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The Effect of Aerobic Exercise on Malondialdehyde Level in Older Adults

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ABSTRACT

The aging process is a natural and physiological process that occurs in every human being. Aging involves many changes within the body, ranging from cellular interactions, hormonal and metabolic processes to the functional aspects of almost all organ systems, resulting in physical, psychological, and social declines that interact with each other. Increased oxidative stress is frequently linked to this process, which raises the production of free radicals that can harm tissue. The body produces malondialdehyde (MDA) as a end product of lipid peroxidation. High levels of MDA indicate oxidative processes in cell membranes, making MDA a marker of tissue damage due to free radicals. Aerobic exercise is said to increase antioxidant activity, thus playing a role in reducing MDA levels in the elderly. This study was conducted using a literature review method. The aim of this study was to review and compare several journals discussing the relationship between aerobic exercise and MDA levels. In conclusion, aerobic exercise has a positive effect on the aging process when performed regularly because it can reduce lipid peroxidation production and increase antioxidant defense.

Keywords : aerobic exercise; malondialdehyde level; older adults

INTRODUCTION

Aging is a complex biological process that involves the entire organ systems in the body. This process occurs gradually, leading to a decline in vital organ functions and an increased risk of many age-related chronic diseases[1]. This unavoidable phenomenon is generally measured based on chronological age, and according to the World Health Organization (WHO), the elderly show a decline in their ability to perform activities in the external environment and are chronologically defined as individuals aged 65 years and older[2,3]. The chronological age of the elderly is further classified into three categories: 65-75 years, known as young old age, marking the transition from working life to retirement; 75-85 years, referred to as advanced old age, during which organ function decline should be observed; and finally, 85 years and above, referred to as very advanced old age, requiring special attention and care[2,4].

The aging process is caused by a variety of causes, which can be classified as intrinsic and extrinsic. Telomere shortening, epigenetic changes, mitochondrial failure, oxidative stress, cellular senescence, and impaired cellular communication are examples of intrinsic factors[5]. However, extrinsic factor include air pollution, UV radiation exposure, bad diets, smoking, irregular sleep patterns, and alcohol usage. Reactive oxygen species (ROS), also referred to as free radicals, are formed as a result of both processes. The body's natural antioxidant defences are suppressed when reactive oxygen species (ROS) build up over time. This upsets the body's redox balance, which increases the risk of tissue damage through processes like lipid peroxidation, protein peroxidation, and DNA damage[1,5]. Malondialdehyde is one of the results of lipid peroxidation.

Since MDA is a reliable and stable chemical, it can be used as a biomarker to indicate the existence of oxidative stress mechanisms in the body. These processes can be found in a variety of biological samples, including blood, urine, and exhaled breath condensate (EBC)[6]. Elevated MDA levels are linked to DNA mutations, alterations in cell membrane characteristics, damage to blood vessel walls, elevated proinflammatory cytokines, and reduced cognitive function. These factors can result in chronic illnesses like cancer, neurodegenerative, pulmonary, and cardiovascular conditions[6–8]. High rates of morbidity and mortality are directly associated with aging-related diseases and the involvement of ROS. Because of this, a lot of study is being done to determine the best ways to slow down aging and strengthen antioxidant defence systems, one of which is exercise.

Exercise can lessen the body's oxidative stress, which lowers the chance of aging-related tissue damage. Regular exercise can work as an anti-aging agent by improving the body's antioxidant defence system's performance. Exercise produces reactive oxygen species (ROS), which interfere with signalling pathways to cause molecular damage and trigger adaptive reactions when under stress again[5]. Compared to elderly people in the same age range who are sedentary, physically active older persons are reported to have reduced levels of oxidative stress[9]. A study found that by raising antioxidant marker levels and lowering some oxidant indicators, regular aerobic exercise may have a beneficial effect on older persons' oxidative stress levels[10]. A other study discovered that aerobic exercise could lessen oxidative stress-induced DNA damage. This study also mentioned that regular aerobic activity with moderate intensity could increase antioxidant capacity in the body and prevent incidents of atherosclerosis disease[11]. A study using samples of middle-aged men also indicated an increase in SOD-2 gene expression and a decrease in MDA and leptin levels in the second month after regularly performing moderate aerobic exercise[12]. This literature aims to analyze the relationship between aerobic exercise and malondialdehyde levels in older adults.

METHODS

This literature review was conducted by collecting secondary data from the internet through various journal searches, journal review and articles. Google Scholar, Pubmed, Science Direct, and Springer Nature were the article databases that were searched using the terms "Aerobic exercise, Malondialdehyde, and Older Adults" with a time frame of 2014 to 2024. Selected articles were those with relationships between aerobic exercise and malondialdehyde levels in elderly or older adults. Articles regarding other types of exercise from aerobic exercise, such as resistance training or endurance training were not included for further analysis. We included some research articles related to this study, as shown in table 1.

RESULTS

Table 1. Studies examining the effects of aerobic exercise on malondialdehyde level in older adults.

Author and year of publication	Sampel	Intervention	Result	Conclusion
Bouzid, et al., 2014[13]	The study included 33 participants, whose mean age was 65.4 ± 3.4 years.	The older adults were split up into 2 groups: an active group (AG) consisting of 18 subjects and a sedentary group (SG) consisting of 15 subjects. The subjects in the active group were those who had been fit for more than two years running for at least two hours a week, for at least 10 months of the year, and who scored between 9 and 16 on the physical activity questionnaire. There were 3 components to the low-intensity aerobic exercise, (1) sessions 5–10 min of general warm-up activity, (2) aerobic exercises involving 15-20 min and (3) muscular endurance exercises 60-120 sec.	MDA (µmol/L) At rest • AG : ±0,55 • SG : ±0,58 After exercise • AG : ±0,60 • SG : ±0,80	Regular exercise may help prevent the oxidative stress response and the aging-related reduction of antioxidants.
Bouzid, et al., 2015[14]	For the primary data analysis, 50 patients with a mean age of 66.1 ± 3.8 years were included.	Three groups were formed from the participants based on their respective levels of physical fitness. There were 15 subjects in the unfit group (UG), 18 in the low physical fitness group (LFG), and 17 in the high physical fitness group (HFG). On a 5 cycle ergometer with electrical brakes, each participant underwent gradual exercise testing until they were exhausted. Following a 3-minute rest interval on the cycle ergometer, the participant began activity with a 3-minute warm-up at 30 watts (W) and 60–70 revolutions per minute of cycling. After that, until the end of the exercise testing, each group's	MDA (µmol/L) At rest • UG : ±0,55 • LFG : ±0,45 • HFG : ±0,77 After exercise • UG : ±0,67 • LFG : ±0,60 • HFG : ±0,90	In older adults, antioxidant defense can counter the aging effects with an active lifestyle. These changes in antioxidant activities have relation with level of physical fitness. A low to moderate degree of physical fitness may be a good strategy to keep antioxidant defenses functional without raising the lipid peroxidation.

		workload was adjusted every three minutes during the activity.		
Alghadir, et al., 2016[15]	In this study, 100 healthy participants (70 men and 30 women) were randomly assigned to groups. Their mean age was 69.7 ± 5.91 years, with a range of 65 to 95 years.	Two groups were randomly assigned to the subjects: an exercise group (n=50) and a control group (n=50). For 24 weeks, the participants engaged in an exercise regimen. The participant warmed up with stretches and walked 10-15 minutes. During the active phase, the subject was allowed to reach his precalculated training heart rate (THR max: 60-70% for 45–60 min) in bouts form using treadmill, bicycle, and Stair Master.	MDA (μmol/L) Baseline • EG : 15.5 ± 6.7 • CG : 4.7 ± 3.5 After 12 weeks • EG : 5.1 ± 1.8 • CG : 2.7 ± 1.7	Over the course of 24 weeks, moderate aerobic exercise significantly improves older persons' redox and inflammatory condition, which in turn improves cognitive performance.
Atashak, et al., 2017[16]	For this study, 24 healthy senior men between the ages of 55 and 80 volunteered.	Subjects randomly allocated into either training (n=12) and control (n=12) groups. Each exercise training session lasted 45–50 minutes and was preceded by 10 minutes of warm-up and 10 minutes of cool-down exercises. These exercises comprised calisthenics, stretching, and moderate walking. Then, using customized workloads set at 50–70% of 1RM, participants engaged in resistance training using five chosen exercises. Every resistance training exercise was done in 3 sets of 10-12 repetitions. The only instruction given to the subjects in the control group was to continue living their ordinary lives without engaging in any unusually demanding activities. The control group subjects were just asked to maintain their previous lifestyle and not to perform any unusual strenuous activity.	MDA (nmol/L) Baseline • TG : ± 2,70 • CG : ± 2,60 After 14 weeks • TG : ± 2,20 • CG : ± 2,55	Exercise training for 14 weeks decreases indices of oxidative stress in elderly men.
Moghadam, et al., 2018[17]	21 healthy volunteers aged 65.47±4.04 years were selected via convenience sampling.	A control group (n = 10) and an aerobic exercise group (n = 11) were randomly assigned to the participants. For 8 weeks, the exercise group's participants engaged in 3 sessions of 45–60 minutes of aerobic training at 50–70% of their maximum heart rate reserve (MHRR).	MDA (mmol/L) Baseline • EG : 12.47±4.75 • CG : 22.09±14.42 After 8 weeks	Frequent moderate-intensity aerobic exercise can enhance antioxidative capacity and lower the risk of cardiovascular disease in older women.

			• EG : 12.27±2.71 • CG : 15.97±7.45	

DISCUSSION

The purpose of this review is to analyse studies addressing the effects of aerobic exercise on malondialdehyde levels in older adults. This review focuses on the elderly because oxidative stress increases gradually during aging[5]. Aging is characterized by progressive decline in tissue and organ function, which is caused by the accumulation of endogenously and exogenously produced reactive oxygen species (ROS) inducing tissue damage[7,18]. By altering protein expression and causing DNA damage at the transcriptional and translational levels, oxidative stress can regulate the pathophysiological processes associated with aging.[19] The aging phenotype is also caused by the accumulation of oxidative damage, which shortens life expectancy by increasing the likelihood of immune system-related or age-related diseases[5]. When free radicals are present in close proximity to tissues and cells, a sequence of events is set off, which triggers several internal defensive cellular activities aimed at removing ROS. To protect itself, the organism's cells have developed a unique antioxidative defence mechanism. They control the activation of genes and enzymes and function as subcellular messengers in crucial biological signalling pathways[20]. Although there are differences in antioxidant defenses amongst individuals, the antioxidant defence system is universal. The redox imbalance has been reported that impaired in older adults due to a decrease in antioxidant capacity markers, reduction in mitochondrial density and increase in lipid peroxidation[18]. Both in adults and the elderly, physical activity reduces lipid peroxidation and strengthens antioxidant defenses. It has been shown that an active lifestyle and moderate exercise can help prevent age-related diseases like Alzheimer's disease, type II diabetes, metabolic syndrome, and cardiovascular disorders. They can also help avoid stress-oxidative diseases(21).

Five studies were included in this review, all of which involved elderly individuals without comorbidities. One study focused on elderly women, while the others included both men and women. Three studies had intervention periods ranging from 8 to 14 weeks, while two studies had single-bout interventions. The average duration of exercise across all related studies was 30-60 minutes. All studies showed a positive effect of aerobic exercise on malondialdehyde levels. In both studies by Bouzid et al. in 2014 and 2015, investigations were conducted to understand the relationship between antioxidant activity and oxidative stress markers, including malondialdehyde. These studies differed in group allocation and exercise interventions. In the 2014 study by Bouzid et al., participants were divided into two groups: an active group and a sedentary group. The active group had scores between 9 and 16 on the physical activity questionnaire, while the sedentary group scored lower than 9, which corresponds to a sedentary life style. The aim was to compare oxidative stress marker levels between those regularly engaging in physical activity and sedentary individuals, by providing aerobic exercise intervention to trigger the emergence of oxidative stress markers and observe antioxidant defense in both groups. The results showed a significant increase in MDA levels in both studied groups ($p < 0.05$), as measured through blood sampling taken 5 minutes after the end of exercise. The increased oxygen consumption due to contracting muscles causes electron leakage from mitochondria, leading to increased ROS production. This rise in ROS stimulates lipid peroxidation, resulting in various products including MDA[22]. Therefore, exercise or strenuous physical activity increases MDA levels. However, the study revealed that the group engaging in regular physical activity experienced a lower spike in MDA levels compared to the sedentary group.

Unlike the second study by Bouzid et al. in 2015, based on the findings from 2014, they aimed to understand the impact of the intensity of the intervention on antioxidant activity and oxidative stress, thus dividing the sample into three groups with different classifications and interventions. These groups were the Low Physical Fitness Level Group (LFG), which had scores between 9 and 16 on the physical activity questionnaire; the Unfit Group (UG), which had scores below 9 on the physical activity questionnaire; and the High Physical Fitness Level Group (HFG), which had scores over 16 on the physical activity questionnaire, indicating a high level of activity in one's daily life. Every three minutes, the UG and LFG groups increased their workload by 20 Watts for males and 10 Watts for women after all participants had completed the identical aerobic exercise at first. Until the end of the exercise testing, the HFG group's effort rose by 30 Watts every three minutes. The findings demonstrated that MDA levels rose in every group. The results showed that MDA levels increased across all groups compared to baseline levels. However, MDA levels were considerably lower in the UG and LFG groups than in the HFG group following exercise ($p<0.05$). MDA levels were also lower in the LFG compared to the UG ($p<0.05$). It can be concluded from this study that MDA levels are also related to the intensity of the exercise load provided, indicating that a greater workload does not necessarily result in better antioxidant activity compared to moderate or light workloads.

The two studies above demonstrate an increase in MDA levels by comparing MDA levels at rest and during recovery after a single bout of exercise. However, the other three studies utilized periods ranging from 8 to 14 weeks, comparing baseline MDA levels before intervention and after intervention. The results showed a decrease in MDA levels associated with an increase in antioxidant capacity within the body. The effects of moderate aerobic exercise on cognitive abilities and redox state biomarkers in older adults were examined in the study by Alghadir et al. The study's participants performed in an exercise designed using Karvonen's formula, with each intervention's training intensity determined by the individual's maximal and resting heart rates. The subjects warmed up by walking for 5 to 10 minutes and doing stretches. Using a treadmill, bicycle, and Stair Master, subjects were allowed to intermittently reach their precalculated training heart rate (THR max: 60 to 70% for 45–60 min) during the active phase. The results showed a significant decrease in MDA levels after participating in a 12-week supervised aerobic training program in the exercise group.

The study by Atashak et al. involved 24 participants divided into 2 groups (training and control groups). The training group participated in three non-consecutive days of a 14-week supervised progressive concurrent aerobic/resistance exercise program. The first 20 minutes of the exercise program consisted of walking and jogging alternately at a personal, regulated intensity. They next performed in weight training using five carefully chosen exercises, each with a customized burden of 50–70% of 1RM, 10–12 repetitions, and 90-second rest intervals in between sets. The study's findings demonstrated that the training group's MDA levels were lower than those of the control group. The study also showed that the positive effects of exercise training on oxidative stress depend on the characteristics of the training performed, including intensity, duration, and type of exercise, especially in older people. Few studies have been conducted thus far that compare the various forms of exercise that have a significant impact on increasing total antioxidant capacity and reducing oxidative stress biomarkers in both young and older adults. The effects of concurrent training (CT), resistance training (RT), and endurance training (ET) on oxidative stress and circulating antioxidant capacity were compared in a study by Azizbeigi et al. In the ET group (p=0.028), the RT group (p=0.025), and the CT group (p=0.047), MDA levels were reported to have considerably lowered by 32.7%, 32%, and 29.1%, respectively. However, the percentage decrease in MDA was not significantly different among the three groups, but resistance training showed the highest increase compared to the other two types of exercise in increasing total antioxidant capacity. Therefore, it can be said that, though at varying speeds, the type of training exercise causes modifications in the redox state, raises SOD activity, and lowers MDA levels[23].

The study by Moghadam et al., which aimed to examine the effects of selected aerobic training on some indicators of oxidative stress in sedentary elderly women in relation to reducing the risk of cardiovascular disease, is the only study reviewed here that included only women as participants. The only study examined here with a female participant population was that conducted by Moghadam et al. and looked at how specific aerobic exercise affected some markers of oxidative stress in older, inactive women in relation to lowering the risk of cardiovascular disease. This study used samples of elderly women, possibly due to the higher mortality rate and poorer prognosis for cardiovascular disease in women compared to men, although the incidence of CVD is higher in men than in women[24]. In contrast to previous studies, this research did not find a significant decrease in MDA levels, indicating that there was no significant reduction in MDA levels in both groups.

Similar results were found in other studies, such as the study by Griadhi et al., which found no significant change in post-exercise MDA and superoxide dismutase (SOD) levels before and after a 3-week training program in sedentary men. The baseline levels of MDA and SOD before and after exercise may be influence by a number of factors, including lifestyle choices, dietary habits, and initial fitness status[25]. Exercise can also increase the formation of reactive oxygen species (ROS), which occurs with the increased oxygen demand during physical activity. Hydroxyl radicals, in particular, stimulate lipid peroxidation, resulting in the production of MDA. To neutralize the outcomes of lipid peroxidation, the body needs to enhance its antioxidant defenses by increasing antioxidant capacity[5]. Increased total antioxidant capacity is formed through regular exercise. According to one study, aging may counteract the benefits of regular physical activity in lipid peroxidation damage and antioxidant defense. It was also reported that age-related declines in antioxidant defense in older persons may be maintained by regular physical activity[26]. Therefore, if exercise is performed over a short period of time and at high intensity, there may be an increase in ROS, which could be reflected in increased MDA levels or insignificant decreases in MDA levels due to the lack of optimal antioxidant capacity.

CONCLUSION

Although the studies included in this review yielded heterogeneous results, this literature review found that regular exercise enhances antioxidant capacity. It is well-known that increased antioxidant capacity is associated with a reduction in the incidence of age-related diseases. With these findings, older adults are recommended to engage in regular aerobic exercise for 30-60 minutes, 3 days per week, with low or moderate intensity. Future studies on this topic should focus on comparing different types, intensities, and durations of exercise to determine the most effective regimen for improving antioxidant defense and reducing lipid peroxidation in older adults, thereby enhancing quality of life and prolonging lifespan.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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