

Three-Weeks Moderate Aerobic Exercise Increase Production of Endogenous Antioxidant Enzyme and Lowering Oxidative Stress Level among Sedentary Men

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Abstract

During exercise, there will be an increase of free radical due to the elevation of oxygen consumption to fulfill the increasing demand for energy. This free radical could produce by muscle and other tissue, especially from the leakage of mitochondria respiratory chain reaction. Moderate exercise training may provide adequate protection against exercise-induced oxidative stress by elevating the antioxidant level and healthier mitochondria that will produce less free radicals. This research will investigate the change of baseline level of MDA and superoxide dismutase (SOD) and also MDA and SOD level after a single bout of moderate exercise before and after three weeks of intervention. Seven sedentary men with age average 17.2 ± 0.2 years recruited for this study. They were meet the criteria of healthy sedentary men. Moderate aerobic exercise of 30 minutes running at 11 – 13 RPE Borg Scale, three times a week for 3 weeks in a row was applied to the subject. MDA and SOD examination was done by chromatographic assays for total plasma level. The collected data the analyzed using dependent student t-test, data was normally distributed. The result of this research found a significant elevation of SOD production ($p < 0.01$) after a single bout moderate exercise after three week training (19.98 ± 15.52 vs 40.43 ± 19.64 mg/ml) and significant depression of MDA production ($p > 0.05$) after training program (0.79 ± 0.62 vs 1.97 ± 0.94 nmol/ml). There is no significant change in post-exercise MDA and SOD level before and after the training program. Initial fitness status, food intake, lifestyle could affect baseline level of MDA and SOD before and after exercise.

Keywords : *malondialdehyde (MDA), superoxide dismutase (SOD), moderate aerobic exercise, oxidative stress*

Introduction

Free radical was produced as a consequence of oxygen metabolism in an aerobic organism. An estimated 2% of the oxygen consumed (VO_2) during normal mitochondrial metabolism in aerobic organisms may be converted to radicals and their products.¹ There will be two to three-fold increase in free radical concentrations of muscle and liver following exercise to exhaustion.² Skeletal muscle clearly produces a variety of ROS and RNS in controlled and regulated processes, both at rest and during contractile activity. This may play some role in muscle damage caused by extensive muscular activity.^{3,4} Higher uptake of oxygen during exercise than at rest, because of the increasing energy demand in many tissues, is related to the production of free-radicals during mitochondrial

respiration.^{4,5} Other sources of free radicals, as well as an increase in lactate formation, as happens in exhaustive exercise, have been proposed to contribute significantly to the overproduction of free-radicals.^{6,7}

Exhausting physical exercise increases lipid peroxidation and causes important muscle damages.⁸ This will increase malondialdehyde (MDA) blood level, a marker of lipid peroxidation due to oxidative stress, in lymphocytes after a single bout of intense exercise.⁹ Lipid peroxidation causes damage on cell membrane, therefore, these markers may also be the indirect markers of oxidative stress.¹⁰ Researchers determined that oxidative stress caused more susceptible to major changes in the body during physical activity in untrained persons as opposed to trained ones.¹¹ Sufficient intensity of training has been shown to stimulate activities of antioxidant enzymes as a defensive mechanism of the cell under oxidative stress. All organisms have developed an antioxidant defense system to counter oxygen and nitrogen radical production. The antioxidant can be classified as enzymatic or non-enzymatic antioxidants. The enzymatic could minimize oxidative damage by catalyzing chemical reactions to detoxify free-radicals in cells and tissues and can be synthesized due to the redox-activation of specific genes.¹²

In trained individuals, regular and moderate exercise training may provide adequate protection against exercise-induced oxidative stress.¹⁰ It has been shown that antioxidant levels may differ according to the intensity, type, and length of the exercises.¹³ It is considered that a decrease in total antioxidant levels may be associated with the utilization of antioxidants during the neutralization process of the oxidants. But, some research found that decrease was not statistically significant.¹⁰ Regular exercise training results in an accumulation of stimulus on the antioxidant production as an adaptive response. These adaptations include limiting oxidative stress during exercise by increased antioxidant systems to buffer free oxygen radicals production or by having healthier mitochondria that produce less oxygen radicals when inactive.¹⁴

Baseline MDA level at rest will reflect the ability of the mitochondria to produce less oxygen radicals when inactive. By measuring the change in the baseline level of MDA and antioxidant enzyme after a period of regular exercise, we could reveal the effect of exercise in lowering the production of oxygen radicals and increasing antioxidant enzyme production at rest. Comparing MDA level after a single bout of exercise before and after three weeks of intervention could reveal the effectiveness of the antioxidant system in buffering free radicals. This research will investigate the change of baseline level of MDA and superoxide dismutase (SOD) after three weeks of regular moderate exercise and comparing the MDA and SOD level after a single bout of moderate exercise before and after three weeks of intervention. Based on previous studies, we might find depression of MDA baseline blood-

level and elevation of SOD baseline blood-level after three week training program. After three weeks of training program, there will be also possible to find elevation of SOD and depression of MDA post-exercise blood level compared to the before training program blood level.

Material and Method

The subject of this study consist of seven sedentary men with age average of 17.2 ± 0.2 years. They choose from medical students who were willing to follow this study. The sample meets the inclusion criteria of sedentary according to the inactive criteria on the IPAQ - Short Form assessment. The moderate aerobic exercise given is 30 minutes running at 11 - 13 RPE Borg Scale, three times a week (Monday, Wednesday and Friday) for 3 weeks in a row. Samples did not allow to do exercise other than this treatment but allowed to consume food as usual. MDA examination was done by chromatographic assays method for total MDA plasma,¹⁵ while SOD examination was done by Western blots method.¹⁶ Venous blood samples were obtain before and after exercise in the first and the third weeks. The collected data then analyzed using student t-test as long the data was normal.

Result

This study showed a significant difference of baseline level of MDA and SOD before and after three week of intervention, respectively 8.16 ± 0.55 vs 8.55 ± 0.67 nmol/ml and 40.43 ± 16.97 vs 29.11 ± 19.85 mg/ml (Table 1). Blood level of MDA and SOD after a single bout of moderate aerobic exercise was found not significant ($p > 0.05$) before and after three week of intervention, 7.37 ± 0.77 vs 6.58 ± 0.71 nmol/ml and 57.41 ± 13.55 vs 69.54 ± 14.91 mg/ml (Figure 1). Since the baseline level of MDA and SOD were different significantly, then we evaluate the depression of MDA level and elevation of SOD level after a single bout of exercise before and after three weeks of intervention. The depression of MDA level were 0.79 ± 0.62 vs 1.97 ± 0.94 nmol/ml and the elevation of SOD level were 16.98 ± 15.52 vs 40.43 ± 19.64 mg/ml. These difference were found statistically significant ($p < 0.05$) (Figure 2). Relative change of these parameters was presented in percentage of previous value (Figure 3).

Discussion

In this study, we did not control the food intake that was found affecting oxidative status during exercising (9). Initial fitness status could also affect the baseline level of SOD and MDA.¹⁷ The baseline data of MDA and SOD before and after a period of moderate aerobic exercise could be affected by those variables, including the body

mass index.^{18,19} Lifestyle, physical activity was found to affect the oxidative and antioxidant level in middle age healthy subject.²⁰ The sample was recruited from the same grade in the university so we could control the effect of age in the antioxidant level and oxidative status and all the subject were male students.^{21,22} Analyzing the elevation and depression of SOD and MDA level before and after a period of training, we could reveal a significant founding. This result was similar to others that found the elevation of antioxidant level and capacity after a period of training in sedentary men. This research found elevation of SOD almost two and half time after three weeks of moderate aerobic training compared to almost twice in other research.⁵ This difference could be due to the age of the subject, the subject of this research was younger (17.2 ± 0.2 years) compared to other research (23.0 ± 0.41 years).⁵

The results of this study indicate that moderate-intensity aerobic exercise could improve the body's ability to produce SOD as an endogenous antioxidant. Increased ability to produce SOD will provide protection against cell damage due to oxidative stress that appears during exercise. It is consistent with other research.^{5,10,23} This finding also supports regular moderate physical exercise in a clinical setting. It has been proven to be a natural antioxidant and anti-inflammatory that prevent the evolution of diabetes and its serious complications²⁴⁻²⁶ and also heart failure.²⁷ It is also beneficial for people with Down syndrome²⁸ and the aging process.^{14,29} Another interesting feature of this study was a decrease in basal levels of SOD in the third week not followed by changes in MDA basal levels. The basal level of SOD in the first week was $40.43 \pm 16.97\%$ while in the third week the basal level of SOD became $29.11 \pm 19.85\%$. In other words, in this study indicated a decrease in SOD basal level by 25%. This result will have clinical implication which suggest that exercise training prevents aging-induced hepatic oxidative damage, especially in the proteins.³⁰ The limitation of this study was firstly we did not control the food intake during the study. This could affect the baseline data of MDA and SOD. Secondly, we did not control other possible confounding variables such as initial physical fitness level and subject lifestyle.

Conclusion

Based on the results of this study, it concluded that moderate-intensity aerobic exercise could increase the body's ability to produce endogenous antioxidants such as SOD. This enhancement capability, adds to the protective effect against oxidative stress that occurs due to exercise or other causes. Other factors such as age, sex, body mass index, initial fitness status, lifestyle should be considered during the assessment of oxidative stress and antioxidant level.

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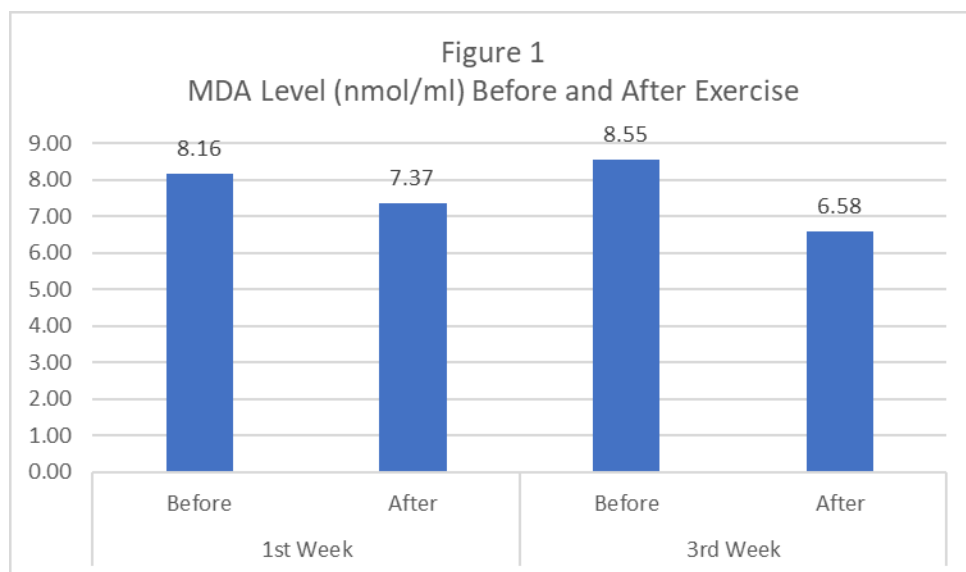
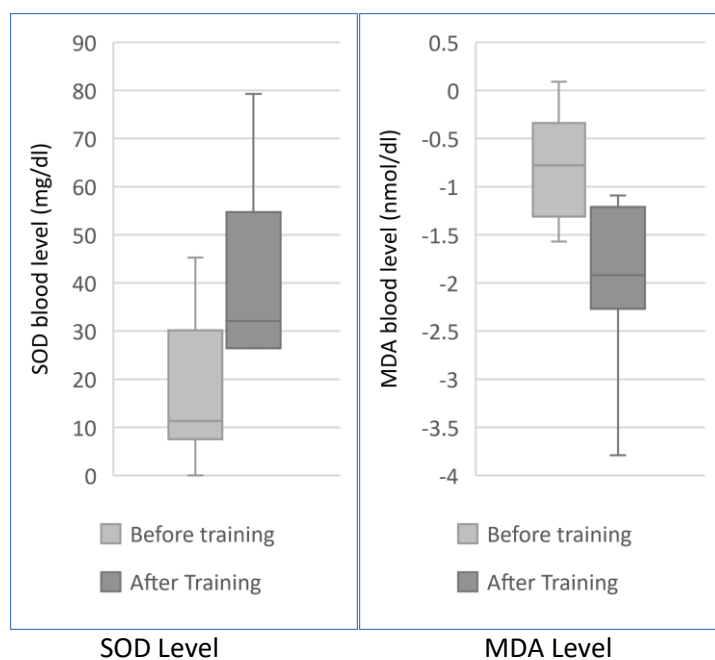


Figure 2

Elevation of SOD after a single bout of moderate exercise.



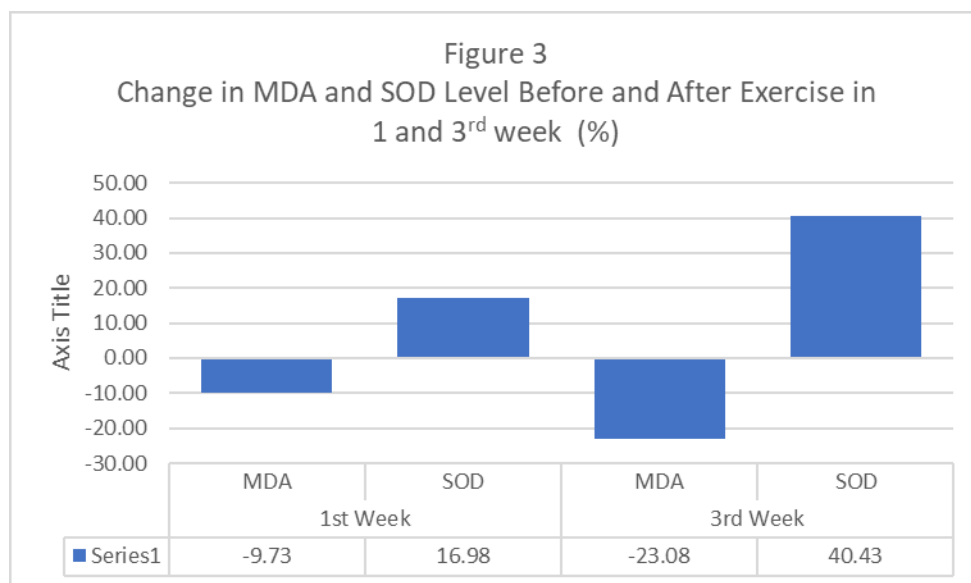


Table 1
MDA and SOD blood level after a single bout of moderate aerobic exercise in 1st and 3rd week

Week	1st week				3rd week			
Parameter	MDA		SOD		MDA		SOD	
Pre/Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	8.28	6.71	39.62	69.81	8.28	6.97	37.74	64.15
2	7.53	6.23	60.38	75.47	7.97	6.05	49.06	81.13
3	9.02	7.71	13.21	58.49	9.58	5.79	5.66	84.91
4	8.62	8.28	26.42	37.74	9.41	7.19	7.55	62.26
5	8.32	7.97	35.85	45.28	8.14	6.93	15.09	47.17
6	7.75	7.84	50.94	50.94	7.97	5.70	54.72	86.79
7	7.62	6.84	56.60	64.15	8.49	7.40	33.96	60.38
Average	8.16	7.37	40.43	57.41	8.55	6.58	29.11	69.54
SD	0.55	0.77	16.97	13.55	0.67	0.71	19.85	14.91