ORIGINAL ARTICLE

Bali Medical Journal (*Bali Med J*) 2019, Volume 8, Number 3: 738-742
P-ISSN.2089-1180, E-ISSN.2302-2914

Published by DiscoverSys

Three-weeks moderate aerobic exercise in increasing production of endogenous antioxidant enzyme and lowering oxidative stress level among sedentary men

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ABSTRACT

Background: 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.

Methods: 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 three 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 were analyzed using dependent student t-test. Data were normally distributed.

Results: 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).

Conclusion: 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: malondialdehide (MDA), superoxide dismutase (SOD), moderate aerobic exercise, oxidative stress

Cite This Article: Griadhi, I.P.A., Mahadewa, T.G.B., Widyadharma, I.P.E. 2019. Three-weeks moderate aerobic exercise in increasing production of endogenous antioxidant enzyme and lowering oxidative stress level among sedentary men. *Bali Medical Journal* 8(3): 738-742. DOI:10.15562/bmj.v8i3.1535

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Received: 2019-06-19
Accepted: 2019-11-24
Published: 2019-12-01

INTRODUCTION

Free radical was produced as a consequence of aerobic cell oxygen metabolism. An estimated 2% of the oxygen consumed (VO2) 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 produces a variety of ROS and RNS in controlled and regulated processes, both at rest and during contractile activity. It 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 activity increases lipid peroxidation and causes significant muscle damages.[8] It 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 the 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 the decrease was not statistically significant.[10] Regular exercise training results in an accumulation of stimulus on 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 fewer oxygen radicals when inactive.[14]

Baseline MDA level at rest will reflect the ability of the mitochondria to produce fewer 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 weeks training program. After the program, there will be possible to find elevation of SOD and depression of MDA post-exercise blood level compared to the before training program blood level.

MATERIAL AND METHODS

The subject of this clinical trial study consists of seven sedentary men with an average of age 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 three 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 is analyzed using student t-test as long as the data was normal.

RESULTS

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

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

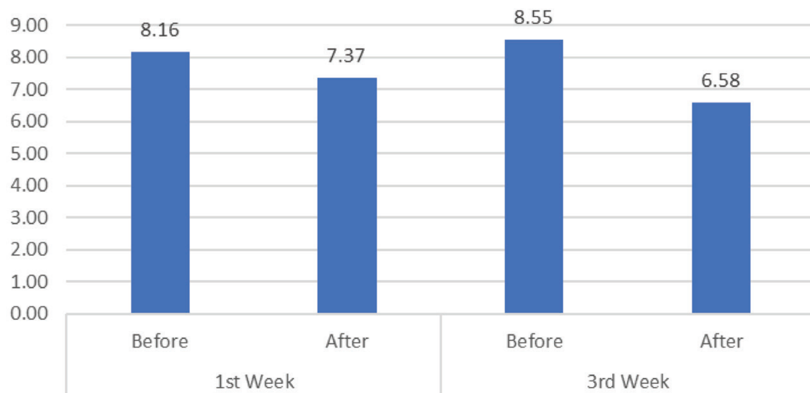

Figure 1 MDA Level (nmol/ml) before and after exercise

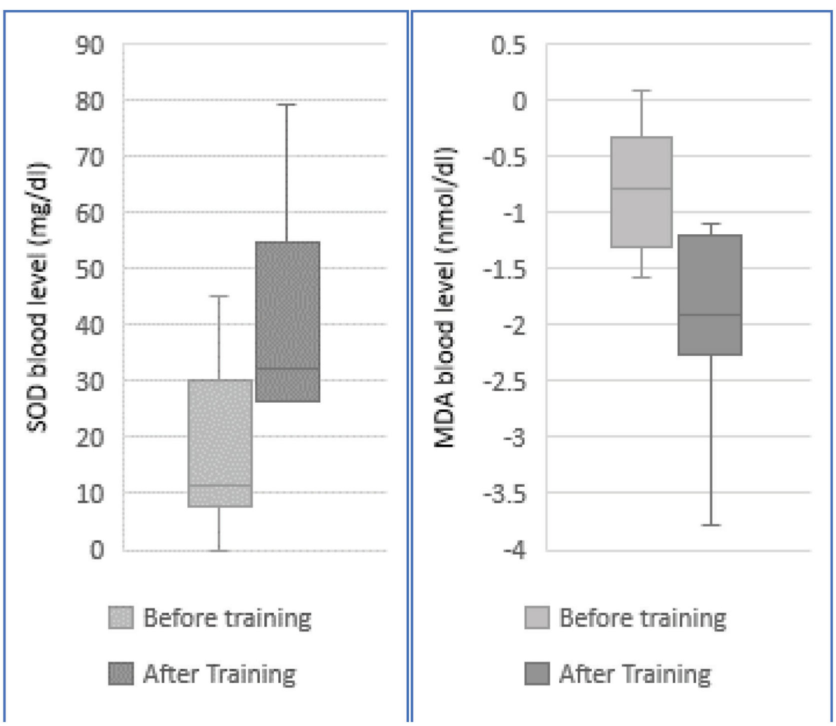

Figure 2 Elevation of SOD after a single bout of moderate exercise

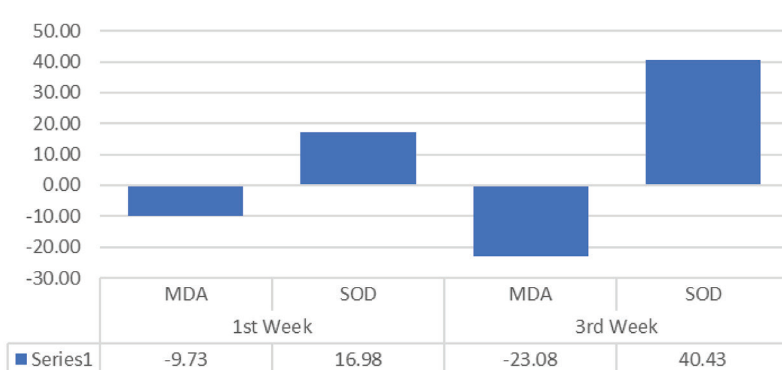

Figure 3 Change in MDA and SOD level before and after exercise in 1 and 3rd week (%)

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 program compared to 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 capability in producing SOD will protect 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 complications[24-26] and also heart failure.[27] It is also beneficial for people with Down syndrome[28] and the aging process.[14,29] Another exciting 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 + 16.97% while in the third week the basal level of SOD became 29.11 + 19.85%. In other words, in this study indicated a decrease in SOD basal level by 25%. This result will

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have clinical implication, which suggests that exercise training prevents aging-induced hepatic oxidative damage, especially in the proteins.[30] The limitation of this study was the absence of food intake controlling during the study. It 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.

ACKNOWLEDGMENTS

We are thankful to all the staff for helping with the data retrieval.

ETHICAL CLEARANCE

This study has obtained ethics approval from the Ethics Committee of Universitas Udayana prior to the study conducted.

CONFLICT OF INTEREST

We declare that there were no conflicts of interest in this study.

FUNDING

The authors are responsible for the study funding without the involvement of grant, scholarship, or any other resources of funding.

AUTHOR CONTRIBUTION

All of authors are equally contributed to the study. Study concept, design, acquisition of data: I Putu Adiartha Griadhi; analysis and interpretation of data: I Putu Adiartha Griadhi and Tjok Gde Bagus Mahadewa; drafting of the manuscript: Tjok Gde Bagus Mahadewa and I Putu Eka Widyadharma; critical revision of the manuscript for important intellectual content: I Putu Adiartha Griadhi; statistical analysis: I Putu Eka Widyadharma; guarantor: Tjok Gde Bagus Mahadewa and I Putu Eka Widyadharma.

REFERENCES

1. Sies H. Role of metabolic H2O2 generation: Redox signaling and oxidative stress. J Biol Chem 2014; 289(13):8735–41. doi: 10.1074/jbc.R113.544635.
2. Davies KJ, Quintanilha AT, Brooks GA, Packer L. Free radicals and tissue damage produced by exercise. Biochem Biophys Res Commun 1982; 107(4):1198–205.
3. Jackson MJ, Edwards RH, Symons MC. Electron spin resonance studies of intact mammalian skeletal muscle. Biochim Biophys Acta 1985; 847(2):185–90.
4. Jackson MJ, Pye D, Palomero J. The production of reactive oxygen and nitrogen species by skeletal muscle. J Appl Physiol 2007; 102(4):1664–70. doi: 10.1152/japplphysiol.01102.2006.
5. Berzosa C, Cebrián I, Fuentes-Broto L, Gómez-Trullén E, Piedrafita E, Martínez-Ballarín E et al. Acute exercise increases plasma total antioxidant status and antioxidant enzyme activities in untrained men. J Biomed Biotechnol 2011; 2011:540458. doi: 10.1155/2011/540458.
6. Powers SK, Jackson MJ. Exercise-induced oxidative stress: Cellular mechanisms and impact on muscle force production. Physiol Rev 2008; 88(4):1243–76. doi: 10.1152/physrev.00031.2007.
7. Ashton T, Rowlands CC, Jones E, Young IS, Jackson SK, Davies B et al. Electron spin resonance spectroscopic detection of oxygen-centred radicals in human serum following exhaustive exercise. Eur J Appl Physiol Occup Physiol 1998; 77(6):498–502. doi: 10.1007/s004210050366.
8. Mohamed S, Lamya N, Hamda M. Effect of Maximal Versus Supra-Maximal Exhausting Race on Lipid Peroxidation, Antioxidant Activity and Muscle-Damage Biomarkers in Long-Distance and Middle-Distance Runners. Asian J Sports Med 2016; 7(1):e27902. doi: 10.5812/asjsm.27902.
9. Yavari A, Javadi M, Mirmiran P, Bahadoran Z. Exercise-induced oxidative stress and dietary antioxidants. Asian J Sports Med 2015; 6(1):e24898. doi: 10.5812/asjsm.24898.
10. Kocabaş R, Namiduru ES, Bagçeci AM, Erenler AK, Karakoç Ö, Örkmez M et al. The acute effects of interval exercise on oxidative stress and antioxidant status in volleyball players. J Sports Med Phys Fitness 2018; 58(4):421–7. doi: 10.23736/S0022-4707.16.06720-7.
11. Stanković M, Radovanović D. Oxidative stress and physical activity. sgia 2012; 8(1):1–11. doi: 10.5550/sgia.120801.en.001S.
12. Chevion S, Moran DS, Heled Y, Shani Y, Regev G, Abbou B et al. Plasma antioxidant status and cell injury after severe physical exercise. Proc Natl Acad Sci U S A 2003; 100(9):5119–23. doi: 10.1073/pnas.0831097100.
13. Banerjee AK, Mandal A, Chanda D, Chakraborti S. Oxidant, antioxidant and physical exercise. Mol Cell Biochem 2003; 253(1-2):307–12.
14. Wiggs MP. Can endurance exercise preconditioning prevention disuse muscle atrophy? Front Physiol 2015; 6:63. doi: 10.3389/fphys.2015.00063.
15. Moselhy HF, Reid RG, Yousef S, Boyle SP. A specific, accurate, and sensitive measure of total plasma malondialdehyde by HPLC. J Lipid Res 2013; 54(3):852–8. doi: 10.1194/jlr.D032698.
16. Weydert CJ, Cullen JJ. Measurement of superoxide dismutase, catalase and glutathione peroxidase in cultured cells and tissue. Nat Protoc 2010; 5(1):51–66. doi: 10.1038/nprot.2009.197.
17. Seifi-Skishahr F, Damirchi A, Farjaminezhad M, Babaei P. Physical Training Status Determines Oxidative Stress and Redox Changes in Response to an Acute Aerobic Exercise. Biochem Res Int 2016; 2016:3757623. doi: 10.1155/2016/3757623.
18. Więcek M, Maciejczyk M, Szymura J, Wiecha S, Kantorowicz M, Szygula Z. Effect of body composition, aerobic performance and physical activity on exercise-induced oxidative stress in healthy subjects. J Sports Med Phys Fitness 2017; 57(7-8):942–52. doi: 10.23736/S0022-4707.16.06409-4.

19. Accattato F, Greco M, Pullano SA, Carè I, Fiorillo AS, Pujia A et al. Effects of acute physical exercise on oxidative stress and inflammatory status in young, sedentary obese subjects. PLoS ONE 2017; 12(6):e0178900. doi: 10.1371/journal.pone.0178900.
20. Carraro E, Schilirò T, Biorci F, Romanazzi V, Degan R, Buonocore D et al. Physical Activity, Lifestyle Factors and Oxidative Stress in Middle Age Healthy Subjects. Int J Environ Res Public Health 2018; 15(6). doi: 10.3390/ijerph15061152.
21. Ahmadian M, Dabidi Roshan V, Leicht AS. Age-related effect of aerobic exercise training on antioxidant and oxidative markers in the liver challenged by doxorubicin in rats. Free Radic Res 2018; 52(7):775–82. doi: 10.1080/10715762.2018.1470328.
22. Baghaiee B, Aliparasti MR, Almasi S, Siahkuhian M, Baradaran B. Antioxidant Expression Response to Free Radicals in Active Men and Women Fallowing to a Session Incremental Exercise; Numerical Relationship Between Antioxidants and Free Radicals. Asian J Sports Med 2016; 7(2):e29901. doi: 10.5812/asjsm.29901.
23. Done AJ, Traustadóttir T. Aerobic exercise increases resistance to oxidative stress in sedentary older middle-aged adults. A pilot study. Age (Dordr) 2016; 38(5-6):505–12. doi: 10.1007/s11357-016-9942-x.
24. Sallam N, Laher I. Exercise Modulates Oxidative Stress and Inflammation in Aging and Cardiovascular Diseases. Oxid Med Cell Longev 2016; 2016:7239639. doi: 10.1155/2016/7239639.
25. Robinson AT, Fancher IS, Sudhahar V, Bian JT, Cook MD, Mahmoud AM et al. Short-term regular aerobic exercise reduces oxidative stress produced by acute in the adipose microvasculature. Am J Physiol Heart Circ Physiol 2017; 312(5):H896-H906. doi: 10.1152/ajpheart.00684.2016.
26. Lemos ET de, Oliveira J, Pinheiro JP, Reis F. Regular physical exercise as a strategy to improve antioxidant and anti-inflammatory status: Benefits in type 2 diabetes mellitus. Oxid Med Cell Longev 2012; 2012:741545. doi: 10.1155/2012/741545.
27. Sties SW, Andreato LV, Carvalho T de, Gonzáles AI, Angarten VG, Ulbrich AZ et al. Influence of exercise on oxidative stress in patients with heart failure. Heart Fail Rev 2018; 23(2):225–35. doi: 10.1007/s10741-018-9686-z.
28. Shields N, Downs J, Haan JB de, Taylor NF, Torr J, Fernhall B et al. What effect does regular exercise have on oxidative stress in people with Down syndrome? A systematic review with meta-analyses. J Sci Med Sport 2018; 21(6):596–603. doi: 10.1016/j.jsams.2017.10.015.
29. Simioni C, Zauli G, Martelli AM, Vitale M, Sacchetti G, Gonelli A et al. Oxidative stress: Role of physical exercise and antioxidant nutraceuticals in adulthood and aging. Oncotarget 2018; 9(24):17181–98. doi: 10.18632/oncotarget.24729.
30. Okudan N, Belviranli M. Effects of exercise training on hepatic oxidative stress and antioxidant status in aged rats. Arch Physiol Biochem 2016; 122(4):180–5. doi: 10.1080/13813455.2016.1199574.