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Original article

Investigation of thiol/disulfide balance and IMA value before and after training in elite female weightlifters

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Abstract. *Study Objectives:* Doing exercise has certain acute and chronic effects on the body. As part of the metabolic processes, the cells in our body constantly produce free radicals and reactive oxygen species (ROS) during aerobic cellular metabolism, while the antioxidant defense system tries to adapt to this condition. Any change in this balanced state in favor of ROS is considered oxidative stress. Thiol-disulfide balance is a unique, easy, and new method for determining oxidative stress. Ischemia-Modified Albumin (IMA) tissue ischemia is accepted as a new indicator specifically revealing oxidative stress. In the accessible literature in the sports sciences field, no previous studies have been found on the thiol/disulfide balance and IMA value, which have recently been discovered to be among the biomarkers of oxidative stress. Therefore, it was aimed to investigate the thiol/disulfide balance and IMA value in elite female weightlifters before and after training. *Methods:* The study group of this research was comprised of elite female weightlifters (N= 12) who participated in competitions on behalf of the Turkish National Weightlifting Team, had a training history of at least 5 years, and who were training 5 days a week and above. Oxidative stress parameters (native-thiol, total thiol, disulfide values, and calculated parameters disulfide / native-thiol, disulfide / total thiol and natural thiol / total thiol ratios) and IMA levels of these athletes were evaluated before the training (Group-I) and after the training (Group-II). *Results:* It was determined that there was no statistically significant difference between Group I and II. *Conclusion:* It can be mentioned that elite female weightlifters in the study provided metabolic adaptation to the training they performed, and the compensation of antioxidant defense was good. This was interpreted that the participants could continue to the next level of heavier training. Since there is only a limited number of studies on this subject, it is considered that the results confirm the need for more comprehensive training plans.

Keywords: Weightlifting, female, oxidative stress, thiol, disulfide, Ischemia-Modified Albumin

Introduction

Exercise can be defined as planned, structured, and repetitive physical activities of the body to achieve sportive goals. The effects of exercise on the body are acute and chronic. Acute effects are observed following a single exercise, while chronic effects are observed depending on repetitive exercise processes (1). There is an extremely complex relationship between training and oxidative stress, depending on the type, severity, and duration of the exercise. It is widely accepted that regular light training is beneficial for oxidative stress and health. Acute exercise, on the other hand, can cause increased oxidative stress, but also the endogenous antioxidant defense mechanism can be stimulated. It is also known that active and inactive skeletal muscles produce reactive oxygen and nitrogen types; however, it is not known exactly where oxidants emerge during physical activity. Many studies have shown that exercise causes oxidative stress and the anti-oxidant defense system adapts to this condition (2-6).

As a part of the metabolic processes, our body cells continuously produce free radicals and reactive oxygen species (ROS) during aerobic cellular metabolism. The main properties of these molecules are that they are ephemeral with extremely high reactivity. Oxidative stress occurs as a result of ROS activity and is normally neutralized by the complex system of antioxidant defense. In other words, oxidative stress reflects the imbalance between the production of reactive oxygen species and appropriate antioxidant defense. This negative condition, which is related to different physiopathological conditions such as aging, exercise, inflammatory, cardiovascular, and neurodegenerative diseases, and cancer, can lead to cellular and tissue damage (2,3,5).

In estimating the oxidative stress status, reactive oxygen species, and other markers of oxidative stress are measured. Thiol groups are important antioxidants and essential molecules that protect the organism against the harmful effects of reactive oxygen species. Thiol-disulfide balance is a unique, easy, and new method for determining oxidative stress (7).

Although thiol biochemistry has been a rapidly growing field in basic and Applied Biosciences in recent years, no notable colorimetric measurement method has been developed in this field, except for the one that Ellman developed in 1979 for detecting -SH groups using DTNB. Thiol-Disulfide balance, which is of vital importance, has been measured only one-sided since 1979; however, with the newly developed method, both variables can be measured separately or together, and they can be evaluated individually or as a whole (8).

Exercise can cause some metabolic and physiological changes in skeletal muscles, resulting in conditions such as ischemia. In acute ischemic cases, albumin metal binding capacity decreases for metals such as copper, nickel, and cobalt, causing IMA (Ischemia-Modified Albumin). In addition to being a proven as an early cardiac marker of myocardial ischemia, IMA is considered a new marker of tissue ischemia, particularly pointing to oxidative stress (9,10).

It was reported in previous studies that there is a difference in oxidant/antioxidant balance among athletes in different sports disciplines and that there is usually an acute and delayed increase in oxidative stress biomarkers in weightlifting training (11).

However, no previous studies were found in the accessible sports sciences literature on the thiol/disulfide balance and IMA value that are newly included in the biomarkers of oxidative stress. Therefore, it was aimed to investigate the thiol/disulfide balance and IMA values before and after training in elite female weightlifters.

Material and Method

Ethical Scope

Necessary approval for the study was gained from the Ethics Committee of Drug and Non-Medical Research of Necmettin Erbakan University Meram Faculty of Medicine, dated 06.22.2018 and numbered 1436.

Material

The study group of this research was comprised of elite female weightlifters (N= 12) who participated in competitions on behalf of the Turkish National Weightlifting Team, had a training history of at least 5 years, and who were training 5 days a week and above. Blood samples of these athletes taken before and after the training were recorded and stored under −20°C until the time of analysis.

The necessary materials and training mechanisms for testing and measurements were prepared in the gym where the test would be performed. The bloodletting (from the right antecubital vein) was conducted by a specialist nurse from the Konya Private Derman Laboratory on the athletes before (Group-I) and after (Group-II) the training using 10 cc biochemistry tubes, and serums were obtained after being centrifuged at 3000 rpm for 10 minutes. The resulting samples were stored at −20°C and taken to the laboratory, where tests would be conducted, in a cold chain with Styrofoam containing dry ice.

Training Program

Before the research, initially, interviews were conducted with the officials from the Turkish Olympic Preparation Center, coaches and athletes included in the research, and certain information was given about the purpose and significance of the research. Based on the interviews with coaches, the content was determined for the static clean and jerk and static snatch that the athletes will apply for maximum strength development as well as the general strength movements for weightlifting sport as shown below. The training was limited to 90 minutes.

Training program;

10 min warm-up exercises,

20 min static snatch 6 sets of 2 reps with the %90 weight, 1 set of 1 rep with the maximal weight,

20 min static clean and jerk 6 sets of 2 reps of shouldering and 1 lowering with 90 % weight, 1 set of 1 rep with maximal weight,

15 min front squat 6 sets of 2 reps with 90 % weight (of the maximal weight),

10 min static dropping moves from the training platform 4 sets of 8 reps with 80 % weight,

10 min snatch dropping 4 sets of 8 reps with 60 % weight (of the static snatch),

5 min stretching exercise.

Thiol Disulfide parameters were analyzed using the automatic measurement method newly developed by Erel and Neselioglu (2014) and the results were expressed as 'µmol/L'. Disulfide/total thiol percent ratios and disulfide/native thiol percent ratios were calculated from the measured disulfide, total thiol, and native thiol parameters as described before (8). IMA levels were analyzed using the rapid, colorimetric method developed by Bar-Or et al. (2000), and the results were expressed as absorbance units (ABSU) (12).

Statistical Analyses

The levels of native thiol, total thiol, disulfide, disulfide/native thiol percentage (%), disulfide/ total thiol %, and natural thiol/total thiol % were stated in tables as mean and standard deviation. The paired t test was used to compare data measured in different time. All analyses were performed with the SPSS 21.0 (IBM, Chicago) program and the significance level was accepted as $p < 0.05$.

Results

It was determined that there was no statistically significant difference between Group-I and Group-II concerning the oxidative stress parameters (Native thiol, total thiol, disulfide values, and calculated parameters disulfide/native thiol, disulfide/total thiol, and natural thiol/total thiol ratios) and IMA levels. The findings are given in Table 1.

Discussion and Conclusion

Physical activity increases the production of free radicals. Previous studies demonstrate that both aerobic and anaerobic exercises cause oxidative stress (5,13,14).

Acute aerobic exercise exacerbates oxidative stress, while regular aerobic exercise reduces oxidative stress by lowering the level of lipid peroxidation and increasing oxidant enzyme activity. This is an adaptation of the organism to oxidative stress (15-17).

Resistance exercise (RE), one of the anaerobic types of exercise, is based on intensity, volume, and frequency (18). Uchiyama et al., (2006) reported that weightlifting exercise causes more burns and/or damage to the muscles than aerobic exercises (19). Chaki et al., (2019) reported that high intensity resistance exercise causes excessive ROS production with increased oxygen consumption in muscles (18).

It was reported that, in resistance exercise, the cause of a radical increase in superoxide, one of the reactive oxygen species, is due to a chain of events; temporary ischemia occurs as a result of muscle contraction, and just after the relaxation of the muscle, an increase in blood flow (reperfusion) occurs, causing the re-oxygenation of tissues which ultimately and radically increases superoxide. Studies are reporting that, during a 6-month resistance exercise, the body responds

Table 1. Thiol/disulfide ratio and IMA values of elite female weightlifters before and after training

Variables	Group (n=12)	Mean	Std. Deviation	P
Native Thiol **(μmol/L)**	G1	298,35	66,05	0,158
	G2	353,18	92,58	
Total Thiol **(μmol/L)**	G1	323,39	65,92	0,182
	G2	369,40	89,65	
Disulfide **(μmol/L)**	G1	12,52	11,06	0,239
	G2	8,11	4,32	
Disulfide-Native thiol **(%)**	G1	4,45	4,17	0,239
	G2	2,71	2,42	
Disulfide-Total thiol **(%)**	G1	3,87	2,99	0,239
	G2	2,48	2,01	
Native thiol-Total thiol **(%)**	G1	92,25	5,98	0,239
	G2	95,04	4,03	
IMA **(ABSU)**	G1	0,71	0,10	0,071
	G2	0,62	0,11	

IMA=Ischemia-modified albumin, ABSU=Absorbance units, the significance level was accepted as p<0.05.

similarly to the cases of aerobic training, reducing lipid peroxidation and increasing antioxidant enzyme (Fr-Zn-SOD and CAT) activities (15).

It was reported that regular exercise causes the body to develop some original adaptations in thiol/disulfide hemostasis (13). In our study, there was no statistical difference in the thiol/disulfide level in pre-training and post-training data. This condition was interpreted as an adaptation to oxidative stress in the body when athletes train regularly for a long time.

The human body can adapt to exercise stress and does so by providing greater tolerance to the next same workload using various ROS-mediated signaling pathways. Exercise-based low levels of ROSs play a critical role in the adaptation of skeletal muscle. Among the factors that help the protein synthesis of skeletal muscle increase in various cytokine and kinase enzyme activities, such as protein kinase and alpha tumor necrosis factor, increase in the number and density of mitochondria, and the antioxidants produced. In this way, adaptation to oxidative stress is achieved in skeletal muscle (14).

Researchers linked the IMA to free oxygen radicals that occur after both aerobic and anaerobic exercise. Numerous studies are reporting that IMA increases after training in athletes (9,10,20). There are also a small number of papers stating that IMA decreases after exercise (21,22). Although there was a decrease in the IMA value after the exercise in this study, it was statistically not significant. This was interpreted that an adaptation was achieved to exercise in athletes.

Conclusion

Consequently, it can be mentioned that elite female weightlifters in the study provided metabolic adaptation to the training they conducted, and the antioxidant defense compensation was good. This was interpreted that the participants could continue to the next level of heavier training. Since there is only a limited number of studies on this subject, it is considered that the results confirm the need for more comprehensive training plans.

Conflicts of Interest

The authors declare that there is no conflict of interest in this manuscript.

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