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Effects of Hatha yoga exercise on plasma malondialdehyde concentration and superoxide dismutase activity in female patients with shoulder pain

Min-Sung Ha[1)], Do-Yeon Kim[1)], Yeong-Ho Baek, PhD[1)*]

[1)] *Department of Physical Education, Pusan National University: 2 Busandaehak-ro 63 beon-gil, Geumjeong-gu, Busan, Republic of Korea*

Abstract. [Purpose] The purpose of this study was to analyze the effects of Hatha yoga exercise on plasma malondialdehyde (MDA) concentration and superoxide dismutase (SOD) activity in female patients with shoulder pain. [Subjects] Subjects comprised 20 female patients with shoulder pain. [Methods] Subjects were divided into 2 groups: a Hatha yoga exercise group (n = 10) and a control group that performed no exercise (n = 10). The subjects' body composition, plasma malondialdehyde concentrations, and superoxide dismutase activities were measured before and after a 16-week Hatha yoga exercise program. [Results] After the 16-week Hatha yoga exercise program, the exercise group had significantly lower plasma MDA concentrations than the control group. In addition, the exercise group had significantly higher plasma SOD activity than the control group. [Conclusions] Hatha yoga exercise improves flexibility, muscle tone and strength, balance, and joint function. Our findings indicate that regular and continuous yoga exercise effectively improved body composition, decrease plasma MDA concentration, and increase plasma SOD activity in female patients with shoulder pain.

Key words: Yoga, Malondialdehyde, Superoxide dismutase

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INTRODUCTION

Excessive exercise beyond an appropriate intensity or duration has negative effects on the human body[1–4] and causes an imbalance between reactive oxygen species (ROS) and antioxidant enzymes. Because of this imbalance, biological structures, membranes, and DNA are damaged, and malondialdehyde (MDA), the final product of lipid peroxidation, increases[5]. Increases in ROS and free radical levels[6, 7] accelerate aging, as indicated by a decrease in telomere length[8, 9] and contribute to the development of various diseases including cancer and genetic diseases related to gene mutations[10, 11].

Stocker et al.[12] found that when ROS are generated after high-intensity exercise, the human body activates antioxidant enzymes in response, as a protective function[13, 14], and to ensure hemostasis[15, 16]. Superoxide dismutase (SOD) is a key detoxification enzyme among the antioxidant enzymes. SOD removes ROS by catalyzing and transforming superoxide into two non-toxic substances, and is frequently monitored and measured as an indicator of oxidative stress[17–19].

Lee et al.[20] have reported that yoga exercise can be used to treat body composition and serum lipid profiles. Previous studies have shown that breathing exercises undertaken during yoga reduce the prevalence of many pathogens by decreasing free radicals. These exercises improve antioxidant responses during musculoskeletal activities in elderly subjects and pregnant women by improving the oxygen supply to various tissues with minimal exertion. In addition, Sinha et al.[21] reported that yoga exercises, performed over a period of six months, increased antioxidant enzyme concentrations in the body of healthy adult men. Another study showed that yoga exercises performed over a period of 16 weeks increased antioxidant enzyme activities, decreased lipid peroxidation, and improved stamina[22]. However, to date, no published review has evaluated the impact of yoga exercise on reactive oxygen species and antioxidant enzymes. Therefore, we investigated the effects of hatha yoga exercise on plasma malondialdehyde concentration and superoxide dismutase activity. Our subjects were females in their twenties with shoulder pain, who performed hatha yoga three times weekly for 16 weeks.

SUBJECTS AND METHODS

Ten females, in their twenties, were included in our study as the exercise group. All had shoulder pain, based on medical examination, physician interview, and physi-

*Corresponding author. Yeong-Ho Baek (E-mail: baek_korea@naver.com)

cal examination. The control group was composed of ten females in their twenties with similar shoulder pain. Body composition was measured prior to the experiment, and the Hatha yoga exercise group engaged in preliminary exercise for one week prior to beginning the yoga program to adapt. The yoga exercises consisted of a five min warm-up, 40 min of main exercise, and a five min cool down, for a total duration of 50 min (Table 2). Subjects engaged in Hatha yoga exercise three times weekly for 16 weeks. Blood was collected before and after the 16-week Hatha yoga exercise program. Changes in plasma MDA concentration and SOD activity levels were analyzed. All participants provided their written informed consent prior to participation, and ethical approval was granted by our Institutional Human Research Committee.

To analyze plasma MDA concentrations, blood was collected in EDTA-treated Vacutainer tubes (Lavender Tube) and centrifuged. The plasma supernatant was separated from the white buffy layer and refrigerated. Plasma MDA concentration analysis was conducted using a colorimetric method in a HP8452A spectrophotometer (Hi-Tech Scientific, USA) using a BIOXYTECH LPO-586 kit (Oxis Biotech, Tampa, FL, USA).

To analyze plasma SOD activity, blood was collected in EDTA-treated Vacutainer tubes (Lavender Tube) and centrifuged. The plasma supernatant was separated from the white buffy layer and refrigerated. The reagent was prepared with tetrazolium in order to measure the superoxide radical, which is generated by xanthine and xanthine oxidase using an IBL kit (IBL International, Hamburg, Germany).

All data are presented as mean ± SD, and all statistical analyses were completed using SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA). All statistical tests used an alpha level set at $p < 0.05$. Changes from baseline to the end of the intervention were determined using the paired t-test and the independent t-test.

RESULTS

All the participants characteristics and percent body fat were measured before the start and at the end of the 16-week exercise-training program. There were no significant differences in baseline demographic characteristics between the study groups (Table 1). Tables 3 and 4 show that the baseline values between the two groups were comparable for plasma MDA concentration and SOD activity. Hatha yoga exercise training resulted in a significant decrease in plasma MDA concentration ($p < 0.05$) and a significant increase in plasma SOD activity ($p < 0.05$). The control group showed an increase in plasma malondialdehyde (MDA) concentration and decrease in plasma SOD at the end of the 16 weeks.

DISCUSSION

Few studies have analyzed lipid peroxidation in human skeletal muscles following exercise. Meydani et al.[6] reported that conjugated dienes of skeletal muscle increased after running exercise (75% of maximum heart rate, 15 min, 3 times). Also, a recent study of patients with chronic obstructive pulmonary disease (COPD) and healthy subjects demonstrated that lipid peroxidation was higher in the vastus lateralis muscle (VLM) than at rest and 48 hours after performing knee extension exercises until exhaustion in the COPD subjects.

The degree of oxidation is determined by exercise type, intensity, and duration[23, 24]. Lipid peroxidation generated by active oxygen and ROS is caused by the oxidation of polyunsaturated fatty acid, which is the main ingredient of biological membranes. MDA levels are widely used as an index of lipid peroxidation.

Prolonged aerobic activities and low-intensity exercise

Table 1. Descriptive characteristics of the study participants

	Yoga exercise (n=10)	Control (n=10)
Age (yrs)	22.4 ± 2.4	22.5 ± 1.4
Height (cm)	161.0 ± 4.5	160.5 ± 6.2
Weight (kg)	50.8 ± 3.9	50.6 ± 4.7
% Body fat (%)	20.1 ± 1.3	19.3 ± 1.1

Table 2. Modified Hatha yoga exercise program

Week	Exercise (type)		Duration
1–16	Warm-up (5 min)	Neck rolls, Shoulder circles, Ankle circles, Stretching exercises	
	Main exercise (40 min)	1. Pranamasana 2. Matsyasana 3. Simhasana	2 min 2 sets
		4. Bhujangasana 5. Salabhasana 6. Ardha Matsyendrasana 7. Dhanura-asana	2 min 2 sets
		8. Vrksasana 9. Halasana 10. Matsyasana	2 min 2 sets
	Cool-down (10 min)	Savasana, Lying leg swinging, Relaxation, Nadishodhna	

Table 3. Changes in MDA after 16-week Hatha yoga exercise within each group

	Pre-test	Post-test
Yoga exercise (n=10)	4.02 ± 0.25	3.78 ± 0.27*
Control (n=10)	3.59 ± 0.20	5.43 ± 0.19*

*p < 0.05

Table 4. Changes in SOD after 16-week Hatha yoga exercise within each group

	Pre-test	Post-test
Yoga exercise (n=10)	7.58 ± 0.27	11.10 ± 0.58*
Control (n=10)	7.56 ± 0.35	6.95 ± 0.32

*p < 0.05

require more energy than being at rest, therefore the supply of oxygen to active tissues increases considerably. An increase in maximal oxygen uptake through exercise is closely related to respiratory health. Several researchers have indicated that the formation of free radicals is mainly the result of muscle damage and fatigue induced by exercise.

In the present study, a significant difference was found in the plasma MDA concentration between the two groups ($p < 0.05$). In the control group, the MDA concentration increased significantly after 16 weeks ($p < 0.05$), whereas in the exercise group, there was no significant difference during the various stages of exercise, but levels were highest immediately after exercise.

This result is consistent with that of a previous study which showed that respiration of mitochondria increased with exercise intensity. Exercise caused the production of oxygen free radicals that increased oxidative stress, causing increased tissue damage and lipid peroxidation. This was because MDA decreased after the one-off training exercise induced oxidative stress, thereby causing an increase in lipid peroxidation. Long-term aerobic training can increase the antioxidant capability of the human body, thereby helping to maintain the oxidation-reduction balance[25)].

ROS generated through exercise play an important role in damaging to oxidized fragments in main tissues, and excessive endogenous oxidants can damage to tissues through enzyme inactivation, lipid peroxidation, and DNA damage. However, antioxidant enzymes [e.g., SOD, catalase (CAT), and GSH peroxidase (GPX)] that protect the human body from oxidative damage can catalyze electron-reduction reactions of ROS. Among these, SOD is the most widely measured as an index of oxidative stress. Many studies have reported that SOD activity in skeletal muscles increases significantly after exercise. However, many studies have failed to accurately determine the exercise adaptation pattern of SOD, despite using similar animal exercise models. Powers et al.[26)] investigated the effect of intensity and duration of exercise and muscle fiber types on SOD activity in mice. An increase in SOD activity was observed in the gastrocnemius muscle of mice who had engaged in only high-intensity exercise. However, exercise adaptation was more significant in the soleus muscle, with an increase in SOD activity in response to exercise duration rather than exercise intensity.

In the present study, there was a significant difference in plasma SOD activity between the two groups ($p < 0.05$). In the control group it decreased significantly ($p < 0.05$), whereas in the exercise group it increased significantly ($p < 0.05$). This result is consistent with a previous study in which antioxidant enzyme activity increased after exercise. This also supports the results of a previous study in which a yoga exercise program that required minimum energy consumption was shown to increase antioxidant capability. The results of that study indicate that yoga exercise over a period of 12 weeks decreased plasma MDA concentration, reflecting decreased ROS levels, and increased plasma SOD activity, reflecting reduced oxidative stress. Hatha yoga exercise offers health benefits through improvement of flexibility, muscle tone and strength, balance, lung capacity, and joint function. Moreover, meditation and breathing techniques inhibit ROS generation and have a positive effect on antioxidant capacity by reducing stress hormones and indicators of muscle damage. Our findings indicate that regular and continuous modified Hatha yoga exercise would effectively improve body composition, decrease plasma MDA concentration, and increase plasma SOD activity in female patients with shoulder pain. Therefore, Hatha yoga exercise should be effective at preventing shoulder pain due to various causes in female patients with skeletal muscle pain syndrome.

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