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Research Article

The effect of aerobic training and complementary of vitamin D + omega-3 on metabolic syndrome indices in obese women

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Abstract

Background: Metabolic syndrome is a set of risk factors for cardiovascular disease and type 2 diabetes. Vitamin D plays an important role in the treatment and prevention of metabolic syndrome. The purpose of this study was to investigate the effect of aerobic training and complementary of vitamin D + omega-3 on metabolic syndrome indices in obese women.

Materials and Methods: In this quasi-experimental study 40 women (26/4±7/6 yrs. 32/26±1/78kg/m2) Volunteered and they were randomly divided into four groups of 10 persons (aerobic training, vitamin D + omega-3 supplements, aerobic training + vitamin D + omega-3 supplements and control groups) . Aerobic training consisted of 12 week, 3 sessions of 1 hour each session at 60% of maximal oxygen consumption (1.6 km of treadmill walking). In supplement groups, supplementation was performed daily with 1000 IU vitamin D and 1000 mg fish oil. Blood samples were taken before and after the research protocol. Data were analyzed using covariance analysis test.

Results: 12 weeks of aerobic training plus supplementation significantly reduced lipid profile, fasting blood glucose, insulin concentration, waist circumference and diastolic blood pressure and the maximum oxygen consumption was significantly increased (p≤0/05).

Conclusion: Aerobic training is a safe and effective way to improve metabolic health. Also, combining vitamin D and omega-3 fatty acids to modify metabolic syndrome-related indicators can increase the beneficial effects of training.

Keywords:
Metabolic syndrome, Vitamin D, Omega-3 fatty acid, obese women

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1. Introduction

Obesity and overweight are the most important causes of chronic diseases, has an increasing prevalence in many countries, including Iran (1). Abdominal obesity, which is known to increase with the size of the waist circumference, is the biggest risk factor for chronic diseases such as diabetes, cardiovascular disorders, hypertension and cancer (1). Various factors such as inactivity and lack of physical activity and deficiency of some micronutrients such as vitamin D and omega-3 fatty acids can be effective in the development of obesity and metabolic syndrome and its progression (2). Metabolic syndrome is a condition that is associated with impaired glucose metabolism and lipid profile, increased blood pressure, and increased anthropometric parameters such as waist circumference (2). The American Heart Association suggests that metabolic syndrome is defined by the presence of two or three factors (Table 1). This syndrome is very important for people who are diagnosed with a risk of cardio vascular disease. The main risk factors for metabolic syndrome are overweight and obesity. The Center for Control, Health, and General Nutrition has estimated itself in the third study, approximately 22% of the adult population, all have metabolic syndrome (3). People with dyslipidemia have inadequate levels of vitamin D. Inadequate levels of vitamin D are associated with an increased risk of chronic diseases and metabolic syndrome. Therefore, achieving adequate serum levels of this vitamin improves glucose homeostasis and indicators of metabolic syndrome (4).

According to studies, regular physical activity and proper diets can prevent secondary diseases to metabolic syndrome by reducing obesity, especially abdominal obesity, increasing insulin sensitivity, lowering blood pressure and improving blood lipid profile (5). Researchers have shown that fitness programs have a significant effect on fat metabolism in obese people, and aerobic training, even with low duration, repetition and intensity combined with lifestyle changes, has a beneficial effect on weight loss and blood pressure (2, 5). Deficiency of omega-3 fatty acids is associated with an increased risk of chronic diseases and metabolic syndrome. Omega-3 fatty acids with their protective role in the health of the cardiovascular system can be effective in reducing serum lipids and thus reduce the risk of cardiovascular disease by reducing systemic inflammation. The results show that omega-3 fatty acids improve the risk factors for cardiovascular disease and weight loss, blood pressure, lipid profile and inflammatory factors (6).

Fish oil is a rich source of omega-3 fatty acids that have an anti-inflammatory nature (6). Wemberg et al. (2013) in their study after 26 weeks of vitamin D supplementation in people with body mass index above 30 and low serum vitamin D levels did not report any significant relationship between increased serum vitamin D levels and reduced obesity-related problems (۲).

Table 1: Diagnosis of metabolic syndrome

Waist size More than 102 cm More than 88 cm	Abdominal obesity -Men -Women
Equivalent to and more than 150 mg / dL	triglycerides
  Less than 40 mg / dL Less than 50 mg / dL	High Density Lipoprotein Cholesterol - Men - Women
۸۵≤/ ۱۳۰≤	Blood pressure
Mg / dL ۱۱۰≤	Fasting glucose

Carpenter et al. (2006) in their study stated that omega-3 fatty acids are effective in reducing insulin resistance as well as the risk of type 2 diabetes in people with metabolic syndrome (7). However, Kim et al. (2015) found in their study that there is no significant relationship between omega-3 fatty acid intake and the risk of metabolic syndrome (8). Given the role of obesity in the prevalence of chronic and debilitating diseases, including metabolic syndrome, and the American College of Sports Medicine's recommendation on the importance of exercise and regular physical activity in controlling this syndrome, In controlling obesity in order to promote the health of body organs and the existence of contradictory results in previous research, the researcher intended to investigate the effect of aerobic training and vitamin D + omega-3 supplementation on the indicators of metabolic syndrome in obese women.

2. Materials and Methods

Subjects

This study was with pre-test and post-test design. The statistical population was women (26.4 ± 7.6 years, 162/4 ±5/1 cm, 5/76 ±4/2kg, BMI=32/2±1/7kg/m2) who referred to the Center for Prevention and Promotion of Elahieh Health. After reviewing the records and information related to anthropometric indices and their metabolic syndrome, 40people were selected as a statistical sample voluntarily and were divided in four groups of 10 people (aerobic training, vitamin D + omega-3supplementation, aerobic training and vitamin D + omega-3 supplementation and control group) randomly. Criteria for inclusion of subjects in the research protocol according to the relevant physician, including physical health, being in the range of body mass index above 30 kg / m2, waist circumference more than 88 cm ,130/85≤ Blood pressure, absence of cardiovascular disease, diabetes, hormonal and menstrual disorders, no smoking, alcohol, drugs and supplements, no medical prohibition on taking vitamin D + omega-3 supplements and not participating in the exercise program at least 4 months before participating in this research exercise program . Necessary information about the nature and manner of conducting the research, possible risks and necessary points to participate in the research were given orally to the subjects and written consent was obtained from them. Subjects were allowed to enter the project after performing the necessary examinations by a general practitioner. Full observance of ethical considerations (confidentiality of the subjects' information and full authority of the subjects to leave the study) at each stage was performed.

The height of the subjects was evaluated using the Seca gauge model 214 made in Germany and the amount of weight and percentage of fat was evaluated using the Borer66 body composition device made in Germany. Before and after the research protocol, the subjects were placed on the machine in thin sports clothes, without shoes, and after entering characteristics such as height, age and sex, they stood motionless for a few seconds, then the weight and body fat percentage were recorded by a Sports expert. The waist circumference of the subjects was measured using a tape measure with an accuracy of 1 mm. To measure waist circumference, the person was first placed with the legs 25-30 cm apart. Then, a tape measure was placed in the midpoint of the distance between the lower part of the last rib and the protrusion of the pelvis without covering or clothing, and without applying pressure to the soft tissues, the waist size was recorded in centimeters. Systolic and diastolic blood pressure were recorded using the Rosmex hand-held sphygmomanometer after 5 minutes of sitting. Body mass index of each subject was also calculated by dividing weight in kilograms by height squared in meters.

Aerobic training of experimental groups for 12 weeks, 3 sessions per week, each session for one hour, which included warming up for 10 minutes, including walking, stretching and running at a slow speed, then over a distance of 1.6 km with 60% of maximum oxygen consumption was performed on Power T940 treadmill (9).

In order to evaluate the effect of aerobic training at the beginning and end of the intervention, Bruce test was used to evaluate the maximum oxygen consumption. This test consists of seven three-minute steps in which for every three minutes, two percent is added to the slope of the device. The speed of the device from the beginning of the test to the end it is 1.7, 2.5, 4.3, 5, 5.5 mph, respectively. Whenever a person becomes extremely tired and can no longer continue to work, the activity stops. Finally, by inserting the number of time to reach exhaustion, the maximum oxygen consumption was calculated with the formula embedded for inactive women (10). VO2 max = (4.38 × TIME) – 3.9

Supplementation

Subjects receiving a supplement of each, a soft gel of vitamin D + omega-3 from seven oceans company prepared by Kish Vitamin Club and Nutrition Company (containing 1000 international units of vitamin D and 1000 mg of fish oil (18% Eicosapentaenoic acid + 12% Docosahexaenoic acid) was consumed daily with their lunch meal and was followed up by telephone to ensure that each subject's supplement was consumed daily (11). To study biochemical variables, in two stages, 24 hours before the start and 48 hours after the end of the research protocol, due to reducing the inflammatory effects of exercise on the body after 12-14 hours of fasting, 7 cc of blood from the left vein of each subject in a sitting position, at rest was taken by a laboratory science specialist in the laboratory of Resalat Hospital present at the clinic and in the presence of the researcher.

After blood sampling of the subjects, blood samples were poured into test tubes containing anticoagulant (EDTA) and centrifuged for 5 minutes to separate plasma at 3000 rpm (German-made Hetich machine) and kept at -20 ° C. All measurements were performed under the same conditions at 7 to 8 in the morning at 26 to 28 ° C. In order to measure the fasting blood sugar of the participants, the laboratory kit of Pars Azmoon Company made in Iran by enzymatic colorimetric method was used by Hitachi 912 device made in Germany. The sensitivity and specificity of this laboratory kit were 0.99 and 0.94, respectively. Triglyceride and total cholesterol were measured enzymatically using US-made kits automatically. The sensitivity of total cholesterol was 3 mg / dL and the sensitivity of triglyceride was 1 mg / dL. Insulin was obtained by ELISA method using a micro calorimetric kit from Monobind, USA, with a sensitivity of 5.5 mg / dL. Germany was used. Direct-Colorimetry method was used to measure HDL and LDL by the Hitachi 912 device made in Germany.

Statistical analysis

Quantitative data were described using central dispersion indices such as mean and standard deviation. Covariance analysis was used for significant changes in each of the research variables between different groups. All data analyzes were performed using statistical analysis software version 22 at a significance level of $p \leq 0.05$.

3. Results

Table 2 shows the physical characteristics of the subjects. Comparison of physical characteristics of the four groups showed that before the study, there was no statistically significant difference between the groups in age, height, weight and body mass index.

The results showed that following aerobic training and supplementation, weight and body mass index of obese women were significantly reduced (Table 2).

Table 2: Physical characteristics of the subjects in the four groups

Group / variable	stages	BMI	Weight	Height	Age
training	pre-test	۳۱/۱ ± ۰/۷	۷۸/۶ ± ۵/۷	۱۵۹/۱ ±6/8	۲۵/۹ ± ۲/۷
	Post-test	۲۹/۱ ± ۰/۶	۷۴/۶ ± ۵/۹		
supplement	pre-test	۳۱/۲ ± ۰/۵	۸۰/۴ ± ۶/۸	۱۶۲/۶ ± ۸/۱	۲۷/٤± ٦/۱
	Post-test	۳۰/۸ ± ۰/۵	۷۹/۹ ± ۶/۸		
Training+ supplement	pre-test	۳۰/۹ ± ۰/۵	۸۲ ± ۷/۴	۱۵۸/۳ ± ۸/۱	۲٦/٤ ±۳/۹
	Post-test	۲۹/۵ ± ۰/۵	۷۸/۳ ± ۷/۲		
control	pre-test	۳۰/۷ ± ۰/۶	۷۷/۹ ± ۷/۸	۱۶۱/۷ ± ۶/۹	۲۷/۳ ± ۳/۲
	Post-test	۳۰/۵ ± ۰/۴	۷۷/۵ ± ۷/۹		

Results in Table 3 show that training and supplementation significantly reduced blood sugar, insulin, triglycerides, cholesterol, LDL, and waist circumference ($P < 0.05$), and increased HDL significantly ($P = 0.03$) in obese women. The most effects are observed in the training + supplement group. The results showed that following the implementation of the research protocol, the values of diastolic blood pressure decreased significantly ($P = 0.043$) and systolic blood pressure decreased in the intervention groups but was not significant ($P = 0.36$).

The results in Table 3 show that the program of aerobic training and supplementation has improved maximum oxygen consumption (Vo2max) ($P = 0.02$). The most effects are observed in the training + supplement group.

Table 3 presents the values of blood biochemical indices in pre-test and post-test stages of the four groups.

Table 3: Blood biochemical indices of 4 groups in pre-test and post-test

Group / variable	stages	control	Training+ supplement	supplement	Training	P value
Blood sugar	pre-test	۹۳/۱۰±۶/۳	۸۹/۱۱±۶/۴	۹۳/۶±۷/۱	۸۷/۹±۷/۹	
	Post-test	۹۳/۹±۶/۹	۸۰/۵±۷/۹	۸۷/۵±۶/۹	۸۵/۱۰±۳/۴	0/04 *
Insulin	pre-test	۲۳/۱۰±۸/۹	۲۱/۶±۱/۶	۱۸/۵±۱/۵	۱۵/۷±۳/۴	
	Post-test	۲۳/۱۰±۷/۴	۱۳/۳±۷/۳	۱۶/۵±۳/۳	۱۲/۵±۹/۹	0/032 *
Tri glyceride	pre-test	۱۱۱/۲۷±۷/۹	۱۲۱/۳۸±۶/۷	۱۲۳/۴۳±۷/۲	۱۴۰/۹۲±۲/۷	
	Post-test	۱۱۱/۲۲±۱/۲	۱۰۱/۲۲±۱/۷	۱۲۰/۴۳±۳/۶	۱۱۰/۵۹±۴/۴	0/009*
HDL	pre-test	۴۹/۸±۴/۹	۵۲/۱۲±۵/۲	۵۲/۸±۱/۵	۵۴/۱۴±۵/۷	
	Post-test	۴۹/۹±۱/۷	۵۴/۴±۸/۷	۵۳/۸±۸/۶	۵۶/۱۲±۱/۱	0/021 *
LDL	pre-test	۱۰۷/۲۱±۲/۳	۱۱۱/۲۲±۲/۷	۹۸/۲۶±۲/۱	۱۰۳/۳۵±۵/۴	
	Post-test	۱۰۷/۲۴±۱/۷	۹۴/۹±۱/۲	۹۵/۲۴±۷/۱	۹۷/۲۹±۲/۳	0/01 *
Cholesterol	pre-exam	۱۸۷/۲۰±۹/۲	۱۸۳/۲۸±۸/۲	۱۷۰/۲۸±۳/۶	۱۷۳/۴۱±۷/۳	
	Post-test	۱۸۸/۲۳±۲/۷	۱۲۰/۹±۱/۲	۱۶۵/۲۸±۱/۲	۱۵۶/۳۴±۳/۱	0/001*
Systolic blood pressure	pre-exam	۱۳/۰±۴/۹	۱۳/۰±۱/۹	۱۳/۰±۱/۸	۱۳/۰±۶/۷	
	Post-test	۱۳/۱±۵/۱	۱۱/۰±۸/۴	۱۲/۳۸±۹/۶	۱۱/۰±۹/۲	0/36
diastolic blood pressure	pre-test	۹/۰±۱/۱	۸/۰±۹/۹	۹/۰±۱/۹	۸/۰±۷/۶	
	Post-test	۹/۰±۲/۲	۸/۰±۲/۵	۸/۰±۹/۶	۸/۰±۴/۵	0/043 *
Waist	pre-test	۱۱۳/۲±۲/۳	۱۱۰/۵±۹/۱	۱۱۲/۴±۶/۴	۱۱۱/۷±۹/۴	
	Post-test	۱۱۳/۲±۷/۶	۸۷/۴±۶/۹	۱۰۶/۶±۷/۶	۱۰۰/۵±۹/۵	0/034 *
Vo2max	pre-test	29±5	26±6	26±3	28±5	
	Post-test	28±6	39±4	27±5	37±3	0/020 *

*Significant between groups

Significant level: p ≤0.05

Analysis of covariance

4. Discussion

This study was performed to evaluate the effect of aerobic training and vitamin D + omega-3 supplementation on the indicators of metabolic syndrome in obese women. The results showed that there was a significant decrease in blood sugar and fasting insulin concentration in the training + supplement group. Columbo et al (2013) examined the effect of 12 weeks of aerobic training and stated that performing moderate-intensity exercise three times a week can significantly improve the anthropometric and metabolic parameters of sedentary people (12). Kim et al (2018) in their study found that there is a relationship between low serum levels of vitamin D and the risk of diseases caused by metabolic syndrome and elevated fasting blood sugar levels in adults (13). Wang et al (2012) stated that supplementation with 700 international units per day with calcium was able to prevent elevated serum glucose levels and insulin resistance, especially in people with impaired glucose metabolism (14). These results are consistent with the results of the present study. High-intensity exercise relies more on glucose fuel than other fuels, which are stored as glycogen in the muscles and liver. Catecholamine levels increase with exercise to increase glucose production. Catecholamine are thought to be responsible for controlling blood sugar during exercise, and the role of insulin during rest after exercise is likely to restore glycogen stores (15). Research has shown that the intensity of exercise is a very important and effective factor in changing insulin levels. So that at intensities above 80% of oxygen consumption, insulin levels increase significantly and at intensities less than 60% of maximum oxygen consumption, insulin levels remain constant or perhaps slightly decrease (16).

Considering the intensity of exercise as an important factor in changing insulin levels, glucose and possible mechanisms of changes in insulin levels, it can be said that as a result of the intensity of exercise in the present study, the levels of these variables also changed. However, Salehpour et al (2013) Who studied the effect of 12 weeks of vitamin D supplementation on glucose homeostasis, found that supplementation improves the function of pancreatic beta cells, but has no effect on glucose hemostasis (11). On the other hand, some researchers have suggested that there is no association between omega-3 fatty acid use and glycemic control, which may be due to the short duration of the study (8-week period). In other words, this factor can cause a lower estimate of the effect of omega-3 fatty acids on glycemic indexes (17-18-19). The reasons for the inconsistency of the results with the present study are the shorter training duration, the diabetic nature of the subjects and the difference in the supplementary dose. The results of the present study showed that aerobic training and supplementation with vitamin D + omega-3 had a significant effect on triglyceride, total cholesterol, HDL and LDL levels and serum lipid profile in the training + supplement group was significantly reduced compared to other groups. Johnson et al (2007) compared the effect of moderate-intensity exercise with high-intensity exercise. The results showed that moderate-intensity exercise, even in the absence of diet, can have significant effects on improving metabolic syndrome. Hence the health authorities recommend. Both adult women and men should do 30 minutes of moderate-intensity exercise daily, especially for its beneficial effects on metabolic syndrome (1).

Regarding the possible mechanism of the effect of physical activity on blood lipoproteins, the researchers stated that physical activity reduces LDL, triglyceride, cholesterol and increases HDL by increasing the activity of lipoprotein lipase and lecithin cholesterol acyl transferase enzymes (5,16). On the other hand, lipoprotein lipase can increase VLDL and LDL catabolism after endurance activities (5). In general, it seems that longer training sessions can be more effective on the lipid profile, because most of the studies that have reported the effectiveness of training have used long-term training programs. One of the risk factors for cardiovascular disease is dyslipidemia, which indirectly affects its incidence. Evidence suggests that low serum vitamin D levels are associated with dyslipidemia and atherogenic lipid profiles. Examination of the results of the relationship between vitamin D levels and metabolic syndrome indices has shown that among all indicators, vitamin D is most associated with HDL levels, and this issue is especially important in non-menopausal women (20). Scientific evidence suggests that omega-3 fatty acids can reduce LDL, total cholesterol, and inflammation through several mechanisms, such as regulating the expression of genes involved in glucose and fat metabolism (21). Podial et al (2011) in their study stated that omega-3 fatty acids have a positive effect on reducing fat mass, body weight and lipid profile and increase the concentration of HDL and liver lipoprotein lipase enzymes (21). Davidson et al (2006) in their study, they stated that consuming 4 grams of omega-3 fatty acids per day can reduce triglyceride levels by 25 to 30 percent, LDL levels by 5 to 10 percent, and serum total cholesterol levels by 1 to 3 percent (22).

The use of omega-3 fatty acids in lower doses but for longer periods of time can also have a reducing effect on serum triglyceride levels, possibly by regulating the expression of mediated genes in carbohydrate metabolism and lipogenesis. Omega-3 fatty acids regulate metabolism in more than 4% of cell nucleus receptors, which triggers the use of triglyceride stores and their oxidation. By reducing the production of triglycerides and increasing the oxidation of fatty acids in the liver cells, less substrate is provided for the production and secretion of vLDL (22). However, Poursoliman et al(2018) Examining the effect of daily consumption of 2 g of omega-3 fatty acid for 6 weeks on the lipid profile and insulin resistance of diabetic patients, stated that supplementation does not have a beneficial effect on the lipid profile and blood sugar in these patients (23). Also in the results of McLean et al (2004) consumption of omega-3 fatty acids had no significant effect on total cholesterol, LDL, HDL, fasting blood sugar and insulin levels in patients with type 2 diabetes or metabolic syndrome (24). The reasons for the discrepancy between the results and the present results are the duration of the intervention, the supplementary dose and the selection of subjects with diabetes. The results of the present study showed that systolic blood pressure decreased after aerobic exercise + supplementation but was not significant, but diastolic blood pressure was significantly reduced. The prevalence of hypertension in Iran is high and it has been reported that 13.7% of people have systolic blood pressure above 140 mm Hg and 9.1% have diastolic blood pressure above 90 mm Hg. Insulin resistance and hyperinsulinemia are the main causes of high blood pressure and metabolic syndrome.

Exercise reduces peripheral vascular resistance, improves glucose tolerance, improves dyslipidemia, improves vascular endothelial function, and lowers blood pressure (25).

Kang et al (2016) conducted a study to investigate the effect of 12 weeks of aerobic exercise on resting heart rate, fitness and vascular stiffness in women with metabolic syndrome. The results of the study showed that in subjects who exercised, the percentage of fat mass, waist circumference, systolic and diastolic blood pressure decreased and serum HDL increased significantly (26). The results of epidemiological studies suggest that there is an inverse relationship between serum vitamin D levels and hypertension. Possible mechanism of action of vitamin D on blood pressure is the possible effect of this vitamin on the renin-angiotensin system, which can inhibit it endogenously and thus reduce blood pressure (27). Vitamin D as a vasodilator can reduce the incidence and spread of atherosclerosis. Increasing serum levels of vitamin D to 75 nmol / L and above can reduce the risk of hypertension by 1.6 times compared to when its levels are less than 35 nmol / liter (27). Omega-3 fatty acids have hypotensive effects on blood pressure, especially in susceptible and middle-aged people (28). Filippovik et al (2018) found that omega-3 fatty acid supplementation reduced systolic and diastolic blood pressure by 4 and 2 mm Hg in healthy individuals, respectively, and that there was an inverse relationship between omega-3 blood concentration and blood pressure. Therefore, the inclusion of omega-3 fatty acids in the diet can be considered as a primary prevention for hypertension in healthy people (28).

Some studies have suggested that the effective dose of omega-3 fatty acid supplementation to reduce blood pressure and triglyceride levels in people with mild hypertension is 4 grams per day (29). However, the results of the present study showed that the use of 1 gram of omega-3 fatty acids along with vitamin D and aerobic training significantly reduces diastolic blood pressure. Other results showed that aerobic training + supplementation with vitamin D + omega-3 significantly increased the maximum oxygen consumption. Exercise can improve cardiovascular system function, improve left ventricular function and reduce myocardial oxygen demand (30). Milanovich et al. (2015) in their review study examining the effect of exercise type on VO2max, stated that aerobic training has a greater effect on VO2max improvement than high-intensity training. The increase in VO2max is higher in people who do not have a history of physical activity, and over time, adaptation is achieved (30). Vitamin D supplementation significantly reduces heart rate as well as improves aerobic function. According to the American College of Sports Medicine, 30 minutes of exercise 5 days a week, or 20 minutes of high-intensity exercise 3 days a week, or Combining both can improve VO2max (30). Vitamin D is directly related to exercise-induced inflammation and skeletal muscle function. Its deficiency has catabolic effects on the tissue and leads to muscle weakness and disruption of the transverse bridge cycle (31). However, Ferberin et al (2018) in their study found that despite the prevalence of vitamin D deficiency in athletes, vitamin D supplementation only increases serum levels of this vitamin in professional athletes and has no effect on improving athletic performance, which is consistent with the results of the present study (32).

Scientific evidence shows that supplementation with omega-3 fatty acids has beneficial effects on athletic performance and fitness. Improving vascular endothelial function by supplementing with omega-3 fatty acids can result in increased maximal oxygen consumption, increased fat oxidation, and vasodilation due to nitric oxide production (33). Hagh Ravan et al (2016) by examining the complementary effect of omega-3 fatty acids on overweight women found that the maximum oxygen consumption increased significantly (33) which is also in line with the results of the present study. The results of this study showed that aerobic training + supplementation with vitamin D + omega-3 significantly increased the waist circumference. According to the World Health Organization, an unhealthy lifestyle can lead to cardiovascular and metabolic diseases, increased waist circumference and serum lipid profile (34). Matunja et al (2018) found that 10 weeks of exercise reduced weight and body mass index and waist-to-hip ratio (34). Increased subcutaneous fat, visceral fat and obesity are associated with decreased serum levels of vitamin D (20). Examination of the results of the relationship between vitamin D levels and metabolic syndrome indices has shown that vitamin D is highly correlated with waist circumference, and this issue is especially important in non-menopausal women. Vitamin D supplementation can significantly reduce the waist circumference (20).

Najarzadeh et al (2014) in their study stated that supplementation with 5000 international units of vitamin D for 6 days in people who are deficient in this vitamin Not only does it increase serum levels of this vitamin to the desired level, but it can also reduce the waist circumference (35). Poodial et al (2011) stated that omega-3 fatty acids, especially EPA and DHA, have a positive effect on reducing fat mass and weight (21). Hagh Ravan et al (2016) also found that supplementation with omega-3 fatty acids had a significant effect on body weight loss, fat mass percentage, waist circumference and abdominal fat thickness (33). These results are consistent with the results of the present study. However, Keating et al. In their study did not find a significant relationship between exercise intensity with liver fat and visceral fat (36), which contradicts the results of the present study.

۵. Conclusion

The results of the present study showed that aerobic training combined with vitamin D + omega-3 supplementation can improve the indicators associated with metabolic syndrome such as blood sugar, insulin, triglycerides, LDL, total cholesterol, waist circumference and blood pressure in obese women. Given that in the field of health, primary prevention is a priority before treatment, so the development of strategies to improve quality of life and improve dietary patterns to prevent chronic diseases such as metabolic syndrome is an important step. Increasing levels of physical activity as well as improving the quality of the diet in order to provide optimal nutrients are important parts in improving the lifestyle. According to the results of the present study, aerobic exercise with vitamin D + omega-3 supplementation can be used as a preventive and therapeutic method to modulate the indicators associated with metabolic syndrome according to the physiological and pathological conditions of the individual recommended.

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Compliance with ethical standards

Conflict of interest the authors declare that they have no conflict of interest.

Ethical approval the research was conducted with regard to the ethical principles.

Informed consent Informed consent was obtained from all participants.

Author contributions

Conceptualization: L.A., M.H.; Methodology: K.M.A., L.A.; Software: A.D., K.M.A., L.A.; Validation: M.H., A.D.; Formal analysis: K.M.A., A.D., L.A.; Investigation: M.H., L.A., K.M.A.; Resources: L.A., K.M.A., ; Data curation: A.D., L.A., K.M.A.; Writing - original draft: M.H., K.M.A., A.D.; Writing - review & editing: M.H., K.M.A.; Visualization: A.D., K.M.A.; Supervision: M.H., K.M.A., L.A.; Project administration: L.A., K.M.A., A.D.; Funding acquisition: M.H.,

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