



Moderate Aerobic Exercise May Reduce Metabolic Syndrome Induced Testicular Oxidative Stress and Deterioration in Sperm Parameters

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Authors' contributions

All authors participated in the design of the study, experimental applications (exercises), laboratory applications (sample collection and biochemical analyzes) data collection and evaluations. All authors contributed the manuscript writing and have read the final version of the manuscript.

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ABSTRACT

Aims: Studies on testicular oxidative stress, sperm density, motility and morphology of exercise applications in the case of metabolic syndrome is limited. In the present study, it was aimed to investigate the effects of aerobic and anaerobic exercise applications on sperm parameters and testicular oxidative stress parameters in metabolic syndrome induced rats.

Study Design: Controlled Trial.

Place and Duration of Study: Firat University Experimental Research Center, Elazığ/Turkey.

Methodology: A total of 24 male Wistar-Albino rats were used in the study. For inducing the metabolic syndrome, 30% fructose solution was prepared fresh every day and administered ad-libitum through the drinking water of the animals. The rats were divided into 4 groups (G1: Control, G2: Metabolic Syndrome, G3: Metabolic Syndrome + Aerobic Ex., G4: Metabolic Syndrome + Anaerobic Ex.). Exercise practices continued 3 days in a week for 6 weeks.

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Results: Sperm concentrations of G2 and G4 were statistically significantly lower than the control group. The abnormality percentage of G4 was statistically significantly higher than the other groups in terms of head abnormality and total abnormality. MDA level of G2 was statistically significantly higher than the other groups, while GSHpx and catalase levels were low.

Conclusion: It can be said that metabolic syndrome may cause oxidative damage in testicular tissue and deterioration in sperm parameters. Moderate-intensity aerobic exercise reduces the deterioration in sperm parameters by creating a protective response against oxidative damage.

Keywords: *Aerobic exercise; anaerobic exercise; metabolic syndrome; testis oxidative stress; sperm parameters.*

1. INTRODUCTION

Metabolic syndrome is defined as a pathological condition characterized by abdominal obesity, insulin resistance, hypertension and dyslipidemia by the World Health Organization [1]. Metabolic syndrome is known to have negative effects on sperm concentration, density and morphology similar to obesity and diabetes. It has been reported that this negative effect is seen in parameters affecting sperm quality rather than circulating hormones [2-4]. It is known that as a complication of metabolic syndrome, oxidative stress negatively affects sperm quality [5]. Oxidative stress is a factor that greatly affects male infertility and structural and functional dysfunction of sperm cells [6]. Metabolic syndrome can cause reproductive system inflammation due to higher levels of pro-inflammatory cytokines found in the prostate, seminal vesicles, testicles, epididymis and ejaculate of men [7]. Although it is known that overproduction has negative effects; with the regular work of skeletal muscle, free radicals produced at low and medium levels can develop special adaptations that benefit oxidative stress resistance by triggering enzyme activities that prevent oxidative damage [8]. Exercise divides into two groups as aerobic and anaerobic exercises in general; depending on the energy metabolism they use. Briefly aerobic exercises; they are relatively long-term exercises that use aerobic energy metabolism in which adenosine triphosphate (ATP) is resynthesized using oxygen and continues below the anaerobic threshold. Exercises that continue above the anaerobic threshold that include short-term high-intensity loads are also defined as anaerobic exercises. In the light of this information, the aim of the research is; to understand which exercises with different intensity are more preventive and / or therapeutic method against testicular oxidative stress induced by metabolic syndrome and decrease in sperm quality.

2. MATERIALS AND METHODS

2.1 Experimental Design

A total of 24 male Wistar-Albino rats, 6 weeks old and weighing an average of 182.82 grams used in the study, the rats were obtained from Firat University Experimental Research Center. Firat University Experimental Research Center, which has controlled temperature and humidity for 12 hours' light and 12 hours' dark was used for the accommodation of the experimental animals during the study and for the exercise applications. In the study, the Resource Equation Method was used for the sample calculations and the number of animals for each group was determined as six. Experimental animals are divided into 4 groups with six animals in each group, as follows;

Group 1 (G1): Control group; The animals in this group were fed standard diet and tap water from the first day until the end of the study and did not do any exercise.

Group 2 (G2): Metabolic Syndrome Control group; The animals in this group were fed ad-libitum with tap water containing 30% fructose in addition to the standard diet from the first day and did not do any exercise.

Group 3 (G3): Metabolic Syndrome + Aerobic Exercise; The animals in this group performed aerobic exercise and were fed ad-libitum with tap water containing 30% fructose in addition to the standard diet from the first day.

Group 4 (G4): Metabolic Syndrome + Anaerobic Exercise; The animals in this group performed anaerobic exercise and were fed ad-libitum with tap water containing 30% fructose from the first day in addition to the standard diet.

According to the glucose, triglyceride and HDL levels of animals fed with high fructose for eight weeks, at least three of the metabolic syndrome

diagnostic criteria of NCEP-ATP III (high fasting glucose > 110 mg / dL, high triglycerides > 150 mg / dL and low HDL < 40 mg / dL) were revealed and the metabolic syndrome was induced [Fig. 1].

2.2 Exercise Protocol

After inducing the metabolic syndrome, rats in G3 and G4 were run for 5 minutes with the lowest speed (stand by) and zero incline of the Treadmill Exercise device on the first day. On the second day, the duration was increased to 10 minutes and the animals were adapted to the device during the first week. Following the adaptation, the maximum running capacity of the groups to be exercised was determined by making each animal run at a gradually increasing speed on the treadmill and ending the test if animal stays on the wires with electric shock for 5 seconds and the final speed was recorded. Animals in G3 did aerobic exercise at the rate of 50-60% of their maximum running capacity with zero incline on the Treadmill Exercise device for 20 minutes a day in the morning hours, 3 times in a week during 6 weeks. The animals in G4 did anaerobic exercise with zero incline on the Treadmill Exercise device for 20 minutes a day, 3 times in a week during 6 weeks. In the first part of anaerobic exercise, which consists of 4 parts, the animals were run at 50-60% of their maximum running capacity for 5 minutes for warming up. In the second part, the animals were run at 85-90% of their maximum running capacity for 3 minutes, in the third part, animals were run at 50-60% of their maximum running capacity for 2 minutes and for the last part animals were run at 85-90% of their maximum running capacity. These four parts lasted 20 minutes in total.

2.3 Sample Collection and Homogenate Preparation

Testes tissues were removed, cleared of adhering connective tissue and weighed. Tissue samples were stored at -20°C until the study day.

2.4 Evaluation of Sperm Parameters

The epididymal sperm concentration and motility was determined with a hemocytometer using a modified method [9]. The percentage of morphologically abnormal spermatozoa was determined by using the method modified before [9].

2.5 Evaluation of Oxidative Stress Parameters

The testicular tissue amount of malondialdehyde (MDA) was used as an index of lipid peroxidation and determined by a method previously developed [10]. The MDA level was expressed as nmol/ml. The level of GSH was expressed as nmol/ml [11]. GSH-Px levels were determined by a previously developed method [12]. The protein concentration was also measured [13] and the GSH-Px activity was expressed as IU/g protein. The catalase (CAT) activity was determined by previously developed method, and was expressed as kU/g protein, where k is the first-order rate constant [14].

2.6 Statistical Evaluations

Kruskal-Wallis and Mann-Whitney U non-parametric tests were used for the statistical evaluations in the IBM SPSS 22.0 package program.

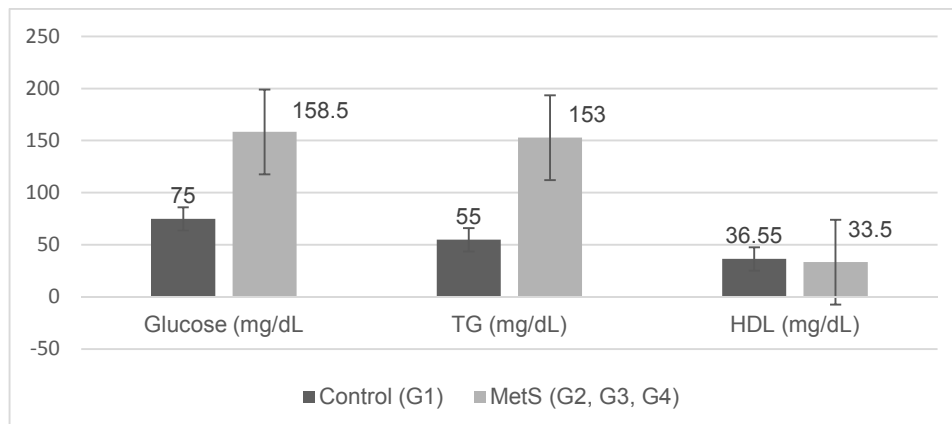


Fig. 1. Glucose, triglyceride and HDL levels of the groups in the 8th week of the study

3. RESULTS

3.1 Alterations in Sperm Parameters

There was a statistically significant difference between the groups in terms of sperm concentration due to G2 and G4 ($p < 0.05$). There was no statistically significant difference in motility levels ($p > 0.05$). There was a statistically significant difference between groups in head abnormality levels due to G4 ($p < 0.05$). There was no statistically significant difference between groups in terms of tail abnormality ($p > 0.05$). There was a statistically significant difference

between the groups due to G4 in the total abnormality levels [Table 1].

3.2 Alterations in Testicular Oxidative Stress Parameters

There was a statistically significant difference between the groups in terms of MDA due to G2 ($p < 0.05$). When the GSHPx levels were examined, there was a statistically significant difference between the groups due to the lowest level of G2 ($p < 0.05$). There was no statistically significant difference in catalase and GSH levels (Table 2).

Table 1. Sperm parameters

Parameter	Group	Mean	Std. D.	X ²	p
Concentration (10 ⁶ /ml)	G1(a)	144,86	35,192	8.31	0.040 (a > b,d)
	G2(b)	109,60	26,922		
	G3(c)	115,67	35,192		
	G4(d)	94,67	14,51		
Motility (%)	G1(a)	80,71	6,07	0.55	0.907
	G2(b)	78,00	6,43		
	G3(c)	80,00	5,49		
	G4(d)	81,11	7,20		
Head Abnormality (%)	G1(a)	2,71	1,55	13.82	0.003 (d > a,b,c)
	G2(b)	3,20	1,89		
	G3(c)	3,66	1,25		
	G4(d)	8,50	2,46		
Tail Abnormality (%)	G1(a)	3,78	1,34	1.45	0.693
	G2(b)	4,40	1,78		
	G3(c)	3,41	1,53		
	G4(d)	4,00	2,54		
Total Abnormality (%)	G1(a)	6,50	2,04	11.86	0.008 (d > a,b,c)
	G2(b)	7,60	1,98		
	G3(c)	7,08	2,08		
	G4(d)	12,50	3,56		

* $p < 0.05$

Table 2. Testicular oxidative stress parameters

Parameters	Group	Mean	Std. D.	X ²	p
MDA (nmol/ml)	G1(a)	4,74	0,68	9.112	0.028* (b > a,c)
	G2(b)	6,40	0,40		
	G3(c)	4,74	1,15		
	G4(d)	5,80	1,06		
GSH-Px (IU/g protein)	G1(a)	45,21	8,41	9.752	0.021* (b < a,c)
	G2(b)	30,73	2,12		
	G3(c)	43,34	5,86		
	G4(d)	40,15	7,76		
CAT (kU/g protein)	G1(a)	20,47	2,66	8.37	0.030* (b < a)
	G2(b)	17,42	2,23		
	G3(c)	19,24	2,17		
	G4(d)	18,63	2,33		
GSH (nmol/ml)	G1(a)	4,08	0,90	1.19	0.75
	G2(b)	3,61	0,58		
	G3(c)	3,56	0,42		
	G4(d)	3,72	0,48		

* $p < 0.05$

4. DISCUSSION

Metabolic syndrome has the potential to trigger male infertility unless it is treated. In studies focusing on this subject, it is emphasized that in terms of some parameters, metabolic syndrome has a negative effect on male fertility [15-19]. In diseases such as obesity and diabetes, the therapeutic effects of some exercise practices have been shown in both human and animal studies [20-22]. There are not enough studies on sperm density, motility and morphology of exercise applications in the case of metabolic syndrome. In this respect, our research is of importance and quality to contribute to the literature. In the present study, we determined that the formation of metabolic syndrome caused a statistically significant decrease in the sperm concentrations of rats compared to the control group. When we examined how this decrease changed with exercise practices, it was found that aerobic and anaerobic exercise practices followed differently. In this respect, it can be said that aerobic exercise is more effective than anaerobic exercise to increase the decreased sperm concentrations. Anaerobic exercise caused further decrease in sperm concentrations. It is considered that this situation may be caused by the oxidative stress that occurs as a result of increased exercise intensity. It was found that metabolic syndrome and exercise practices did not affect the percentage of motility. We examined sperm morphology in terms of head, tail and total abnormality percentages, each could be important negative effects on male fertility. According to the head abnormality assessment, although it was not statistically significant, metabolic syndrome caused an increase compared to the control group. The head abnormality percentage of the group that was applied anaerobic exercise was statistically significantly at the highest level. It can be said that this situation was caused by the oxidative stress that occurs depending on the intensity of the exercise. In this context, exercise practices do not provide a therapeutic effect on the head abnormality that occurs in the metabolic syndrome model, and exercise with high intensity has the potential to further increase this abnormality. It was found that while there was no statistically significant difference between the groups in tail abnormality, the metabolic syndrome increased the percentage of tail abnormality. In the group which we applied aerobic exercise, the percentage of abnormality was at the lowest level compared to the other groups. In this case, aerobic exercise in the

presence of metabolic syndrome may have therapeutic effects in terms of tail abnormality. When considering the total abnormality percentages, it was found that anaerobic exercise application increased the abnormality percentage statistically significantly compared to the other groups, aerobic exercise application and control group values were very close to each other. Based on this information, it can be said that anaerobic exercise may have negative effects on sperm morphology in patients with metabolic syndrome, but aerobic regular exercises do not have a negative effect on sperm morphology.

It is known that oxidative stress has negative effects on the male reproductive system and triggers infertility. Due to the high level of cell division and mitochondrial oxygen consumption and the relatively high level of unsaturated fatty acids in the testicle, this tissue is more prone to oxidative stress [23]. There are studies emphasizing that diabetes increases oxidative stress and effects on reproductive system [24-26]. Studies examining the relationship between metabolic syndrome and testicular oxidative stress parameters are limited in the literature. As in many systems, increases in MDA levels also affect the reproductive system negatively. To reduce this negative effect, antioxidant systems come into play with the effect of different regulators. Although exercise practices have become popular as a stress factor that increases oxidative damage, it is known that this situation may vary depending on the intensity of the exercise. Therefore, depending on its intensity, exercise can trigger antioxidants in order to prevent damage that may occur as a result of lipid peroxidation. When the MDA levels were examined, we see that the MDA levels of G2 were statistically significantly at the highest level. When the correlations between the oxidative stress parameters and sperm parameters of the groups examined, it was found that there was a statistically significant and positive relationship only between the MDA and tail abnormality percentage in G2. Considering this result, it can be said that increased lipid peroxidation with metabolic syndrome defects sperm cells, especially in the tail regions, and in this way may cause damage to the male reproductive system. In the groups we exercised, it was found that the MDA levels in G3 were at the same levels as the control group.

In G4, on the other hand, the situation was slightly different, and the MDA levels were similar

to G2. In terms of these results, it is possible to deduce that regular aerobic exercises can reduce oxidative damage in testicular tissue, which increases with metabolic syndrome. In anaerobic exercises, it was seen that this situation proceeded in the opposite direction due to the increasing exercise intensity. Anaerobic exercise is also known as high intensity exercise. High intensity exercise itself is a stress factor for the organism. Although the positive aspects of high intensity loads cannot be ignored, the formation of oxidative stress may have harmful effects for the reproductive system. Although there was no statistically significant change in GSH levels, we saw a statistically significant decrease in GSHPx and catalase levels in G2 compared to other groups. While GSHPx levels decreased with the effect of metabolic syndrome, with the application of aerobic exercise it almost approached the control group levels. Although GSHPx levels tended to increase with anaerobic exercise application, this increase was not statistically significant. Similarly, aerobic exercise application also increased catalase levels, although it was not statistically significant. In this respect, it can be said that regular aerobic exercises trigger the increase in antioxidant parameters and provide protection against oxidative damage caused by the effect of metabolic syndrome.

5. CONCLUSION

As conclusion; it can be said that metabolic syndrome may cause oxidative damage in testicular tissue and deterioration in some sperm parameters. Moderate-intensity aerobic exercise reduces the deterioration in sperm parameters by creating a protective response against oxidative damage via increased antioxidant balance. Further studies are needed to understand how different intensities of exercise affects the molecular mechanisms of male reproductive system in metabolic syndrome.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The study was approved by Firat University Animal Experiments Local Ethics Committee (Meeting Number: 2018/05, Decision No: 60, Protocol No: 2108/27) and supported by Firat University Scientific Research Projects Unit (FUBAP).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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