Effect of regular exercise with different intensities on oxidized LDL levels in obese men

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Abstract

Introduction: Macrophages and oxidized low-density lipoprotein (ox-LDL) have been verified playing vital roles in the pathogenesis of atherosclerosis. The role of exercise intensity in circulating ox-LDL is not clearly understood in obesity and it is not well known which exercise intensity is needed to ox-LDL reductions in response to endurance training. Thus the purpose of this study was to comparison the effect of regular high-intensity *vs.* moderate-intensity exercise on ox-LDL in obese men.

Material & Methods: Twenty four sedentary obese men (aged: 41.0 ± 5.9 years and BMI: 31.1 ± 3.4 kg/m^2; $\pm$ SD) volunteered to participate in this study. The subjects were randomly assigned to moderate-intensity exercise (MIE) group (n=8), high-intensity exercise (HIE) group (n=8) or control group (n=8). The subjects in MIE group walked 2 miles in 30 minutes on a treadmill on 4 days per week for 12 weeks according to the guidelines of the Centers for Disease Control and Prevention and American College of Sports Medicine; however, the subjects in the HIE group performed

endurance training 4 days a week for 12 weeks at an intensity corresponding to 75-80% individual heart rate reserve (HRR) for 45 min.

Results: The results showed that total cholesterol (TC), triglycerides (TG) and LDL were decreased and HDL increased after MIE and HIE (P<0.05). ox-LDL concentration was decreased only after HIE. For TC and HDL significant differences were observed between MIE group and HIE group (P<0.05).

Conclusions: The results suggest that although lipid profile of obese men improves after regular moderate and high-intensity exercise, ox-LDL levels decreases only after regular high-intensity exercise.

1. Introduction

Atherosclerosis and its main form coronary artery disease (CAD), leads to many fatalities in developed countries. Serum total and low density lipoprotein cholesterol (LDL) are among the firmly established risk factors of CAD (1). Lipid lowering therapies have shown to reduce the occurrence of clinical events (2). After oxidation, LDL becomes more toxic and plays a primary role in the development and progression of atherosclerosis (3). The plasma levels of oxidized low density lipoprotein (ox-LDL) increased in CAD patients and increased even higher in patients with acute coronary syndrome (4,5). Macrophage uptake of ox-LDL induces the migration and proliferation of smooth muscle cells, resulting in foam cell formation, which develops into the fatty streaks characteristic of cardiovascular disease (6). In addition, ox-LDL is associated with increased incidences of metabolic syndrome (7) and obesity (8,9), and is considered a risk factor for cardiovascular disease (10).

Some recent cross-sectional and longitudinal studies recently report that plasma concentrations of circulating ox-LDL are directly associated with

body mass index (BMI), waist circumference, obesity, weight loss, and physical fitness (11). Physical exercise modulates inflammatory reactions in leukocytes, according to reactions based on the exercise type/intensity/duration (12). Previously, Cornelissen et al. (2009) indicated that ox-LDL concentration is reduces after 10 weeks endurance exercise with 66% of heart rate reserve (HRR) in old sedentary men and women but it had not significant changes after 10 weeks endurance exercise with 33% of HRR (13). Furthermore, 12-week healthy-life exercise program with 50-70% of HRR has been reported to decrease ox-LDL concentrations in obese elderly women (14). The role of exercise intensity in circulating ox-LDL is not clearly understood in obesity and it is not well known which exercise intensity is needed to ox-LDL reductions in response to endurance training. Thus the purpose of this study was to comparison the effect of regular high-intensity *vs.* moderate-intensity exercise on ox-LDL in obese men.

2. Materials and Methods

Subjects

Fifty sedentary obese men enroll and volunteered to participate in this study. All the people were asked to complete a personal health and medical history questionnaire, which served as a screening tool. Twenty four obese men with a mean ($\pm$SD) body mass index of 31.1 ± 3.4 kg/m^2 selected as the subject after screening by inclusion criteria. All the subjects had slightly insulin resistance and all of them were complete inactive at least 6 month before the study and they were nonsmokers and free from unstable chronic condition including dementia, retinal hemorrhage and detachment; and they have no history of myocardial infarction, stroke, cancer, dialysis, restraining orthopedic or neuromuscular diseases. Thereafter, the subjects were randomly assigned to moderate-intensity exercise (MIE) group (n=8), high-intensity exercise (HIE) group (n=8) or control group (n=8). The subjects were given both verbal and written instructions outlining the experimental procedure, and written informed consent was obtained.

Exercise training

The subjects in the MIE group walked 2 miles at 30 minutes (40-59% HRR) on a treadmill without incline on 4 days/week for 12 weeks according to the CDC and ACSM guidelines. The subjects in the HIE group performed endurance training 4 days a week for 12 weeks at an intensity corresponding to 75-80% individual HRR for 45 min and control group were instructed not to change their physical activity and diet.

Anthropometric and body composition measurements

Height and body mass were measured, and BMI was calculated by dividing body mass (kg) by height (m^2). Waist circumference was determined by obtaining the minimum circumference (narrowest part of the torso, above the umbilicus) and the maximum hip circumference while standing with their heels together. The waist to hip ratio (WHR) was calculated by dividing waist by hip circumference (cm) (15). Fat mass and lean body mass were assessed by bioelectrical impedance analysis using a Body Composition Analyzer (Biospace, Inbody 3.0, Jawn, Korea).

Measurement of VO_{2max}

VO_{2max} was determined during graded exercise testing using modified Bruce protocol (16). Each subject performed a graded treadmill exercise test to estimate VO_{2max} by indirect calorimetry. A pulmonary gas exchange system (Cosmed, Quark b2, Italy) was used to evaluate the participants' VO_{2max}. Oxygen uptake (VO_2) was measured continuously via breath by breath analysis with the use of a computerized system. To ascertain that VO_{2max} had been attained, standard criteria had to be met. The criteria for reaching VO_{2max} test were: RER > 1.00, HR $> 85\%$ percentile of age predicted maximum and plateau of VO_2 maximum (17).

Biochemical analyses

Fasting blood samples were collected at rest (before training) and after training. All the subjects fasted at least for 12 hours and a fasting blood sample was obtained by venipuncture. The serum ox-LDL-c level was measured in duplicate using an enzyme-linked immunosorbent assay

(ELISA) kits (Mercodia, Upssala, Sweden). The assay sensitivity was 1 mU/l and its intra assay coefficient of variation was 8.5%. Fasting serum total cholesterol (TC), triglycerides (TG) and high-density lipoprotein (HDL) concentrations were measured by an enzymatic colorimetric method (Pars Azmun, Tehran, Iran). LDL concentration was calculated with the Friedwald formula.

Statistical analysis

Results were expressed as the mean $\pm$ SD and distributions of all variables were assessed for normality. Data were analyzed using one-way ANOVA and paired sample t-test. Post hoc analyses (Tukey) were then performed when warranted. The level of significance in all statistical analyses was set at P<0.05. Data analysis was performed using SPSS software for windows (version 17, SPSS, Inc., Chicago, IL).

3. Results

Physical and physiological characteristics of the subjects at baseline and after training are presented in Table 1. Before the intervention, there were no significant differences in any of variables among the three groups. Body mass, BMI, body fat percent and WHR decreased and VO_{2max} increased (P<0.05) after 12 weeks MIE and HIE compared to the control group (Table 2). Post hoc Tukey indicated that there were no significant differences in any of anthropometric, body composition and physiological parameters between MIE and HIE groups.

Table 1. Anthropometric, body composition and physiological characteristics (mean $\pm$ SD) of the subjects before and after training

	Baseline (mean $\pm$ SD)	After intervention (mean $\pm$ SD)	Paired t-test (Sig)	One-way ANOVA
Body mass (Kg)				
MIE (n=8)	86.1 $\pm$ 4.6	84.1 $\pm$ 4.3[ab]	0.001	
HIE (n=8)	87.8 $\pm$ 8.5	85.1 $\pm$ 8.8[ab]	0.001	0.001
Control (n=8)	90.4 $\pm$ 13.9	90.6 $\pm$ 14.1	0.3	
BMI (Kg/m^2)				
MIE (n=8)	30.3 $\pm$ 2.1	29.5 $\pm$ 2.1[ab]	0.001	
HIE (n=8)	30.9 $\pm$ 2.1	29.9 $\pm$ 2.2[ab]	0.001	0.001
Control (n=8)	32 $\pm$ 5.3	32.1 $\pm$ 5.3	0.4	

	Baseline (mean ± SD)	After intervention (mean ± SD)	Paired t-test (Sig)	One-way ANOVA
Body fat (%)				
MIE (n=8)	30 ± 3.4	28.1 ± 3.2[ab]	0.001	
HIE (n=8)	29.5 ± 3.1	27.2 ± 3.7[ab]	0.008	0.002
Control (n=8)	31.4 ± 5.5	31.4 ± 5.5	0.9	
WHR				
MIE (n=8)	0.96 ± 0.03	0.95 ± 0.03[ab]	0.004	
HIE (n=8)	0.96 ± 0.03	0.95 ± 0.02[ab]	0.02	0.01
Control (n=8)	0.99 ± 0.08	0.99 ± 0.08	1.0	
VO_{2max}(ml.Kg^{-1}.min^{-1})				
MIE (n=8)	30.3 ± 3.7	34.5 ± 2.6[ab]	0.002	
HIE (n=8)	32.0 ± 3.6	36.0 ± 3.5[ab]	0.005	0.001
Control (n=8)	31.8 ± 5.6	31.9 ± 5.7	0.3	

(a) P<0.05 for differences with control group.

(b) P<0.05, pretraining *vs.* posttraining values.

Biochemical analyses of the subjects are presented in the Figure 1 to Figure 5. As the shown in the Figure 1, LDL concentration was decreased after 12 weeks MIE and HIE (P<0.05). No significant differences were observed between MIE and HIE groups.
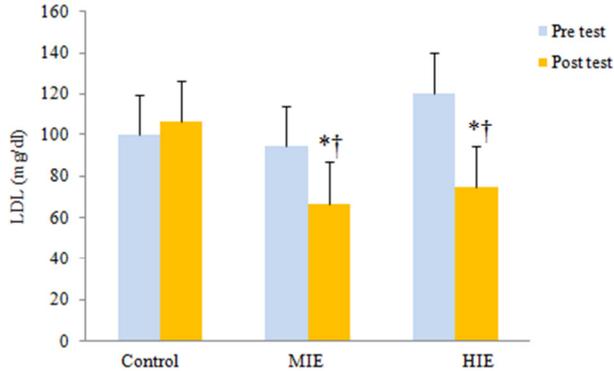

Figure 1. Changes on LDL after 12 weeks MIE and HIE

* P<0.05, Significant differences between pre test and post test
† P<0.05, Significant differences with control group

Changes on HDL after 12 weeks MIE and HIE are presented in the Figure 2. One-way ANOVA indicated that HDL levels were increased

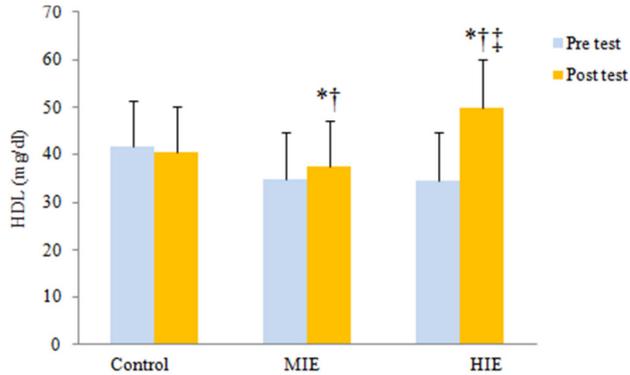after 12 weeks MIE and HIE (P<0.05). The increase of HDL was higher in the HIE group than the MIE group.

Figure 2. Changes on HDL after 12 weeks MIE and HIE

* P<0.05, Significant differences between pre test and post test
† P<0.05, Significant differences with control group
‡ P<0.05, Significant differences between MIE and HIE group

Changes on TC after 12 weeks MIE and HIE are presented in the Figure 3. The results indicated that TC concentrations were decreased after 12 weeks MIE and HIE (P<0.05). No significant differences were observed between MIE and HIE groups.
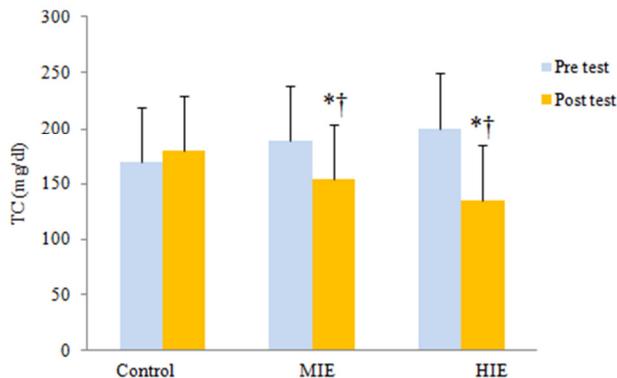

Figure 3. Changes on TC after 12 weeks MIE and HIE

* P<0.05, Significant differences between pre test and post test
† P<0.05, Significant differences with control group

Changes on TG after 12 weeks MIE and HIE are presented in the Figure 4. The results indicated that TG concentrations were decreased after 12 weeks MIE and HIE (P<0.05). The decrease of TG was higher in the HIE group than the MIE group.
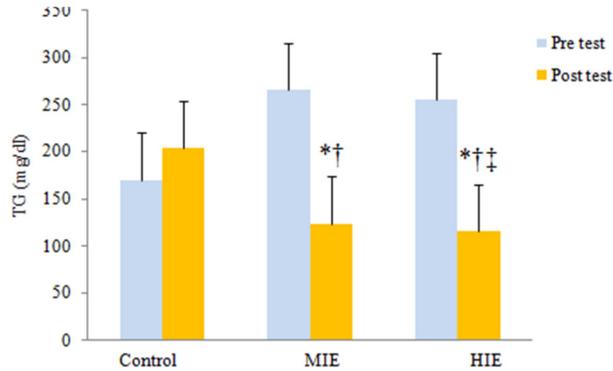

Figure 4. Changes on TG after 12 weeks MIE and HIE

* P<0.05, Significant differences between pre test and post test
† P<0.05, Significant differences with control group
‡ P<0.05, Significant differences between MIE and HIE group

Changes on ox-LDL after 12 weeks MIE and HIE are presented in the Figure 5. One-way ANOVA indicated that ox-LDL levels were decreased after 12 weeks HIE (P<0.05).
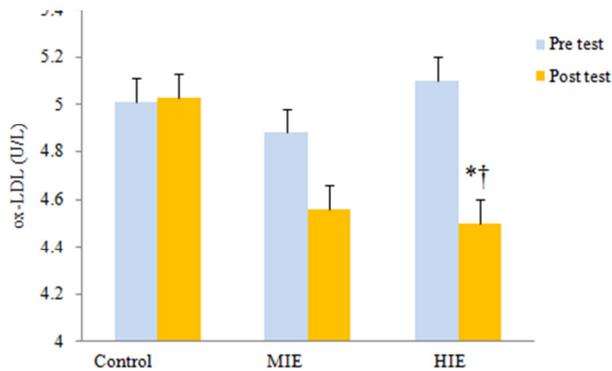

Figure 5. Changes on ox-LDL after 12 weeks MIE and HIE

* P<0.05, Significant differences between pre test and post test
† P<0.05, Significant differences with control group

4. Discussion

This study compared the effect of regular high-intensity *vs.* moderate-intensity exercise on ox-LDL in obese men. The main findings of this study are that TC, TG and LDL were decreased and HDL increased after MIE and HIE. ox-LDL concentration was decreased only after HIE. For TC and HDL significant differences were observed between MIE group and HIE group (P<0.05).

Although physical activity apparently appears to play an important role in preventing and treating atherosclerosis (18), its underlying mechanisms have not been well understood. Oxidative modification of LDL has been implicated in the early stages of atherosclerotic lesion formation (19,20). Some studies also suggested that ox-LDL can directly enhance platelet aggregation and thromboxane A2 release (21,22), possibly increasing the risk of thrombotic events. Increased oxidative stress and lipoprotein oxidation have been linked to atherosclerotic diseases including coronary artery disease (23). It has been shown that there is a positive relationship between ox-LDL and cardiovascular mortality (24).

On the other hand, the role of exercise intensity in circulating ox-LDL is not clearly understood in obesity and it is not well known which exercise intensity is needed to ox-LDL reductions in response to endurance training. The results of the present study indicated that ox-LDL concentration was decreased only after HIE (75-80% HRR). Previously, Cornelissen et al. (2009) indicated that ox-LDL concentration is reduces after 10 weeks endurance exercise with 66% of HRR in old sedentary men and women but it had not significant changes after 10 weeks endurance exercise with 33% of HRR (13). Furthermore, 12-week healthy-life exercise program with 50-70% of HRR has been reported to decrease ox-LDL concentrations in obese elderly women (14). However, Afzalpour et al. (2008) reported that serum ox-LDL was not affected by 8 weeks of moderate (60-65% HRR) and vigorous (80-85% HRR) aerobic exercise in healthy subjects (25). These discrepant results may be attributed to differences in study population and exercise training duration. Previous studies indicated that regular moderate exercise suppresses ox-LDL promoted platelet activation by enhancing nitric

oxide (NO) release (as an antioxidant) of platelets (26). It may be that NO increases after only HIE.

Studies show that exercise induced decrease in LDL is associated with the decrease in ox-LDL (27). The results indicated that ox-LDL was associated with LDL after HIE (r = 0.82; P= 0.01) however no significant relationship was observed after MIE (r = 0.08; P= 0.8).

Aerobic exercise is believed to reduce the risk of cardiovascular disease partially through increasing serum levels of HDL and decreasing serum levels of TC, TG and LDL. Improving in blood lipid profile is related to the amount and intensity of the exercise (28,29). O'Donovan et al. (2005) suggested that changes in coronary heart disease risk factors are influenced by exercise intensity and high-intensity training is more effective in improving cardiorespiratory fitness than moderate-intensity training of equal energy cost (29).

Durstine et al. (2001) reported that weekly energy expenditure greater than 1200 kcal/wk was frequently associated with elevations in HDL level (30). HIE induced approximately 2000 kcal/wk, thus it seems that these training has sufficient stimuli to increase HDL levels, however, MIE induced approximately 1000 kcal/wk. Despres (1994) suggested that changes in TG and HDL concentrations may dependent on substantial reductions in body fat mass (31). The decreasing body fat mass and BMI after 12 weeks MIE and HIE may respectful for decrease of TG and increase of the HDL respectively.

5. Conclusion
The results suggest that although lipid profile of obese men improves after regular moderate and high-intensity exercise, ox-LDL levels decreases only after regular high-intensity exercise.

6. Acknowledgment

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