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Aerobic exercise versus mediterranean diet on insulin resistance in obese prediabetic postmenopausal women: A randomized controlled study

Wpływ ćwiczeń aerobowych i diety śródziemnomorskiej na insulinooporność u otyłych kobiet po menopauzie w stanie przedcukrzycowym: randomizowane badanie z grupą kontrolną

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Abstract

Purpose. To find out the effect of Mediterranean diet and exercise on weight reduction and their influences on insulin resistance in obese prediabetic postmenopausal women.

Methods. Randomized controlled trial. This study was carried out on 40 obese postmenopausal women with sedentary life and with insulin resistance. They were selected from Cairo University Medical Hospitals and divided randomly into two equal groups; group A, Diet group (n = 20), enrolled on a Mediterranean diet for 12 weeks and group B, Exercise group (n = 20), enrolled on exercise training for 12 weeks. For each patient the weight, height, body mass index (BMI), waist and hip circumferences and ratio and Hemoglobin A1c were estimated and recorded before and after intervention.

Results. After intervention, the Mediterranean diet and exercise groups showed significant weight reduction, lower BMI, waist and hip circumferences and ratio and HbA1c. However, there was significant differences between both groups. Mediterranean diet showed significant reduction in all weight parameters and HbA1c than exercise group.

Conclusion. The Mediterranean diet resulted in better weight reduction and improvement of insulin resistance than exercise in obese prediabetic postmenopausal women.

Key words:

obesity, mediterranean diet, exercise, postmenopausal women, prediabetic women, insulin resistance, waist, and hip circumferences

Streszczenie

Cel. Zbadanie wpływu diety śródziemnomorskiej i ćwiczeń fizycznych na redukcję masy ciała oraz ich wpływ na insulinooporność u otyłych kobiet w stanie przedcukrzycowym po menopauzie.

Metody. Randomizowana próba kontrolowana. Badanie przeprowadzono na 40 otyłych kobietach po menopauzie, prowadzących siedzący tryb życia z insulinoopornością. Kobiety zostały wybrane ze szpitali medycznych Uniwersytetu w Kairze i podzielone losowo na dwie równe grupy; grupa A (n = 20) stosująca dietę śródziemnomorską przez 12 tygodni i grupa B (n = 20) wykonująca trening wysiłkowy przez 12 tygodni. Dla każdej pacjentki oszacowano i zarejestrowano wagę, wzrost, wskaźnik masy ciała (BMI), obwód talii i bioder oraz stężenie hemoglobiny A1c przed i po interwencji.

Wyniki. Po interwencji w grupie stosującej dietę śródziemnomorską i ćwiczenia zaobserwowano znaczną redukcję masy ciała, niższy BMI, obwód i stosunek talii i bioder oraz poziom HbA1c. Istniały jednak istotne różnice między obiema grupami. Dieta śródziemnomorska spowodowała znaczną redukcję wszystkich parametrów wagi i poziomu HbA1c w stosunku do grupy ćwiczącej.

Wniosek. Dieta śródziemnomorska spowodowała lepszą redukcję masy ciała i poprawę w zakresie insulinooporności niż ćwiczenia u otyłych kobiet po menopauzie w stanie przedcukrzycowym.

Słowa kluczowe

otyłość, dieta śródziemnomorska, ćwiczenia fizyczne, kobiety po menopauzie, kobiety w stanie przedcukrzycowym,

Introduction

Obesity and overweight are serious global health concerns. It is widespread, and it is becoming more so [1]. Overweight is defined as an excess of body fat accumulated as a result of calorie intake exceeding energy expenditure. The body weight measurement is used as a proxy for excess body fat, and the body mass index (BMI) can be determined when combined with height. The BMI is used to classify the severity of obesity, which is based mostly on the relationship between BMI and mortality [2]. Obesity was defined as a BMI of ≥ 25 kg/ m2. The median BMI for an adult population should be in the range of 21 to 23 kg/ m2 for optimal health [3].

Excess adipose tissue, which is mediated mostly by obesity, raises the risk of various major medical disorders. With a higher BMI, the risk of coronary heart disease, ischemic stroke, and type 2 diabetes rises. Breast, colon, prostate, endometrial, kidney, and gall bladder cancers are all linked to a higher BMI [4]. Furthermore, being overweight is linked to greater depression and anxiety, as well as a lower quality of life. Many obese people face social stigma and suffer from decreased psychosocial and physical functioning [5, 6].

Following the termination of ovarian follicular activity, menopause is the permanent cessation of menstrual periods. Menopause strikes all women between the ages of 45 and 55. The average age of menopause is 51, however it can strike sooner in some people [7, 8]. A complex and mostly unknown genetic, hormonal, and environmental factors influence the functional life span of human ovaries. When the follicles in a woman's ovaries become depleted, she enters menopause [9]. Hypothalamic and functional ovarian ageing, environmental, genetic, and lifestyle variables, and systemic disorders all contribute to decreased ovarian function and the onset of menopause [10].

Obesity is more common in postmenopausal women than in premenopausal women. This is the result of a complex process that includes decreased energy expenditure as a result of physical inactivity, which can be exacerbated by depression, as well as muscular atrophy and a lower basal metabolic rate. Menopause does not cause weight gain in and of itself, but it does cause an increase in total body fat and a redistribution of body fat from the periphery to the trunk, resulting in visceral adiposity [11, 12]. According to some researchers, the absence of estrogens, which may be a key obesity-triggering component, is the cause of rising obesity in menopausal women [13].

Obesity and overweight in postmenopausal women are serious public health concerns [14]. Following menopause, the incidence of visceral obesity and insulin resistance increases dramatically [15, 16]. Estrogen shortage put postmenopausal women at risk for type 2 diabetes, the metabolic syndrome, and heart disease [17]. The metabolic syndrome (MetS) is defined as having three or more of the following characteristics: abdominal obesity, low HDL cholesterol, and high serum triglycerides, fasting glucose, and/or blood pressure. The most common component of the syndrome that favors insulin resistance, a proinflammatory and prothrombotic state, and the risk of diabetes, hypertension, and other chronic illnesses is abdominal obesity [18].

Weight loss is recommended by the American Heart Association for overweight and obese patients to lessen the severity of CV risk factors. Many cardio metabolic risk factors, such as metabolic syndrome prevalence, insulin resistance, type 2 diabetes, dyslipidaemia, hypertension, pulmonary illness, CV disease, and inflammation, have been linked to weight loss in these patients [19]. The Mediterranean diet refers to the customary dietary patterns of people who live around the Mediterranean Sea. It is distinguished by a high intake of vegetables, monounsaturated fatty acids (mostly from olive oil), fruits, whole grains, legumes, and fish; moderate intake of dairy products, fish, and red wine; and minimal intake of red or processed meats [20]. The Mediterranean diet is widely regarded as one of the healthiest eating plans available. Because of its antioxidant and anti-inflammatory properties, it has been linked to significant improvements in glycemic control and weight loss, as well as the prevention of cardiovascular diseases, cancer, and diabetes mellitus type 2 [21].

A Greek adult population was studied to see if there was a link between a Mediterranean diet and insulin sensitivity. The Mediterranean diet was found to have an inverse relationship with indices of glucose homeostasis and insulin resistance (as measured by HOMA) in this study. It is worth emphasizing, however, that this link was only seen in the non-diabetic patients subgroup [22]. The effects of three different dietary interventions on body weight and glucose metabolism were compared in another study (two Mediterranean diets supplemented with olive oil or mixed nuts and a low-fat diet, LFD). After a year of follow-up, the reduced fat, olive oil, and nut diets all had higher adiponectin/leptin ratios, as well as adiponectin/HOMA-IR ratios. In both Mediterranean diet groups, but not in the low-fat group, these findings were linked to significant weight loss. [23]. A further research revealed that a Mediterranean-style diet supplemented with almonds or extra virgin olive oil reduces the risk of T2D by 52 percent when compared to a control diet, regardless of weight loss. [24]. The consumption of olive oil as part of one's diet has been linked to the prevention and management of T2D. It includes a high concentration of biophenols, such as oleuropein, HT, and their derivatives, which have been linked to many anti-diabetic processes, including immunomodulatory, antiproliferative, antioxidative, and anabolic actions. [25].

After menopause, regular physical activity (PA) is suggested to preserve muscle strength and balance and increase their glycemia and insulin sensitivity. PA may achieve these effects via inducing an increase in skeletal muscle glucose absorption during resistance training or by increasing mitochondrial density and glucose transporter protein expression during aerobic exercise [26]. The aim of this study to find out whether weight reduction by Mediterranean diet or exercise induce weight reduction and influences insulin resistance in obese prediabetic postmenopausal women.

Subjects and methods

Design

A randomized control trail was conducted to find out the effect of Mediterranean diet and exercise on weight reduction and their influences on insulin resistance in obese prediabetic post-

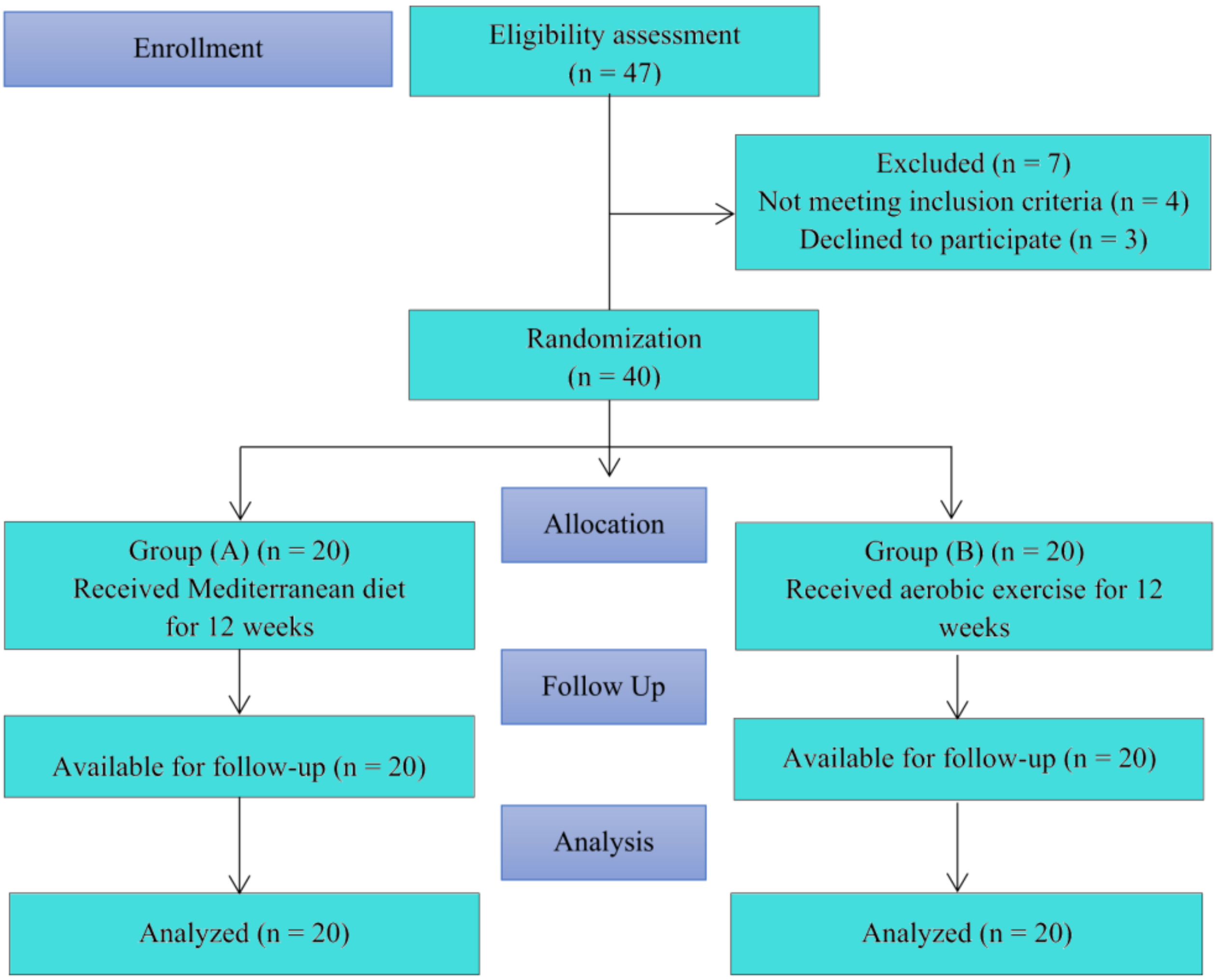

Figure 1. Flow chart of the study

menopausal women. Data were collected pre and post interventions from March 2020 to April 2021. Research protocol was approved by Ethical Committee, Faculty of Physical Therapy, Cairo University, Egypt. [No. P.T.REC/012/002466].

Participants
This study was carried out on 40 women ranging in age between 49-57 years. They were selected randomly from Cairo University Medical Hospitals, Cairo, Egypt. All participants were obese postmenopausal women with sedentary life (body mass index (BMI) was from 30 to 45 kg/m2) and have insulin resistance (Glycated hemoglobin = 5.7 to 6.4). Exclusion criteria include any medical problems other than insulin resistance such as hypertension and hypothyroidism and patients using any antihyperglycemic drugs or any hormonal treatments [23].

Randomization
The recruited patients were randomly assigned, after signing consent form, into two equal groups. A single blind randomization was carried out by assigning the odd numbers to group (A) (control group) and the even numbers were assigned to group (B) (experimental group). Following randomization, there was no dropping out of subjects from the study, Figure 1.

Interventions
Group (A) included 20 participants who received Mediterranean diet for 12 weeks, whereas Group (B) included 20 participants who received aerobic exercise for 12 weeks.

Mediterranean diet
For each patient, the number of calories needed per day to maintain current weight (total daily energy expenditure or TDEE) was calculated first. Then, the number of calories need to lose weight was calculated. There are 3500 calories in 1 lbs. (0.45 kg) of fat. Thus, 500 calories were needed for each patient, to burn daily more than the total daily energy expenditure to lose 1/2 lbs. of fat per week [27]. The daily calorie requirements were calculated by calculating the basal metabolic rate (BMR) from the formula [27]:

Women BMR = 655 + (9.6 X weight in kg) + (1.8 x height in cm) – (4.7 x age in years).

The number in brackets are multiplied first, then added and subtracted. Then the Total Daily Energy Expenditure (TDEE) was calculated by multiplying the BMR by Activity Factor (Table 1).

Table 1. Activity Factor Table [27]

Amount of Exercise/Activity	Description	TDEE/ Maintenance
Sedentary	Little or no Exercise/ desk job	TDEE = 1.2 x BMR
Lightly active	Light exercise/ sports 1 – 3 days/ week	TDEE = 1.375 x BMR
Moderately active	Moderate Exercise, sports 3 – 5 days/ week	TDEE = 1.55 x BMR
Very active	Heavy Exercise/ sports 6 – 7 days/ week	TDEE = 1.725 x BMR
Extremely active	Very heavy exercise/ physical job/ training 2 x/ day	TDEE = 1.9 x BMR

A Mediterranean diet plan was prescribed for 12 weeks. The calorie intake per day in diet should not be reduced than the basal metabolic rate per day. This diet is characterized by a high consumption of whole grains, olive oil, legumes, vegetables, fruits, cereals, moderate to high consumption of fish and moderate to low consumption of meat and meat products, milk and dairy products, and alcohol in the form of wine is often consumed at meals [20].

Aerobic exercise

The aerobic exercise program involved individually prescribed exercise at 60 - 75% of heart rate reserve (based on the initial maximal graded exercise tolerance test), using treadmills, for 12 weeks. According to Karvonen Formula [28] the target heart rate reserve was calculated from the formulae: Heart rate reserve = Maximum heart rate – resting heart rate. Maximum heart rate = 220 – Age. Resting Heart Rate (RHR) = pulse rate at rest (the best time to get a true resting heart rate is first thing in the morning). To achieve good early results from training, exercise was started at the target heart rate reserve which is below MHR to find an excellent aerobic base while allowing body to recover.

Aerobic exercise interventions included in this study were aerobic exercise including walking and running on treadmill. Walking exercise was performed on treadmill in three stages: First stage (warming up) consists of walking on treadmill without resistance or inclination for five minutes. The second stage (aerobic training) consists of walking on treadmill with 15 ° inclination at training heart rate of each patient for thirty minutes. The third stage (Cooling down) consists of walking on treadmill without resistance or inclination for five minutes.

Outcome measures

Body weight, height, and calculation of the body mass index (BMI)

Each participant's weight was measured (kg) by weight scale and height was measured (cm) by height scale before and after the treatment program whether it was diet or exercise. BMI was calculated from the formula: ***BMI = weight (kg) / [height (m)]***^{2}. Where, where kg is a person's weight in kilograms and m2 is their height in meters squared.

Measurement of waist and hip circumference and calculating waist/hip ratio

Measurement of waist and hip circumference (cm) was carried-out by a measuring tape before and after the treatment program. For waist measurement, the tap was wrapped around the patient's waist midway between the bottom of women ribs and the top of her hips. For hip circumference measurement, the tape was wrapped around the patient's larges t part of hips. The participant was asked to breathe out naturally before taking these measurements. Waist hip ratio (WHR) was calculated by dividing the patient's waist circumference by her hip circumference (WHR = waist circumference (cm) / hip circumference (cm).

Measurement of glycated hemoglobin percent (HbA1c)

Measurement of glycated hemoglobin level was performed by laboratory blood analysis before applying the treatment in both groups, then after 12 weeks of applying the treatment.

Statistical analysis

The statistical analysis was carried out with the statistical SPSS Package application for Windows version 25. (SPSS, Inc., Chicago, IL). The normality assumption test and homogeneity of variance were used to screen the data. The Kolmogorov–Smimov test for normality was used to determine whether the study variables have a normal distribution. The results of this test revealed that all data were normally distributed and were subjected to parametric analysis. Quantitative descriptive statistics such as the means and standard deviations were calculated for all data. Within groups (A) and (B), a paired t-test was used to compare before and after interventions to assess the effect of Mediterranean diet and exercise. Independent samples t- test between Mediterranean diet and exercise groups before and after treatment was conducted. Equal variance was assumed between the two groups before and after interventions as indicated by Leven's test. At the statistical level, all statistical analyses were significant at a probability threshold of less than 0.05 ($p \leq 0.05$). and highly significant at $p \leq 0.001$.

Results

At baseline, both groups were similar in terms of age, gender, and all outcome measures ($p > 0.05$) (Tables 2–3).

The effect of Mediterranean diet and exercise on weight, BMI, waist, and hip circumferences, waist/ hip ratio and HbA1c are shown in table (3). There was a highly significant reduction in weight, BMI, waist, and hip circumferences and waist/ hip ratio after 12 months of Mediterranean diet ($p \leq 0.001$). The mean weight reduction was 7.45 kg (8.5%). Also, HbA1c percent after 12 months of Mediterranean diet showed a highly significant decrease ($p \leq 0.001$). The mean HbA1c percent was 6.025 ± 0.20 before diet and 5.51 ± 0.340 after diet, which indicate change from prediabetic to normal level. In the exercise group, there was a highly significant reduction in weight, BMI, and waist, and hip circumferences after 12 months of exercise ($p \leq 0.001$). While the waist/ hip ratio and HbA1c percent decreased significantly after exercise ($p \leq 0.05$). The mean weight reduction was 4.83 kg (5.3%). The mean HbA1c percent was 5.96 ± 0.23 before exercise and 5.79 ± 0.40 after exercise, which indicate no change from prediabetic to normal level. Independent t-test between the two groups showed significant differences after treatment in all weight parameters and HbA1c percent ($p \leq 0.05$). The Mediterranean diet group resulted in significant reduction in all weight parameters and HbA1c percent than the exercise group.

Table 2. Demographic data of participants in both groups

	Group A (n = 20)	Group B (n = 20)	P-value
Age [years]	52.825 ± 3.150	51.95 ± 2.372	0.327^{NS}
Gender [n (%)]:			
Female	20 (100%)	20 (100%)	

NS p > 0.05 = non-significant, p = probability

Table 3. The effect of Mediterranean diet and exercise groups

		Group A (Diet)		Group B (Exercise)		Group t-test
		Mean ± SD	P-Value Pre- and post- diet	Mean ± SD	P-Value Pre- and post- diet	P-Value between group A and B
Weight [kg]	Pre-treatment	87.68 ± 7.06	0.001**	90.81 ± 10.239	0.001**	0.268
	Post-treatment	80.23 ± 6.461		85.98 ± 9.428		0.030*
BMI [kg/m^2]	Pre-treatment	33.17 ± 1.78	0.001**	33.47 ± 2.798	0.001**	0.691
	Post-treatment	30.15 ± 1.838		31.66 ± 2.64		0.042*
Waist (cm)	Pre-treatment	97.78 ± 9.99	0.001**	100.55 ± 7.86	0.001**	0.335
	Post-treatment	89.65 ± 7.72		95.55 ± 7.24		0.017*
Hip (cm)	Pre-treatment	116.05 ± 9.42	0.001**	117.325 ± 6.55	0.001**	0.622
	Post-treatment	108.43 ± 1.53		113.10 ± 6.91		0.038*
WHR	Pre-treatment	0.84 ±.04	0.001**	0.857 ±.041	0.009*	0.210
	Post-treatment	0.82 ±.03		0.8435 ±.036		0.031*
HbA1c (%)	Pre-treatment	6.025 ±.20	0.001**	5.96 ±.23	0.008*	0.381
	Post-treatment	5.51 ±.340		5.79 ±.40		0.023*

** Significant at $p \leq 0.05$. ** Significant at $p \leq 0.001$.*

Discussion

After menopause, weight reduction and regular physical activity (PA) are suggested to reduce risk of insulin sensitivity, but it is not known which is better for the reduction of weight and risk of insulin sensitivity. The results of this study showed a highly significant reduction in weight, BMI, waist, and hip circumferences and waist/ hip ratio after 12 months of Mediterranean diet ($p \leq 0.001$). The mean weight reduction was 7.45 kg. (%8.5). In a study of 77 obese postmenopausal women, six months of diet with or without aerobic exercise resulted in a weight loss of roughly 7 kg (7 kg diet only and 7.2 kg diet + exercise) [29]. Postmenopausal women with central obesity and at least one additional MetS criterion were randomly assigned to one of two energy-restricted diets – the CED or the MED – in a research (Mediterranean diet). It was discovered that postmenopausal women dropped 7.6 kg on average, with no differences in diets. [30]. Esposito et al. [31] discovered that an energy-restricted MED can help postmenopausal women lose weight and improve their MetS risk factors. Similar results were recorded in a study comparing the effects of three different dietary interventions on body weight and glucose metabolism (two Mediterranean diets supplemented with olive oil or mixed nuts and a low-fat diet, LFD). After a year of follow-up, the reduced fat, olive oil, and nut diets all had higher adiponectin/leptin ratios, as well as adiponectin/HOMA-IR ratios. In both Mediterranean diet groups, but not in the low-fat group, these findings were linked to significant weight loss [23]. In postmenopausal women, a low-calorie, low-fat diet was compared to the Mediterranean diet (MED). The MED is defined by a high fat consumption (up to 40% of total

daily calories), with monounsaturated fatty acids (MUFAs) accounting for 15–25% of total energy. The advantages of the two nutritions for body weight loss in postmenopausal women have been highlighted [32].
In the exercise group, there was a highly significant reduction in weight, BMI, and waist, and hip circumferences after 12 months of exercise ($p \leq 0.001$). While the waist/ hip ratio decreased significantly after exercise ($p \leq 0.05$). The mean weight reduction was 4.83 kg (% 5.3). The fact that the exercise group lost less weight could be explained by the fact that the extra exercise likely increased total energy expenditure. Additionally, exercise causes the release of lipolytic hormones, allowing for increased post-exercise energy expenditure and fat burning [33]. Even though this study only demonstrated a little weight loss (less than 5 kg), clinical trials of fitness training show a variety of health benefits for overweight and obese adults with disease risk factors. One of these benefits is better glucose control [34]. Regular physical activity after menopause is recommended to maintain muscle strength and balance, reducing the risk of falling and fracture. It indicates that a high and consistent amount of impact activity is required to enhance bone density [35]. However, clinically relevant weight loss (less than 5% of baseline body weight) has been shown to be more effective in decreasing CV and T2DM risk factors. As a result, clinicians have a compelling case for advising overweight and obese patients to make at least a small weight loss effort [36].
Independent t-test was performed between the two groups before and after intervention. There were no differences in baseline characteristics of weight reduction (weight, BMI waist and hip circumferences and ratio) and HbA1c level between the diet and exercise groups. This indicates that randomization was effective and does not affect the women's response to the treatments. Thus, the trial was adequate to test the main hypothesis. After treatment, there was a significant difference between both groups ($p \leq 0.05$). The Mediterranean diet group resulted in significant reduction in all weight parameters than the exercise group. This finding suggests that diet restriction is more effective in weight reduction than the exercise group in postmenopausal women. Weight reduction trials examining diet regimens with or without exercise in obese postmenopausal women indicated that exercise is not more effective than a calorie restriction in lowering intra-abdominal and subcutaneous abdominal fat. [29, 37, 38]. Van Gemert et al. [39] conducted a study to compare weight reduction generated by exercise combined with a small calorie restriction versus weight loss induced alone by diet. Diet alone or diet mixed with exercise resulted in a 6–7% weight loss in overweight to obese postmenopausal women. In the activity plus diet group, there was no statistically significant weight loss.
The HbA1c percent after 12 months of Mediterranean diet showed a highly significant decrease ($p \leq 0.001$). The mean HbA1c percent was 6.025 ± 0.20 before diet and 5.51 ± 0.340 after diet. The antioxidant, anti-inflammatory, and nutrient-rich foods found in the traditional Mediterranean diet may be responsible for the lower HbA1c levels. Inflammatory and toxic foods with artificial substances, processed sugars, high amounts of saturated fats, and pesticides are also avoided in the Mediterranean diet, which contribute to ageing and genetic degeneration [40]. Possible mechanisms by which intake of the Mediterranean diet may be associated with lower diabetes risk include fiber increasing satiety through prolonged mastication and antioxidants reducing the stress of beta cell dysfunction and insulin resistance [41]. Additionally, the drop in HbA1c following the Mediterranean diet could be attributable to weight loss. The American Heart Association recommends weight loss for overweight and obese patients to reduce the severity of CV risk factors, insulin resistance, and type 2 diabetes [19]. Omega-3 fatty acids and B vitamins are two nutrients included in the Mediterranean diet that contribute to a good mood and joyful ageing (eugeria). The Mediterranean diet's psychological benefits may aid in the prevention of type 2 diabetes [42].
Studies on the effects of Mediterranean diets on body weight and glucose metabolism found similar results. Mediterranean diets have been linked to significant weight loss and the prevention of type 2 diabetes [23–25]. According to a meta-analysis, a Mediterranean diet supplemented with nuts or extra virgin olive oil reduces the risk of T2D by 52 percent when compared to a control diet, regardless of weight loss [24]. MD has been reported to help individuals with T2DM achieve glycemic control, reduce insulin resistance, and lower cardiovascular risk factors [43].
The HbA1c percent after 12 months of exercise decreased significantly ($p \leq 0.05$). The link between physical exercise and blood glucose is mediated by a number of processes. First, physical exercise increases energy intake, which helps to prevent obesity, which is a risk factor for high blood glucose levels. Second, physical activity causes glucose transporter 4 to transfer to the surface of muscle cells, resulting in an increase in skeletal muscle glucose absorption and a reduction in insulin resistance in patients [26, 44].
After intervention, there was a significant difference between both groups ($p \leq 0.05$). The Mediterranean diet group resulted in significant reduction in HbA1c percent than the exercise group. In the Mediterranean diet group, the mean HbA1c percent was 6.025 ± 0.20 before diet and 5.51 ± 0.340 after diet, which indicate change from prediabetic to normal level. While, in the exercise group, there was no change from prediabetic to normal level since, the mean HbA1c percent was 5.96 ± 0.23 before exercise and 5.79 ± 0.40 after exercise. This conclusion could be attributable to the benefits of the Mediterranean diet and weight loss in postmenopausal women in the diet group versus the exercise group. Even while exercise has a lower effect on HbA1c than the Mediterranean diet, it has several health benefits for overweight and obese adults with disease risk factors. One of these benefits is better glucose control [34]. Furthermore, higher levels of physical activity energy expenditure suggest that weight loss produced by diets will be maintained. [45].

Study limitations

The findings reported in this study have certain limitations. The sample size (20 postmenopausal women in each group) is the first concern, as it may not be sufficient to identify differences between groups. Second, our study was only 12 weeks long, which may have been insufficient time to discover the metabolic effects of diets and exercise on insulin resistance. Furthermore, to demonstrate the potential impacts of exercise and diet-induced weight loss, a longer intervention or follow-up period may be required.

Conclusion

The Mediterranean diet and exercise showed reduction in all weight parameters and insulin resistance in obese prediabetic postmenopausal women. However, the Mediterranean diet resulted in better weight reduction and improvement of insulin resistance.

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