Original Article

The effect of concurrent endurance and resistance training on cardio-respiratory capacity and cardiovascular risk markers among sedentary overweight or obese post-menopausal women

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Abstract

Context: Exercise training has been inversely associated with cardiovascular risk factors. However, the clinical trials examining the effect of exercise training on reducing cardiovascular risk factors have produced conflicting results.

Aims: We aimed to assess the effect of concurrent exercise training on cardiorespiratory capacity and cardio-vascular risk factors among sedentary overweight or obese post-menopausal women.

Settings and Design: This randomized controlled trial was done in 2016.

Materials and Methods: This study was conducted on 22 healthy post-menopausal overweight and obese females, which randomly divided into concurrent endurance and resistance (ER) exercise ($n = 12$) and control ($n = 10$) groups. The participants did not have any history of any serious medical condition or using drugs. Demographic questionnaire was completed, vital signs and biochemical tests were measured, and Rockport one-mile submaximal exercise test for assessing maximal oxygen consumption (VO_{2max}) was performed before and after the study.

Statistical Analysis Used: Mean, standard deviation, and paired and independent *t*-test were used for statistical analysis.

Results: The data from the ER groups showed that the body mass index (BMI), heart rate (HR), systolic and diastolic blood pressure, triglyceride, high-sensitivity C-reactive protein (CRP) decreased, high-density lipoprotein, and VO_{2max} increased significantly, during the 8 weeks ($P < 0.05$). Moreover, no changes were found in the cardiovascular risk factors of women who did not exercise ($P > 0.05$).

Conclusion: Concurrent ER training can be a suitable exercise program for improving plasma lipid profile as well as reducing body composition, high-sensitivity CRP, and increasing VO_{2max} in postmenopausal women.

Keywords: Body composition, Cardiovascular system, Exercise training, Menopause

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INTRODUCTION

Cardiovascular disease (CVD) is the most leading cause of mortality,[1] complications, and disability in worldwide[2] and Iran.[3] Recent report of the World Health Organization in 2011 mentioned that annually 17.3 million deaths were attributed to CVD, and it will be raised up to 23.6 million deaths by 2030.[4] Although sex differences had no significant impact on the death rate consequent to heart disease, worse complications have been noted by females with heart diseases than males[5] that may be due to some female-specific risk factors, i.e., pregnancy, menopause, and polycystic ovarian syndrome.[6] Furthermore, incidence of CVD is higher in women aged more than 55 years old than younger women.[7-9] Framingham CVD risk score[10] and Reynolds score[11] are the first-line clinical methods in asymptomatic adults. They both evaluate several biomarkers including total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), hemoglobin A1c, and/or high-sensitivity C-reactive protein (Hs-CRP). They had been noted that significant changes in these biomarkers were commonly observed long before the occurrence of overt clinical symptoms or a cardiovascular attack. Therefore, monitoring these measurable markers during the latent phase can decrease the risk of further pathologies and complications,[12] and prevention by reducing the risk factors of CVD is commonly recommended.[13] Menopause can also significantly increase the risk of CVD[9,14] as a result of physiological aspects as well as physical inactivity and insufficient diet.[15]

Postmenopausal women can reduce or control their whole and central adiposity by aerobic exercise.[16-18] The risk of CVD can be decreased consequent to the improvements in cardiorespiratory fitness.[19] It is noted that vascular aging can be combated by regular exercise as a therapeutic strategy.[20] Furthermore, it is reported that exercise is an effective action in improving maximal oxygen consumption (VO_{2max}) and HDL levels and reducing the level of plasma TG.[21,22] However, it is not a sufficient method for preservation and maintenance of fat-free mass. Furthermore, resistance training can improve muscle mass and strength, but, in turn, its effectiveness in the reduction of body fat is unclear.[23] Although the effect of aerobic or resistance training alone was assessed previously,[16-18,24] three is a limited investigation which assessed the combination of concurrent resistance and endurance training in menopause women.[25] We aimed to examine the effect of concurrent endurance and resistance (ER) training on cardiorespiratory capacity and cardiovascular risk factory among sedentary overweight or obese postmenopausal women.

MATERIALS AND METHODS

Study design and participants

This study was a randomized controlled trial, conducted in 2016 in Rasht, Iran. The study participants were sedentary overweight or obese (body mass index [BMI] ≥25 kg/m^2) females (n = 24) aged 50–60 years. The entry criteria were lack of participation in any regular physical activity (regular physical activity is at least 30 min of moderate activity for 5-days per week),[26] no history of drug use, and no history of any serious medical conditions including stroke, heart attack, and arthritis. Exclusion criteria were lack of participation in more than three sessions of program or being injured during exercise. Among 38 menopause women who met the criteria, 24 entered voluntarily in the study. Twenty-four overweight and obese postmenopausal women were randomly divided into exercise (n = 12) and control (n = 12) groups, using simple randomization. Ethical approval was obtained from the Ethical Committee of Islamic Azad University, Rasht Branch, and has been registered on the Iranian Clinical Trials Registry (IRCT2015122222498N5). Written informed consents were obtained from all participants.

Instruments

The primary outcome of this research was defined as change in body composition, lipid profile, and inflammatory factor, and the secondary outcome was defined as change in VO_{2max}. A demographic form consisting of questions about age, sex, location, job status, education status, past medical history, drug history, and smoking was completed by all of the participants at the beginning of the study. Wall stadiometer (Seca, Hamburg, Germany) and scale measured height (cm) and weight (kg), respectively, and BMI was measured as weight (kg) divided by height (m^2). A flexible tape meter measured waist circumference at the maximal narrowing of the waist from the anterior view. At the point of the maximal gluteal protuberance, the hip circumference was measured from the lateral view and the waist/hip ratio (WHR) was calculated. Systolic and diastolic blood pressure (SBP and DBP) and heart rate (HR) were measured using a validated automated oscillometric cuff (Rossmax Medical, Cincinnati, USA). Double blood pressures were measured and mean was assessed. If the results differed more than 5 mmHg, a third measurement was obtained. The average of the two closest values (within 5 mmHg) was averaged and analyzed.

Cardiorespiratory capacity (maximal oxygen consumption or VO_{2max}) was calculated as a measure of aerobic endurance. Rockport one-mile submaximal exercise test, which has been proven to be a reliable and valid protocol in predicting VO_{2max} in untrained participants, was performed. The reliability coefficients of Rockport test is more than 0.66 and its validity coefficient is more than 0.68.[27]

In addition, the Rockport one-mile submaximal test lessens problems of exhaustion and injuries associated with exercise testing.[28] Maximal oxygen uptake scores were predicted from the Rockport one-mile walking test formula: $VO_{2max} = 132.853 - (0.0769 \times \text{body mass}) - (0.3877 \times \text{age}) + (6.315 \times \text{gender}) - (3.2649 \times \text{time}) - (0.1565 \times \text{HR})$.[29] The procedure of the test started with a warm-up of about 8–10 min. The participants' postexercise HR and times to complete the one-mile distance were recorded using a polar HR monitor.

Blood biochemistry

A blood sample was drawn after a 12-h fasting period. Serum lipid profiles (total cholesterol, TG, LDL-C, and HDL-C), Hs-CRP, and blood glucose were measured at baseline and at week 8 and compared. LDL-C and HDL-C were measured directly with commercially available kits (Pishtazteb, Tehran, Iran) by immunoturbidimetry methods. Serum TG was analyzed using a total glycerol test kit (BioSystems, Barcelona, Spain) by full automation glycerol phosphate oxidase/peroxidase/endpoint methods. Serum cholesterol was analyzed using a total cholesterol test kit (BioSystems, Barcelona, Spain) by full automation cholesterol phosphate oxidase/peroxidase/endpoint methods. Serum glucose was analyzed using a total glucose test kit (BioSystems, Spain) by full automation glucose oxidase/peroxidase/endpoint methods. Hs-CRP was examined through a turbidimetric method (BioSystems Kit, Spain). All measurements were carried out on a Hitachi 747 autoanalyzer (Hitachi Ltd., Tokyo, Japan). All of the variables were measured at the beginning of trial and week 8, in both exercise group and control group, by one of the researchers. If the participants had not the psychological readiness for field tests such as Rockport one-mile walking test, the test was postponing to another day.

Procedures

The exercise group underwent 8 weeks of intervention. Control group maintained their common level of activity during the trial period. The progressive concurrent exercise training programs were 8 weeks, three times per week for 90 min per session, 35 min of strength training with weights of 50%–75% of one-repetition maximum (1RM), and 40 min of endurance training with an intensity of 50%–80% exercise target HR (THR) was calculated using the Karvonen equation (Target Heart Rate = ((Maximum Heart Rate − Resting Heart Rate) x %Intensity) + Resting Heart Rate).[30] The workouts included 5–10 min warm-up and cooling. Endurance exercises such as running on a treadmill or pedaling on a bicycle ergometer were noted intermittently for 6 weeks at 50%–70% of THR. Then, the intensity was increased to 70%–80% of THR. The resistance exercise protocol aimed to work out major muscle groups of the lower and upper limbs[29] for 35 min and involved the following exercises: chest press, knee extension, hamstrings curl, leg press, hip abduction, seated row, shoulder abduction, and plantar flexion. Intensity of resistance exercise was initially set at 50% of the predetermined 1RM test of muscular strength for 1 week and then was increased 10% every 2 weeks to a maximum of 80% of the 1RM. The 1RM measurement was done using the Brzycki 1RM prediction equation.[31] To warm up before the test, participants performed two series with light loads for each exercise and then the resistance was increased in order to meet the requirement of 1RM measurement using the Brzycki 1RM prediction equation $1RM = (100 \times W)/(102.78 - [2.78 \times R])$, where W = weight used (in kg) and R = maximal number of repetitions performed which can be used only if 9 or less repetitions can be completed.[32]

Statistical analysis

Data were reported by mean and standard deviation. The normality of distribution was assessed by the Shapiro–Wilk test. Paired *t*-test was used for comparing quantitative parameters in intervention group before and after the 8 weeks of exercise training. Furthermore, differences in clinical parameters between the two groups (exercise vs. control group) were analyzed using independent *t*-test. $P < 0.05$ indicated statistical significance and 95% confidence interval was noted. SPSS version 22.0 (Statistical Package for Social Science, SPSS Inc., Chicago, IL, USA) was used for all the statistical analyses.

RESULTS

The results are based on ten females in the control (56.90 ± 4.93 years old) and twelve females in the combined ER group (54.83 ± 4.72 years old). Two females in control groups did not participate in posttests due to illness. Independent *t*-test did not show any significant differences between two group characteristics, i.e., weight, BMI, WHR, VO_{2max}, HR, BP, cholesterol, TG, HDL, LDL, fasting blood sugar (FBS), and CRP at the beginning of the trial [Table 1]. The effects of 8 weeks combined ER training program on body composition indices, VO_{2max}, rest HR, and blood pressure were shown in Table 1. The paired *t*-test which assessed ER group before and after of intervention showed decreased weight, BMI and WHR,

Table 1: Body composition indices, maximum oxygen consumption, rest heart rate, and blood pressure, plasma lipid profile, blood sugar, and high-sensitivity C-reactive protein pre- and post-8 weeks of exercise training in the exercise and control groups

Variables	Control			ER			Significant†
	Pre	Post	Significant#	Pre	Post	Significant#	
Weight (kg)	71.9±6.1	72.3±6.2	0.12	72.6±5.06	71.1±5.0	0.001*	0.001*
BMI (kg/m^2)	28.6±2.4	28.8±2.5	0.03*	28.4±1.13	27.8±1.16	0.001*	0.001*
WHR (cm)	0.90±0.07	0.91±0.08	0.01*	0.91±0.02	0.87±0.03	0.01*	0.001*
VO_{2max} (ml/kg/min)	20.3±2.03	20.4±2.3	0.7	19.5±0.87	23.2±2.2	0.001*	0.001*
HR_{rest} (pulse/min)	77.9±5.7	79.1±5.9	0.01*	81.5±9.2	79.3±7.4	0.04*	0.006*
SBP (mmHg)	12.3±1.1	12.5±0.84	0.3	12.8±1.02	12.08±0.9	0.01*	0.009*
DBP (mmHg)	80.1±5.3	80.4±5.6	0.49	88.7±6.07	79.6±6.06	0.001*	0.001*
Cholesterol (mg/ml)	191.4±22.5	198.3±22.6	0.27	189.6±31.8	181.6±25.6	0.001*	0.1
TG (mg/ml)	194.6±17.5	187.6±21.5	0.07	178.7±22.8	135.6±15.8	0.001*	0.001*
HDL (mg/ml)	37.5±3.4	33.6±3.5	0.18	33.1±8.06	42.9±7.1	0.001*	0.001*
LDL (mg/ml)	173±9.2	172.7±9.5	0.8	177.9±13.9	172.7±12.5	0.17	0.28
LDL/HDL ratio	4.64±0.49	4.7±0.63	0.4	5.65±1.45	4.1±0.62	0.001*	0.001*
FBS (mg/dl)	99±13.1	100.8±17.4	0.85	102.5±9.9	106.3±7.6	0.15	0.57
Hs-CRP	1.29±0.67	1.32±0.63	0.5	1.53±0.74	1.08±0.64	0.001*	0.001*

*Statistical significant, #Paired *t*-test, †Independent *t*-test (between groups in posttest). ER: Endurance resistance training group, BMI: Body mass index, WHR: Waist-to-hip ratio, $V0_{2max}$: Maximum oxygen consumption, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, Hs-CRP: High-sensitivity C-reactive protein, FBS: Fasting blood sugar, BP: Blood pressure, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, TG: Triglyceride, HR_{rest}: Rest heart rate

HR rest, SBP and DBP ($P < 0.05$), and increased VO_{2max} significantly ($P = 0.001$). However, in the control group, there was a significant increase in BMI and HR rest after experimental period. On the other hand, the independent *t*-test showed a significant difference between control and intervention groups regarding all the above variables.

In the intervention group, triglyceride, Hs-CRP, and LDL-to-HDL ratio were significantly decreased ($P = 0.001$). These women also had increased HDL by an average of 2.9% ($P = 0.001$) during experimental period. However, no significant change was noted based on cholesterol, LDL, and FBS. Moreover, no changes were found in the cardiometabolic risk factors of control group. The independent *t*-test conducted on groups showed that the TG, HDL, LDL-to-HDL ratio, and Hs-CRP levels were significantly changed during the 8-week intervention ($P = 0.001$). However, it was not significantly different between the two groups in the pre- and posttest exercise of cholesterol, FBS, and LDL. Correlation between cardiorespiratory capacity and TG ($r = 0.76$, $P = 0.001$), cardiorespiratory capacity and HDL-C ($r = 0.60$, significant = 0.003), and cardiorespiratory capacity with LDL/HDL ratio ($r = 0.63$, significant = 0.002) had shown in Figures 1-3, respectively.

DISCUSSION

This study was conducted to examine the effects of 8 weeks of concurrent exercise training on cardiovascular risk factor among sedentary overweight or obese postmenopausal women. Woman transition during menopause induces irreversible complications.[33] Menopause induces a 60% increase in the risk of developing metabolic syndrome independent of age, BMI, and physical activity.[34] Our results showed that an 8-week ER exercise produced positive, significant reduction in several body composition and made a significant increase in VO_{2max}. In postmenopausal women, 6%–7% weight loss presented mainly by combination of endurance and strength training and resulted in a more favorable body composition and better physical fitness.[35] A modest body weight reduction of 3%–5% has been shown to result in clinical improvements in health. The degree of weight loss was directly related to health benefits regarding cardiovascular outcomes.[36] On the other hand, many studies showed that exercise training could improve HR variability.[37,38] Our study showed a significant increase in HDL levels and decrease in TG after 8 weeks of ER training. In contrast, some studies had demonstrated that exercise training did not improve HDL and TG significantly.[39,40] This contrast might be due to the type, duration, and intensity of different exercise programs. Menopause causes an imbalance of the autonomic nervous control of the cardiovascular system that shifts toward sympathetic vagal hyperactivity and sympathetic activities in the postmenopausal group which were lower and higher than those of the premenopausal group, respectively.[37] Postmenopausal women have lower VO_{2max} and a greater risk of CVD compared to premenopausal women. Sedentary lifestyle and reduced cardiorespiratory fitness (peak oxygen consumption [VO_{2peak}])[41] were associated with an increased cardiac sympathetic stimulation, hypertension,[42] and/or obesity. They played a critical role in the onset and/or progression of CVD (mainly coronary heart disease), especially in postmenopausal women. The significant increase in

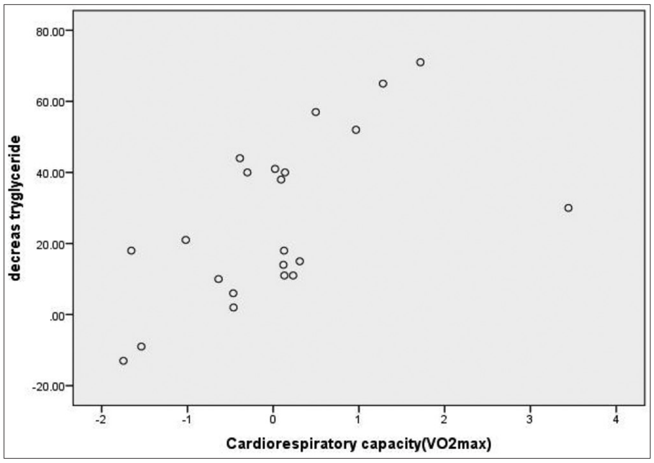

Figure 1: There was a negative correlation between cardio-respiratory capacity and triglyceride

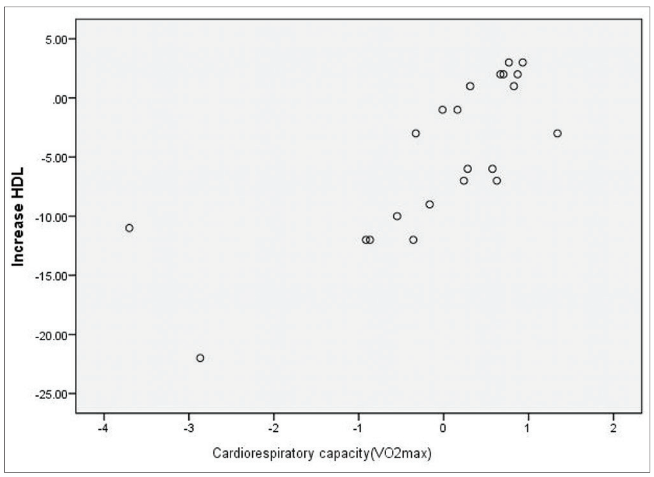

Figure 2: There was a positive correlation between cardio-respiratory capacity and high-density lipoprotein cholesterol

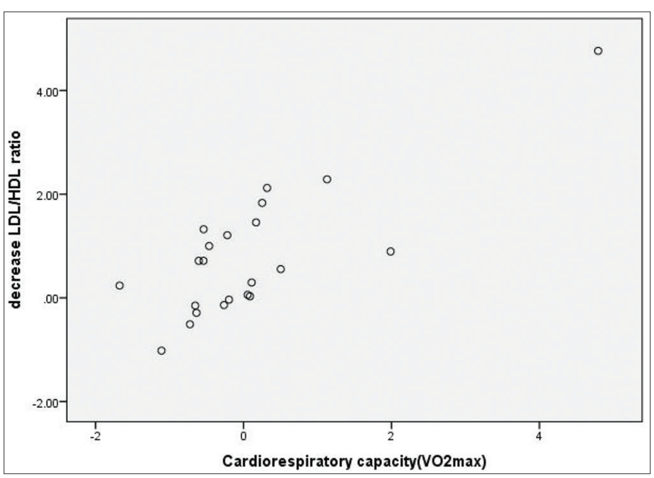

Figure 3: The improvement in cardiorespiratory capacity was significantly associated with decreased in low-density lipoprotein/high-density lipoprotein ratio

VO_{2peak} was consistent with previously observed aerobic training effects on postmenopausal women.[43]

Our study showed that eight-week supervised ER training significantly improved some of the metabolic markers consist of HDL-C, LDL-to-HDL ratio and plasma TG but had no significant effect on cholesterol, LDL-C, and blood sugar in post-menopausal women. The combined training in obese postmenopausal women after the training program made a reduction in the percentage of body fat. HDL-C levels increased in the combined group, and the cholesterol/HDL ratio (atherogenic index) decreased in the aerobic group.[44] Some studies showed increases of plasma HDL-C levels after menopause in Korean and Iranian population.[45,46] Exercise which induced weight loss could similarly improve lipid profiles but with the added benefit of reducing serum TG.[47] The findings of the current study are limited due to its small sample size. Another limitation of this study was the lack of controlling their diet lack of control on psychological parameters that can effect on field tests. Most of the studies work on endurance exercises while we worked on the impact of the simulation of resistant and endurance exercises because resistance exercises can have a significant effect on cardiovascular risk factors and strengthen type 2 muscles. Further trials are needed to corroborate our findings about the optimal dose and type of exercise required to lower CRP, cholesterol, LDL-C levels, and their effects on levels of body fatness and fitness.

CONCLUSION

The results of the current study indicated that Hs-CRP had a significant decrease after 8 weeks of combined training in menopause women. These results suggested that engaging in exercise training is associated with a decrease in Hs-CRP levels. In conclusion, based on the results obtained in this study, an 8-week concurrent ER exercise training could improve some plasma lipid profiles as well as a reduction in body composition, cardiorespiratory endurance (measured with VO_{2max}), and decreased Hs-CRP. In other words, exercise training programs were effective for improving body composition and inducing an antiatherogenic status. These findings suggested that exercise training is a necessary component of lifestyle modification in obese postmenopausal women.

Conflicts of interest

There are no conflicts of interest.

Author contribution

All authors contributed to this research.

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