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Effect of Aerobic Exercise in Water on Serum Estrogen and C-Reactive Protein and Body Mass Index Level in Obese and Normal Weight Postmenopausal Women

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Background: Menopause is associated with increasing incidence of cardiovascular disease, and different exercise regimens can variously affect different cardiovascular risk factors.
Objectives: The aim of this study was to investigate the effect of an aerobic exercise in water on serum estrogen, C-reactive protein (CRP) and body mass index (BMI) levels in obese and normal weight postmenopausal women.
Patients and Methods: This quasi-experimental study comprised 29 volunteer non-athletic postmenopausal women with mean age 57.04 ± 4.68 years. The study subjects were divided into two groups of obese (n = 15; BMI = 30.21 ± 3.89) and normal weight (n = 14; BMI = 22.43 ± 2.45) according to their BMI. The subjects of both groups participated in aquatic exercise training for 8 weeks, 3 sessions a week, with progressive intensity of 50 to 70 percent of maximum heart rate for 45 minutes between 10-11 am. The blood samples were taken the day before and two days after the exercise sessions through the left brachial vein. Wilcoxon signed ranks test and Mann-Whitney test were used for data analysis.
Results: In the obese and normal weight groups exercise caused significant increase in estrogen (P=0.001, P = 0.001, respectively) and decreased the BMI (P = 0.009, P = 0.003, respectively); however, CRP decreased significantly when compared to pre exercise in the normal weight group (P = 0.005), No statistically significant change was observed in the obese group (P = 0.084). There was no significant difference in estrogen (P = 0.32), BMI (P = 0.62) and CRP (P = 0.35) changes following exercise between obese and normal weight groups.
Conclusions: In the present study, aquatic aerobic exercise caused similar reduction in some cardiovascular risk factors among obese and normal weight postmenopausal women. However, future studies are recommended for more clarification.

Keywords: Aerobic exercise; C - reactive protein; Estrogen; Body Mass Index; Post menopause

1. Background

Annually, cardiovascular diseases (CVD), especially atherosclerosis, cause death of many people and it is predicted that atherosclerosis will be a dominant disease in 2020 (1). The most known factors of mortality for CVDs such as age, gender, high cholesterol, smoking, hypertension, lipid profile and glucose tolerance cannot be considered as the only risk factors for all coronary diseases. Nevertheless, recent studies have indicated the incidence of cardiovascular events in persons with normal range or even low blood lipid and cholesterol and it was suggested that systemic and local inflammatory factors play a more important role in cardiovascular disorders than previously known factors (2-4).

CRP is one of important inflammatory factors. Elevated plasma levels of C-reactive protein have been associated with an increased risk of coronary heart disease (2), ischaemic stroke (5), peripheral artery disease, hypertension (5), and any cardiovascular disease (6), in individuals with no prior cardiovascular disease. Moreover, elevated plasma C-reactive protein levels have been associated with obesity (7).

In addition to inflammatory indices, obesity indices increases are predictive factors for cardiovascular disease. According to some studies, body composition of such indices as BMI and waist-hip ratio (WHR) are closely associated with CRP (8). Stewart et al. indicated that combined aerobic and resistance training reduced CRP in young and old subjects (9). The cross sectional study by Tchernof (2002) showed that adiposity was a significant predictor of plasma CPR in postmenopausal women and caloric restriction–induced weight loss decreased plasma CRP levels (10).

Estrogen is a female sex hormone that plays a role in increasing the level of cholesterol in high and low-density lipoprotein (HDL and LDL) and is associated with obesity (11). Estrogen induce protective effect on the cardiovascular system through indirect effect on liver which leads to an increase in HDL and a decrease in LDL and plasma cholesterol levels (12). Death rate from cardiovascular disease in premenopausal women is 20%, but after menopause, due to reduction of the protective effect of estrogen, death rate increases exponentially until it reaches the mean level (13). Based on various studies regarding the strong association between inflammatory markers and cardiovascular diseases, any methods that reduce these markers can lower the cardiovascular events. One of the suggested effective non-pharmacological methods for reducing inflammatory factors is exercise which causes weight loss (14).

Some studies have suggested that body weight is associated with CRP and estrogen. Esposito (2003) found that a multidisciplinary program reduces body weight in obese women and changes estrogen and CRP as a result of exercise training (15). Roberts et al. found that a short-term, intensive lifestyle modification program was effective in ameliorating metabolic risk factors in non-obese and obese children and suggested that obesity per se was not the primary driver of the phenotypes noted and that dietary intake and physical inactivity induce the phenotypic changes (16). Different inflammatory mechanisms are involved in water and on land exercises (17). Therefore, considering body weight as well as aerobic exercises in water emphasizes the importance of studies on this issue.

2. Objectives

The primary aim of this study was to determine whether the influence of aerobic exercise in water is different in obese and normal weight women regarding CRP, estrogen and BMI. The second aim of the study was to explore the effect of aerobic exercise in water on the estrogen, CRP and BMI level in inactive obese and normal weight middle aged menopausal women.

3. Patients and Methods

This experimental study was conducted on postmenopausal women living Isfahan, Iran. The inclusion criteria were being healthy with no history of cardiovascular diseases or physical activity limitation, for at least 5 years following last menstruation, and age range between 52 to 62 years. The exclusion criteria were CVD or metabolic diseases associated with the study variables, any effective medications, and any diseases or disorders preventing physical activity or exercise, regularly participating in exercise program or sport activities. Participants were informed and called for study based on the information obtained from the Retirement Center. A cardiologist confirmation about exercise participation and health was necessary for all participants. Prior to exercise program an introductory session was held in which the workout and exercise procedure was explained to the subjects. A written and signed informed consent to take part in the study was obtained from all participants. Thus, of 35 volunteer women, 29 non-athletic postmenopausal women from Isfahan with inclusive criteria were enrolled in the study with mean age 57.04 ± 4.68 years, weight 65.23 ± 10.47 kg and height 154.70 ± 9.47 cm. The study participants were divided into two obese (n = 15; BMI = 30.21 ± 3.89) and normal weight (n = 14; BMI = 22.43 ± 2.45) groups in terms of BMI. The study participants of both groups took part in the aquatic aerobic exercise program for 8 weeks, 3 sessions per week and progressive intensity of 50 to 70 percent of maximum heart rate for 45 minutes, during 10-11 am. Each aquatic exercise session included 10 min warm up exercise, 25 min synchronized aerobic exercise by all upper and lower body muscles comprising the following exercises: long-lever pendulum like movements of the lower extremities; forward and backward jogging with arms pushing, pulling, and pressing; and leaps, kicks, leg crossovers, and hopping focusing on traveling in multiple directions, and 10 min cool down exercises. Heart rate was controlled every 15 minutes.

Following the instructor's training, the study participants controlled their pulse rate by carotid artery. The entire course of the exercise was conducted in presence of the researcher. To calculate the maximum heart rate, the following formula was used:

Target heart rate = (maximal heart rate-rest heart rate)*target percent + rest heart rate

Maximal heart rate was calculated by the following formula:

Maximal heart rate = (220-age), (18). In addition, BMI was calculated using the following Equation 1 (19):

$$\frac{\text{Weight(kg)}}{[\text{height(m)}]^2} \tag{1}$$

All measurements including wight, height and blood sampling were performed 24 hours before and 24 hours following the exercise program. To measure the estrogen and CRP, the study subjects' blood samples were taken from the left brachial vein in sitting position. Serum CRP was quantified by Elisa method. Human estrogen (Estradiol) was measured through radioimmunoassay method.

Wilcoxon signed ranks test and Mann-Whitney test were used for analysis of the difference between the means in pretest and posttest of each group and between groups, respectively. All the statistical analysis was done using SPSS version 16 (SPSS inc., Chicago, IL, USA) with significant level of 0.05.

4. Results

Table 1 shows the descriptive data of the study variables before and after the exercise program in the two groups of obese and normal weight women.

Wilcoxon signed ranks test was used to compare the changes created by exercise within each group. Table 1 indicates Wilcoxon signed ranks test results for the obese and normal weight groups.

As shown in Table 1, estrogen increased significantly in the obese (Z = 3.40, P = 0.001) and normal weight (Z = 3.29, P = 0.001) groups where BMI decreased significantly in obese (Z = 2.60, P = 0.009) and normal weight (Z = 2.93, P = 0.003) groups. However, CRP decreased significantly after exercise compared to the pre exercise in normal weight group (Z = 0.005, P = 0.005), but no statistically significant difference was observed in the obese group (Z = 1.72, P = 0.084) (P > 0.05).

The comparison of the changes in the variables between the obese and normal groups is shown in Table 2. Gain scores (pre- post changes) of study variables were compared between the two groups using Mann whitney test. There was no significant difference in estrogen (Z = 0.97, P = 0.32), BMI (Z = 0.43, P = 0.62) and CRP (P = 0.35) changes following exercise between obese and normal weight groups.

Table 1. Comparison of the Variables Before and After the Exercise Program in the Obese and Normal Weight Groups Using Wilcoxon Signed Ranks Test

Groups and Measurement Time	Mean	Median	Maximum	Minimum	Z	n	P
Estrogen, pg/mL							
Obese					3.40	15	0.001
Pre exercise	31.64	30.10	51.30	25.40			
Post exercise	35.44	33.60	53.00	27.70			
Normal weight					3.29	14	0.001
Pre- exercise	28.48	29.55	37.00	20.70			
Post- exercise	33.62	33.50	57.00	24.10			
CRP, mg/L							
Obese					1.72	15	0.084
Pre- exercise	4.74	2.90	10.50	2.30			
Post- exercise	4.05	2.60	8.10	1.90			
Normal weight					2.80	14	0.005
Pre- exercise	3.35	2.65	10.50	2.20			
Post -exercise	2.27	2.15	4.80	1.20			
BMI, kg/m^2							
Obese					2.60	15	0.009
Pre- exercise	30.21	28.20	38.50	26.30			
Post- exercise	29.96	27.98	38.32	26.12			
Normal weight					2.93	14	0.003
Pre- exercise	22.43	22.44	24.91	18.57			
Post- exercise	22.24	22.14	24.24.83	18.54			

Table 2. Comparing the Changes in the Variables Between the Two Groups Using Man Whitney Test [a]

Group	n	Mean	Median	Maximum	minimum	Z	P
Estrogen						0.974	0.352
Obese	15	3.80	3.50	7.20	0.90		
Normal weight	14	5.14	4.25	20.00	1.80		
CRP						1.070	0.291
Obese	15	0.69	0.60	3.70	1.70		
Normal weight	14	1.07	0.60	7.70	0.50		
BMI						0.439	0.626
Obese	15	0.24	0.18	1.12	0.48		
Normal weight	14	0.19	0.11	0.71	0.00		

[a] Abbreviations: BMI, body mass index; CRP, C-reactive protein.

5. Discussion

Diagnosis of cardiovascular risk factors is very important in preventing and treating cardiovascular diseases. The aim of this study was to evaluate the influence of aquatic aerobic exercise on CRP, estrogen and BMI in two groups of normal weight and obese menopause women.

The results of the present study showed that eight weeks of aquatic aerobic exercise reduced the CRP in both normal weight and obese women and this difference was statistically significant in normal weight but not in the obese group. The results of this study was in part consistent with the findings of some previous investigations conducted by Nicklas (2004, who showed that exercise had no significant effect on CRP during 18 months of study on elderly subjects (20). The study by Marcell et al. (21) showed that changes in lipid profile percentage brought about by moderate to intense exercises were significantly associated with changes of insulin sensitivity, but not in relation to CRP, where no significant decrease was found in CRP despite improved physical fitness and body composition. Kohut et al. (22) compared a flexibility to a strength aerobic exercise and stated that aerobic exercise, 3 sessions a week, each session 45 minutes for 10 months, can cause a significant reduction in CRP in women and men aged more than 64 years. Colbert et al. (23) showed that chronic activities can reduce the CRP level and inflammatory factors. Okita et al. (24) also showed that aerobic exercise for two months can cause a considerable reduction in weight and CRP in women. The findings of foregoing studies proposed a hypothesis that in the setting of obesity, exercise may influence inflammation through adipocyte function. However according to the present study findings showed that although BMI reduced following training in both obese and normal weight groups, CRP did not change significantly in the obese group. Probably, in the normal weight group exercise has been more effective in reducing inflammatory factors leading to decreasing CRP. Also, the results obtained might be influenced by the small sample size.

Oberbach et al. (25) found that four weeks of exercise reduced body fat in all participants. Mora et al. (26) in a study concluded that higher BMI can be a stronger and more important factor than lack of physical activity for high inflammatory indices. Santos et al. (27) believed that physical activity and exercise as well as weight loss, in case of obese individuals, could decrease the factors causing inflammation in regard to atherosclerotic disease since the very childhood. Selvin et al. (28) considered weight loss as one helpful and effective methods in reducing CRP. Exercise may cause weight loss by increasing energy cost related to more physical activity and increasing fat oxidation related to exercise metabolism and requirements and by decreasing appetite after exercise (29). Exercise training may also reduce C-reactive protein through more direct effects on the inflammatory process. Some previous studies suggest that exercise training reduces the expression and blood levels of leukocyte adhesion molecules, inhibits interactions between monocytes and endothelial cells, decreases the production of pro-inflammatory cytokines, and increases the production of anti-inflammatory cytokines by mononuclear cells and maintains balance between the production of pro-inflammatory and anti-inflammatory cytokines in skeletal muscles (30). Also CRP modulates the expression of genes that contribute to both pro- and anti-inflammatory responses in human monocytes (31). Since in present study CRP has not changed significantly in obese group, it is concluded that exercise has maintained a balance between inflammatory and anti-inflammatory response. Long term exercise training causes vagus nerve stimulation. According to the study conducted by Corcoran et al. (2005) vagus nerve stimulation is associated with marked peripheral increases in pro- and anti-inflammatory circulating cytokines which are not reflected in CRP levels (32). These findings support the results of present study regarding CRP levels in the obese group.

Discrepancies between the present and previous findings may also be related to various exercise designs and methods and factors such as age, gender, weight, diet, lifestyle, smoking, stress, duration of sessions and intensity of exercises.

There are conflicting results about the influence of physical exercise on sex hormones in the postmenopausal women. The results of this study revealed that estrogen level increased significantly after the exercise program in both groups of normal weight and obese women. The results of this study were not in accordance with the results of Copeland et al. (33). However, it was in agreement with the results of Tartibian's study (34), Chan and Atkinson (35, 36). Copeland et al. believed that the increased serum estrogen after an exercise session was due to reduced purification and metabolism of estrogen following exercise and this, per se, is resulted from decreased hepatic blood flow (33). Chan et al. conducted a study to review the association between physical activity and sexual hormones in postmenopausal women; the results showed that increased physical activity was associated with significant decrease in estradiol and testosterone level. They believed that the discrepant findings might be due to differences in type of exercises, their duration and intensity; they also indicated that the conditions responsible for reducing estrogen and decreased aromatization of androgens were reduction in adipose tissue and weight loss (35).

Atkinson et al. (36) mentioned that body fat in postmenopausal women may have an influence on the metabolism of estrogen. Also low levels of aromatase activity in abdominal fat may be effective in reducing estrogen.

According to the findings of the present study, aquatic aerobic exercise caused reduction in BMI; but increased estrogen, thus it can be concluded that despite reduction in fat tissue as one of the sources of estrogen secretion, other entities of estrogen secretion such as ovaries may be influenced by exercise. Perhaps one mechanism by which exercise mediates estrogen metabolism is through the regulation of P450 cytochrome enzymes which is responsible for controlling estrogen hydroxylation and catechol estrogen methylation. Future studies are warranted to corroborate our results but also determine the exact mechanisms by which exercise leads to favorable changes in estrogen metabolism.

The findings of our study indicated that there was no significant difference in estrogen, CRP and BMI mean difference (gain score) between obese and normal weight groups. This indicates that exercise has comparable impact on obese and normal weight groups. Although no study was found to compare influence of exercise on BMI, CRP and estrogen, Esposito (2003) found that a multidisciplinary program reduces body weight in obese women through lifestyle changes, associated with a reduction in markers of vascular inflammation and insulin resistance (15). Roberts et al. found that a short-term, intensive lifestyle modification program was effective in ameliorating metabolic risk factors in non-obese and obese children .This suggests that the obesity per se was not the primary driving force for emergence of phenotypes noted and that dietary intake and physical inactivity are other inducers of the phenotypic changes (16). Yaghootkar et al. provided the genetic evidence for an association between the three diseases of the metabolic syndrome and pointed to reduced subcutaneous adiposity as a central mechanism (37). According to the findings of the present study, we can conclude that exercise training exerted similar impact on CRP, BMI and estrogen in obese and normal weight women and that adiposity does not interfere with the effect of exercise. According to the results of the present study, aerobic exercise in water was useful and similarly reduced some cardiovascular risk factors in obese and normal weight groups.

One of the limitations of this study is the small sample size, which was due to the relatively long duration of the study and inclusion or exclusion criteria. Thus, extending the present findings requires future studies including large number of participants. Another limitation of the study was the imprecise control of participants' diets, despite reminding them not to change their usual diet during the course of study.

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