The rehabilitation training and antioxidant status in patients with myocardial infarction

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Abstract

Introduction: Myocardial infarction (MI) is associated with increased oxidative stress and reduced antioxidants. Some studies have shown that exercise training increases the serum level antioxidants. Therefore, this study investigated the effect of rehabilitation training on antioxidant status in patients with myocardial infarction.

Materials and methods: In this study, 20 patients with myocardial infarction were selected and randomly assigned to training group (n=10) or control group (n=10). Training program included 3 sessions of concurrent training per week for eight consecutive weeks. To measure the values of malondialdehyde (MDA), protein carbonylation (PC) and total antioxidant capacity (TAC), 10 ml of blood were taken pre- and post-training in each patient. The t-test was used to analyze the data. $P<0.05$ was considered significant in all tests.

Results: The data showed that 8 weeks of rehabilitation training significantly reduces MDA (2.37±0.59 µM and 3.74±1.34 µM in training and control groups, respectively; P=0.000) and PC (9.15±1.77 nmol/mg protein and 11.48±1.60 nmol/mg protein in training and control groups, respectively; P=0.006) levels and significantly increases TAC (10.09±1.70 U/ml and 8.34±1.56 U/ml in training and control groups, respectively; P=0.031).

Conclusion: Since the findings of the present study show a reduction in oxidative stress markers (MDA, PC) and an increase in total antioxidants capacity, it seems that eight weeks of concurrent training may improve the antioxidant capacity in patients after myocardial infarction.

Keywords: Rehabilitation, Oxidants, Antioxidants, Myocardial infarction

Introduction

Heart failure due to myocardial infarction is associated with increased oxidative stress (1). Lipid peroxidation is a chain of reactions that occurs during oxidative stress and causes the formation of active compounds such as propanediol and 4-Hydroxynonenal leading to cellular damage (2). Measurement of malondialdehyde (MDA) values in various biological systems can be utilized as an important indicator of lipid peroxidation in vitro and in vivo studies (3). Due to abundance in biological systems as well as their role in most intracellular functional processes, proteins are one of the main objectives of reactive oxygen species. Protein carbonylation (PC) which is the most common and known type of protein oxidation is an irreversible deformation caused by oxidative stress, leading to the loss of function of the protein and change in its biological activity. Therefore,

increasing in values of protein carbonyl has severe destructive effects on cellular and organ functions (4). However, the poisoning effects caused by excessive amounts of Reactive oxygen species (ROS) could be preventable by antioxidant defense system which provides a healthy cellular environment. The total antioxidant capacity (TAC) is a rough estimation of the ability of different antioxidants in body which interact with each other. It seems that the measurement of total antioxidant capacity is better than measuring the separate antioxidants, because of complex interactions in the body between oxidants and antioxidants and TAC shows the net result of these interactions (5).

In some studies, increased antioxidant capacity of androgens by regular exercise training has been reported. In patients with chronic heart failure (CHF), it has been shown that exercise training increases the activity of catalase and decreases lipid peroxidation in skeletal muscles (6). The inconsistent findings have been reported regarding the impact of physical activity on ROS and antioxidants after myocardial infarction. Yamashita et al (7) and Brown et al (8) reported that exercise training increases the amount of myocardial Superoxide dismutase (SOD) and improve the recovery after ischemia-revascularization damage. Nevertheless, others have reported that exercise training protects the heart, without changing the content of myocardial SOD (9).

As stated, the exercise training has a significant effect on antioxidant system. But there is no sufficient information regarding the role of exercise training on antioxidant system in patients with myocardial infarction. Therefore, the present study has been designed to investigate effect of exercise training on antioxidant status of patients with myocardial infarction during the rehabilitation period.

Materials and methods

Subjects: Twenty male patients presenting with myocardial infarction in Shahid Modarres hospital who were stable and consented to follow up were selected and randomly assigned to training (n=10) and control (n=10) groups (table 1). Exclusion criteria were occurrence of unstable angina, decompensated heart failure, ventricular arrhythmias, orthopedic problems, cigarette smoking and alcohol consumption during the study. This study was carried out under supervision of Shahid Modarres hospital's ethics committee in Tehran.

Training program: Eight weeks of concurrent training protocol consisting three sessions per week was performed in the training group. Subjects began to warm up by walking slowly for 5 minutes and then resistance training using the rubber band and weights (free weights and machines) with an intensity of equal or less than 13 RPE (Borg Rating of Perceived Exertion), (less than 30% of one repetition maximum, 5 to 10 reps, 1 to 3 sets), in order to improve muscular endurance. Duration of resistance exercise was 10 to 15 minutes in each session. The intensity of resistance training was gradually extended to RPE <15 (50 to 60% of one repetition maximum, 8 to 15 repetitions, 1 to 3 sets) of the individuals. Then, the subjects exercised with an intensity equal to 50% of VO2 peak (12 to 13 RPE, 60 percent of maximum heart rate) by an ergometer bicycle and treadmill. The intensity of aerobic training gradually increased to 80% of VO2peak (15 to 16 RPE, 90 percent of maximum heart rate). Then, the subjects started to cool down for 5 minutes (10).

Blood Sampling: Thirty minutes before starting the first training session, and 24 hours after the last training session blood samples were taken. At each sampling time, 10 mls of blood were taken from the brachial vein of subjects. The chemical colorimetric method and malondialdehyde

assay kit, product of Germany's ZellBio Company (within-test coefficient variation of 4.2 and sensitivity of 0.1 μM), were used for MDA assay, and chemical colorimetric method and TAC assay kit, product of Germany's ZellBio Company (within-test coefficient of variation of 5.4 and sensitivity of 0.1 U/Ml), were used to measure the TAC. Additionally, commercial ELISA and PC assay kits, the product of China's SunLong Company (within-test coefficient variation of 6.1 and sensitivity of 1 nmol/ml), were used to assay the PC.

Statistical analysis

The SPSS (version 18, SPSS Inc., Chicago, IL) software was used for data analysis. The statistical Kolmogorov-Smirnov method was used to check the normality of the data. Then, independent t-test was used to compare the initial values (pre-test) of the measured factors of the two groups. The dependent and independent t-tests were used to investigate within-group and between-group differences (post-test) respectively. The significance level in all tests was considered to be $P<0.05$.

Results

The research data analysis showed that 8 weeks of concurrent training decreases MDA and the PC ($P=0.009$ and $P=0.006$ respectively) and increases the TAC levels ($P=0.031$) in myocardial infarction patients (Table 2).

Table 1. Demographic data of myocardial infarction patients in training and control subjects.

Variable	Training group	Control group
Age (year)	57.3 ± 5.56	58.4 ± 5.44
Height (cm)	172.2 ± 5.2	173.4 ± 5.57
Weight (kg)	76.9 ± 8.1	78.1 ± 7.2
Body mass index (Kg/m^2)	25.9 ± 1.4	26.1 ± 1.6

Data are shown as Mean ± SD.

Table 2. Mean and standard deviation of MDA, PC and TAC levels.

	Training group		Control group	
Variable	Pre-test	Post-test	Pre-test	Post-test
MDA(μM)	3.44±0.86	2.37±0.59	3.63±1.76	3.74±1.34
PC (nmol/mg protein)	12.35±1.05	9.15±1.77	11.87±2.91	11.48±1.60
TAC(U/ml)	8.32±1.35	10.09±1.70	8.18±1.34	8.34±1.56

Data are shown as Mean ± SD. MDA, malondialdehyde. PC, Protein carbonylation. TAC, total antioxidant capacity.

Discussion

This study revealed that 8 weeks of concurrent training decreases MDA and PC (oxidative stress markers) and increases the TAC levels in patients with myocardial infarction (Table 2). Farhat et al. indicated that 6 weeks of running on treadmill reduces the production of free OH radicals (11). Yoshida et al. also observed that 27 sessions of concurrent training (5 days per week) in patients with cardiovascular diseases reduced oxidative stress through increasing antioxidant capacity (7). Mlakar and his colleagues investigated the short-term effect of cardiac rehabilitation on men's oxidative stress after myocardial infarction. Their findings showed that two-weeks of exercise training has a significant effect on antioxidant increment and oxidant reduction in MI patients (12). Contrary to the above findings, some studies have demonstrated lack of effect of training on oxidative stress and antioxidant capacity in these patients (13). These differences

could be partly due to the disease status during the study, subjects' characteristics (such as age, gender and disease stage), the exercise protocol and measured biomarkers. It should be noted that the biomarkers in many cases do not have the same reaction; so, unsurprisingly different studies which measure various biomarkers, obtain different findings. Therefore, part of the lack of effectiveness on some findings might be due to shortage of measured biomarkers.

It has been shown that exercise training increases the production of ROS that can be seen in certain diseases (6-8). What is unclear is whether the increased production of ROS caused by exercise in patients has positive or negative effects on them. The idea that ROS production caused by exercise can be a useful phenomenon, derives from a series of recent studies in which antioxidant supplements consumption to relieve exercise-induced oxidative stress led to a sharp decline in positive adaptations of mitochondrial biogenesis and antioxidant defenses after a period of aerobic training in rodents (14) and human (15). Although the use of antioxidant supplements for oxidative stress reduction and health improvement has brought some successes, the up-regulation of androgens' antioxidant capacity by regular exercise training has made a desirable compatibility in most studies (16).

Although most of these findings have been obtained from healthy subjects, it is certainly possible that the increased oxidative stress in response to exercise training in patients can be an important signaling mechanism in up-regulation of antioxidant defenses, which in turn could have a useful effect on that disease (16).

One of the limitations in the present study was the limited sample size. Another limitation of the present study was the lack of control on medications of patients during the study because the research subjects were not thoroughly at the disposal of researchers (after 24 hours). Finally, the other limitation of this study was the lack of dietary control over the subjects. Therefore, it is recommended that the subjects' nutritional status and medications be controlled in the future studies in order to achieve more accurate results.

Conclusion

Exercise training up-regulates antioxidant defense mechanisms in different tissues. The existing studies show the important role of antioxidant capacity in pathogenesis of cardiovascular diseases. Exercise training may prevent the reoccurrence of cardiovascular diseases by increasing plasma antioxidant capacity and help treat them. The present study findings also demonstrated that exercise training reduces oxidative stress and increases antioxidant capacity of MI patients. So, it seems that the exercise training has a positive effect on antioxidant system of MI patient’s though, more studies are needed.

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References

1. Heymes C, Bendall JK, Ratajczak P, Cave AC, Samuel JL, Hasenfuss G, Shah AM. Increased myocardial NADPH oxidase activity in human heart failure. J Am Coll Cardiol. 2003; 41(12): 2164-71.
2. Michiels C, Remacle J. Cytotoxicity of linoleic acid peroxide, malondialdehyde and 4-hydroxynonenal towards human fibroblasts. Toxicology. 1991; 66(2): 225-34.
3. Zhang Y, Chen SY, Hsu T, Santella RM. Immunohistochemical detection of malondialdehyde-DNA adducts in

human oral mucosa cells. Carcinogenesis. 2002; 23(1): 207-11.
4. Sun Y. Myocardial repair/remodelling following infarction: roles of local factors. Cardiovasc Res. 2009; 81(3): 482–90.
5. Dennis KE, Hill S, Rose KL, Sampson UK, Hill MF. Augmented cardiac formation of oxidatively-induced carbonylated proteins accompanies the increased functional severity of post-myocardial infarction heart failure in the setting of type 1 diabetes mellitus. Cardiovasc Pathol. 2013; 22(6): 473-80.
6. Linke A, Adams V, Schulze PC, Erbs S, Gielen S, Fiehn E, et al. Antioxidative effects of exercise training in patients with chronic heart failure: increase in radical scavenger enzyme activity in skeletal muscle. Circulation. 2005; 111(14):1763–70.
7. Yamashita N, Hoshida S, Otsu K, Asahi M, Kuzuya T, Hori M. Exercise provides direct biphasic cardioprotection via manganese superoxide dismutase activation. J Exp Med. 1999; 189(11): 1699-706.
8. Brown DA, Jew KN, Sparagna GC, Musch TI, Moore RL. Exercise training preserves coronary flow and reduces infarct size after ischemia-reperfusion in rat heart. J Appl Physiol. 2003; 95(6): 2510-18.
9. Brown DA, Lynch JM, Armstrong CJ, Caruso NM, Ehlers LB, Johnson MS, et al. Susceptibility of the heart to ischaemia reperfusion injury and exercise-induced cardioprotection are sex-dependent in the rat. J Physiol. 2005; 564(Pt 2): 619-30.
10. Fletcher GF, Ades PA, Kligfield P, Arena R, Balady GJ, Bittner VA, et al. Heart Association Exercise Standards for Testing and Training: A Scientific Statement from the American. Circulation. 2013; 128(8): 873-934.
11. Farhat F, Dupas J, Amérand A, Goanvec C, Feray A, Simon B, et al. Effect of exercise training on oxidative stress and mitochondrial function in rat heart and gastrocnemius muscle Redox Rep. 2015; 20(2):60-68.
12. Mlakar P, Salobir B, Cobo M, Prezelj M, Tercelj M, Sabovic M. Influence of Short-Term Cardiac Rehabilitation on Oxidative Stress in Men After Myocardial Infarction Depends Upon Smoking Status. J Cardiopulm Rehabil Prev. 2013; 33(6):401-5.
13. Rall LC, Roubenoff R, Meydani SN, Han SN, Meydani M. Urinary 8-hydroxy-2'-deoxyguanosine (8-OHdG) as a marker of oxidative stress in rheumatoid arthritis and aging: effect of progressive resistance training. J Nutr Biochem. 2000; 11(11-12): 581-4.
14. Gomez-Cabrera MC, Borras C, Pallardo FV, Sastre J, Ji LL, Vina J. Decreasing xanthine oxidase-mediated oxidative stress prevents useful cellular adaptations to exercise in rats. J Physiol. 2005; 567(Pt 1):113–20.
15. Strobel NA, Peake JM, Matsumoto A, Marsh SA, Coombes JS, Wadley GD. Antioxidant supplementation reduces skeletal muscle mitochondrial biogenesis. Med Sci Sports Exerc. 2011; 43(6):1017–24.
16. Radak Z, Chung HY, Goto S. Systemic adaptation to oxidative challenge induced by regular exercise. Free Radic Biol Med. 2008b; 44(2):153–9.