) kg, and 26.69 (2.15) kg/m^2, respectively. As indicated in Table 1, there was no significant difference between the study groups in any of characteristics and body composition, before the experiments. Also, no significant changes were observed in physical activity and diet according to IPAQ and diet recall. Comparison of groups following the experiments revealed significant differences in mean changes of weight (p=0.001), BFM (p=0.003), SMM (p=0.010), waist circumference (p=0.008), and VFL (p=0.044) (Table 1).

Comparison of pre and post-test variables using t test indicated that in MD group, body weight

Table 1: Description and comparison of variables.

Variable		Groups				P value**
		MD	HIIT	MD+HIIT	Control	
Weight (kg)	Pre	70.15 (8.89)	67.56 (8.42)	70.79 (7.62)	69.11 (5.93)	0.826
	Post	68.47 (8.75)	67.57 (8.53)	68.34 (6.66)	69.45 (6.07)	0.967
	Mean difference	1.67 (1.87)	-0.01 (0.69)	2.45 (2.11)	-0.33 (0.98)	0.001
	P value*	0.039	0.963	0.005	0.366	
BMI (kg/m^2)	Pre	26.49 (2.08)	26.08 (1.93)	26.81 (1.70)	26.63 (2.27)	0.880
	Post	25.76 (2.19)	25.48 (2.90)	25.91 (1.55)	26.78 (2.27)	0.681
	Mean difference	0.73 (0.57)	0.59 (1.40)	0.90 (0.72)	-0.14 (0.39)	0.091
	P value	0.008	0.236	0.003	0.324	
BFM (kg)	Pre	26.45 (3.94)	21.42 (5.59)	24.94 (4.95)	27.17 (3.23)	0.064
	Post	25.42 (4.73)	20.63 (5.32)	23.04 (4.16)	28.07 (3.92)	0.014
	Mean difference	1.02 (1.71)	0.78 (1.23)	1.90 (1.49)	-0.90 (1.21)	0.003
	P value	0.136	0.091	0.003	0.075	
SMM (kg)	Pre	23.78 (3.50)	25.40 (3.24)	25.20 (3.08)	22.68 (2.21)	0.237
	Post	23.43 (3.24)	25.88 (3.66)	24.86 (3.05)	22.42 (1.75)	0.014
	Mean difference	0.35 (0.49)	-0.48 (0.74)	0.34 (0.46)	0.26 (0.53)	0.010
	P value	0.087	0.085	0.047	0.209	
Waist circumference (cm)	Pre	95.62 (5.50)	89.44 (8.64)	92.50 (8.73)	92.81 (3.97)	0.385
	Post	92.37 (4.40)	89.94 (9.51)	90.50 (6.54)	92.68 (4.75)	.789
	Mean difference	3.25 (2.37)	-0.50 (2.52)	2.00 (2.62)	0.12 (1.24)	0.008
	P value	0.006	0.569	0.039	0.785	
WHR	Pre	0.90 (0.04)	0.88 (0.06)	0.86 (0.06)	0.88 (0.06)	0.580
	Post	0.89 (0.03)	0.88 (0.05)	0.86 (0.05)	0.88 (0.06)	0.606
	Mean difference	0.01 (0.02)	-0.00 (0.03)	0.00 (0.02)	0.00 (0.01)	0.286
	P value	0.062	0.703	0.256	0.599	
Visceral fat level	Pre	10.00 (1.41)	8.33 (2.12)	9.20 (2.15)	10.38 (1.59)	0.136
	Post	9.50 (1.60)	7.67 (1.65)	8.60 (2.01)	10.50 (1.60)	0.014
	Mean difference	0.50 (0.53)	0.66 (0.70)	0.60 (0.69)	-0.12 (0.35)	0.044
	P value	0.033	0.022	0.024	0.351	

**P* value of paired t-test between pre- and post-intervention data. ***P* value of one-way analysis of variance (ANOVA) between groups. MD: Mediterranean diet; HIIT: High intensity interval training; BMI: Body mass index, BFM: Body fat mass; SMM: Skeletal muscle mass; WHR: Waist hip ratio.

(p=0.039), BMI (p=0.008), waist circumference (p=0.006) and VFL (p=0.033) decreased significantly, while changes for BFM, WHR and SMM were not significant (p>0.05). In MD+HIIT group, weight (p=0.005), BMI (p=0.003), BFM (p=0.003), SMM (p=0.047), waist circumference (p=0.039) and VFL (p=0.024) decreased in post- compared to pre-test; while, WHR did not change significantly (p>0.05). In HIIT group, just VFL decreased significantly (p=0.022), while other variables including weight, BMI, BFM, SMM, waist circumference, and WHR did not change significantly. Regarding the control group, none of the variable changed significantly in post-test when compared to pre-test (Table 1).

Discussion

The objective of the present study was to analyze and compare the effects of a MD pattern, HIIT, and a combination of both, on body composition parameters of premenopausal women. To our knowledge, this research was one of the few studies that have evaluated this combination. One of the main findings of the present study was comparison of HIIT and MD leading to more favorable changes in body composition and anthropometry measurements including weight, BFM, and waist circumference. However, adding HIIT to MD pattern resulted to an increase of the effect on weight and fat mass reduction. Our result was supported before, which showed a greater efficacy for a combined lifestyle intervention in comparison to diet or exercise alone (4).

According to our findings in MD group, body weight, BMI, waist circumference and VFL decreased significantly in post-test when compared to pre-test, while BFM, WHR and SMM did not change significantly. It has been suggested that higher adherence to a healthy dietary pattern, such as the MD, is adversely associated with being overweight/obese in premenopausal and postmenopausal women (16). In our study, after 8 weeks of non-caloric restricted MD intervention, a non-significant decrease of 1.67 (1.87) kg in weight, and a significant decrease of 3.25 (2.37) cm in waist circumference was observed. In a 5-year cohort of 373,803 individuals, those with high MD adherence lost 0.16 kg and were 10 % less likely to become overweight or obese than the low adherent participants (17). Our result regarding waist circumference is in consistent with another study that reported a reduction in waist circumference of MD group (18). Moreover, in a cross-sectional study in Turkey (19), exploring the association between adherence to MD and anthropometric measurements, it was shown that weight, waist and hip circumference, BMI, WHR, and body fat percentage were significantly lower among subjects with the highest adherence to MD. A systematic review by Franquesa *et al.* concluded that the MD prevented increased weight and waist circumference in non-obese individuals and that the supporting evidence was moderate to high (20).

Fat mass has a close relationship with health status and a greater fat mass has been related to an increase in the probability of suffering cardiovascular diseases, overweight and obesity, arterial hypertension, diabetes and metabolic syndrome. Greater adherence to the MD has been associated with lower percentages of fat mass. However, in the present study, a non-significant decrease in body fat percent was observed which is in contrary with the results of previous studies. In a study by Prieto-González *et al*., where fat% was estimated using skinfolds, adherence to MD showed a strong negative correlation with BMI, fat%, and abdominal girth, and a weak correlation with WHR (21). In another cross-sectional study, by Kalkuz *et al*., the researchers used bioelectrical impedance analysis technology (Tanita DC 360) for body composition measurements and reported a negative correlation between the MD adherence score and fat mass (22). In a review by Bendall *et al*., six out of the ten studies that did not include an energy-restricted intervention, confirmed a reduction of central obesity parameters with the MD, with an impact on waist circumference of between 0.5-7 cm, albeit assessed at different time intervals (23). Subsequently, an Italian trial confirmed that a low-calorie MD reduced body weight by approximately 2 kg after three months; the effect was comparable to that achieved by a low-calorie vegetarian diet. Similar results were observed in BMI and fat mass too (24). In an 18-month RCT, comparing isocaloric low-fat or low- carbohydrate MD+28 g walnuts per day, with or without added physical activity, a modest but significant weight loss of 3.2% was reported in both groups. However, the MD induced greater decrease in waist circumference and was superior in mobilizing fat deposits at hepatic, cardiac and pancreatic levels (25). In a study, all participants marginally reduced weight and increased waist circumference after the 4.8 years of follow-up. Compared with the control, the extra virgin olive Oil (EVOO) group lost more weight (-0.43 kg), while both the EVOO and the nut groups showed lower waist circumference increase than the control group (-0.55 and -0.94 cm) (26).

Even our nutrition intervention was not caloric restricted, the restricted consumption of cereals/grains, (and elimination of white cereals), as well as the restriction of sugar and sweetened foods and

beverages potentially could decrease the calorie intake of participants which might be the main mechanism involved in the observed weight-loss. In support of this claim, one cross-sectional study has reported lower daily dietary energy intake of males with high adherence to MD; however, there was no difference in daily energy intakes among female participants (19). Findings of our study revealed that in HIIT group, just VFL decreased significantly, while other variables including weight, BMI, BFM, SMM, waist circumference, and WHR did not show a significant change. HIIT programs have been shown to be an efficient exercise protocol to reduce body weight and total and abdominal FM in women, while cycling HIIT being more effective than running (27). In one study, comparing a 28-minute HIIT exercise protocol with a 60-minute combined training (walking and resistance exercises), HIIT was demonstrated to be a more time-efficient method for decreasing visceral adiposity tissue (taking less time and producing greater results) (28).

In our study, the HIIT protocol was not sufficient to induce significant changes in weight and BFM, but a non-significant trivial increase in SMM was observed. In a meta-analysis comparing the effects of short-term and long-term HIIT, it was concluded that at least 12 weeks of HIIT was necessary to improve body composition (reducing waist circumference and percentage of body fat) in overweight/obese populations (29). On the other hand, a meta-analysis by Dupuit *et al.* illustrated that HIIT interventions longer than 8 weeks had significant effects on body weight and composition (27). Regardless of its duration, exercise alone could improve body composition if the energy expenditure led finally to a negative energy balance (30). However, the varying results of exercise interventions could be due to unwanted or uncontrolled alterations/compensations in the diet. For instance, after a 12-month moderated-to-vigorous exercise comprised of aerobic and resistance training, participants' weight was not affected, but body composition changed favorably (31).

One potential reason for our non-significant changes in HIIT group could be that we had no control over this group's diet. Although participants were instructed to maintain their usual eating habits, there might have been changes and increases in their food intake. Findings of our study indicated that in MD+HIIT group, weight, BMI, BFM, SMM, waist circumference and VFL decreased in post- when compared to pre-test; while, WHR did not change significantly. Literature data showed that adopting a holistic approach with the combination of diet and physical activity was the best way for promoting longer-term weight and/or fat mass loss (32). Our study showed that HIIT intervention alone did not impact weight or BFM significantly. Instead, MD approaches without calorie restriction, significantly decreased weight and BFM. Though, a combination of both interventions resulted in greater decreases in these variables. In a meta-analysis study, it was stated that both dietary and exercise interventions resulted in a greater weight loss when compared to control groups, however, combined interventions resulted in a greater weight, fat and lean mass losses. It was also shown that the effect of diet on weight loss was more than exercise alone (4). In another study, after an 18-month trial, a calorie restricted MD plus an aerobic exercise intervention could cause moderate reductions in weight, waist circumference, and visceral adipose tissue and these changes were greater when compared to the group receiving basic health promotion guidelines and exercise program (33).

There were some limitations in our study including only participation of female patients and based on the gender-specific responses, our results may not be generalizable to male populations. Small number of participants may be an important limitation of the study too, so our findings generalization must be with caution. Regarding our methodologies, adherence to MD was assessed through self-reported dietary intake assessment tool, which may be subjected to error and moreover, there are some potential limitations in the BIA methodology, resulting from the chemical composition of FFM (i.e., water, proteins, glycogen, and minerals) (34).

Conclusion

Comparing MD to HIIT, we observed that MD could induce more favorable results regarding body composition and anthropometry measurements. However, adding HIIT to MD improved the impact on weight, fat and waist circumference reductions, so a combined intervention of MD and HIIT would be superior for weight loss purposes. Therefore, in order to attain a healthy body composition, combining exercise with healthy eating patterns such as MD could be recommended.

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Conflict of Interest

None declared.

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