ORIGINAL ARTICLE

Investigation of Male Reproductive System Organ Weights and Serum Testosterone Levels In Terms Of Different Exercise Loads in Rat Metabolic Syndrome Model

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ABSTRACT

Background: While the effects of high fructose-induced metabolic syndrome on the male reproductive system continue to be the focus of attention, exercise interventions gain importance to avoid these effects in terms of intensity.

Aim: The purpose of the present study is to investigate the change in testicular and accessory glands weights caused by different exercise loads in metabolic syndrome induced rats by high fructose and to examine the relationship between testosterone and tissue weights.

Methods: 24 male Wistar-Albino rats were used in the study. Rats were divided into 4 groups in equal numbers in each group. Metabolic syndrome induced by 30% fructose in tap water. Rats in exercise intervention groups exercised for six weeks. At the end of the study rats were sacrificed and tissue samples collected and weighed immediately.

Results: Metabolic syndrome caused significant reductions absolute weight of testis, entire epididymis, cauda epididymis, seminal vesicle and ventral prostate ($p<0.05$). It also caused decreased serum testosterone levels in the same group. Moderate aerobic exercise intervention increased testis weights, cauda epididymis weights and serum testosterone levels significantly. Cauda epididymis and testosterone increases in exercise intervention groups also significantly positive correlated ($p<0.05$).

Conclusion: As a conclusion, metabolic syndrome induced by high fructose causes reductions in male rat reproductive system organ weights and serum testosterone levels, and aerobic exercises have positive effects on weight and serum testosterone level reductions.

Keywords: metabolic syndrome, male reproductive system, reproductive organ weights, serum testosterone, aerobic exercise, anaerobic exercise, fructose

INTRODUCTION

Decreases in male reproductive health have been reported due to factors such as sedentary lifestyle, air pollution, waste and radiation contaminating the air, food and water with endocrine disruptors[1-3]. As a dietary based disease, metabolic syndrome is a cardiovascular risk factor that occurs with components such as dyslipidemia, hypertension, abdominal obesity and high glucose[4]. High fructose, which is widely used in the food and beverage industry today and taken with diet, is effective in the emergence of metabolic syndrome components after a while[5]. In addition to diet habits, physically inactive lifestyle plays a role in the formation of metabolic syndrome[6]. Although the underlying mechanisms are not clear yet, studies on metabolic syndrome and male fertility emphasized the negative effects of metabolic syndrome on reproductive system[7-10]. Metabolic syndrome may increase the inflammation in testis, seminal vesicles, epididymis and prostate, and sperm quality becomes poor as a result of this inflammation[11, 12]. In addition, metabolic syndrome may associate with erectile dysfunction and may be treated by lifestyle modification (nutrition program and physical activity intervention) approaches[13]. It has been reported in studies that men who do regular physical activity show a better reproduction health than men who have a sedentary lifestyle[14-16]. Physical activity interventions gain importance in order to return the male reproductive system to a healthy state, which is disrupted by the effect of metabolic syndrome. Exercises at different intensities have different effects on the male reproductive system in metabolic syndrome[16]. The aim of the present study is to investigate the change in testicular and accessory glands weights caused by different exercise loads in metabolic syndrome induced rats by high fructose and to examine the relationship between testosterone and tissue weights.

MATERIAL & METHODS

Experimental Design: A total of 24 male Wistar-Albino rats were used in the present study. The rats were housed in rooms with controlled humidity, temperature and lighting. All rats were fed standard food and had free access to water. Rats were divided into 4 groups in equal numbers in each group. These groups were named as; Control group (G1), Metabolic Syndrome Group (not exercising) (G2), Metabolic Syndrome + Aerobic Exercise Group (G3) and Metabolic Syndrome + Anaerobic Exercise group (G4). While the control group was drinking standard tap water, 30% of fructose[17] was added to the drinking water of the animals in the other 3 metabolic syndrome groups. Drinking water which containing 30% fructose was refreshed every day. After 8 weeks of feeding in this way, blood samples were taken from the animals and serum fasting blood glucose, triglyceride and HDL levels were evaluated in order to make a diagnosis of metabolic syndrome. Metabolic syndrome formation was confirmed by considering the NCEP ATP III diagnostic criteria (high fasting glucose > 110 mg / dL, high triglycerides > 150 mg / dL and low HDL < 40 mg / dL)[18] (Figure 1).

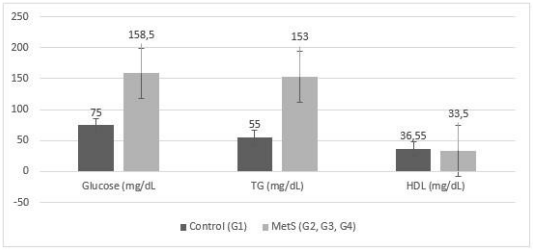
Exercise Protocol: Rats in G3 and G4 groups were the exercise groups. For one week these groups performed

adaptation exercises on the treadmill exercise device for 5 minutes on the first day and the adaptation period went up to 20 minutes on the next days with an increasing amount of time each day. All rats exercised at a constant speed throughout the adaptation week. After the end of the adaptation week the maximum running capacity of all rats that will be exercised is determined as previously explained by Koch and Britton[19]. Aerobic exercises are applied to 50-60% of the maximum running capacity of the animals in G3. Anaerobic exercises were applied to 80-90% of the animals in G4 at their maximum running capacity as it was explained by Karaman et al.(2021)[15].

Sample Collection: After 6 weeks of exercise interventions, animals in all groups were sacrificed and blood and tissue samples were taken. Testes, epididymis, prostate and vesicular seminal tissues were removed, cleared of adhering connective tissue and weighed. Testosterone levels determined by fallowing the ELISA method procedure of commercial ELISA kit.

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

Figure 1. Fasting Glucose, Triglyceride and HDL Levels Before Exercise Interventions



RESULTS

High fructose mediated metabolic syndrome (G2) found to reduce the testis (A), epididymis (B), cauda (C) and seminal vesicle (D) weights significantly ($p<0.05$). Accordingly, it caused an increase in prostate (E) levels as shown in the Figure 2. Cauda and prostate weights and serum testosterone (F) levels were significant in the aerobic exercise group (G3).

Figure 2. Alterations in Testis, Entire Epididymis, Cauda Epididymis, Seminal Vesicle, Ventral Prostate Weights and Serum Testosterone Levels

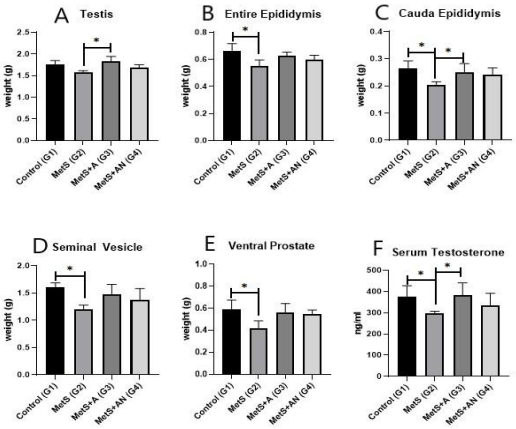


Table 1. Association in Serum Testosterone and Cauda Epididymis Weight

Cauda Epididymis	G1	G2	G3	G4
Testosterone	Ns	Ns	R = 0.842 p = 0.035	R = 0.880 p = 0.021

As a result of the correlation analysis between all parameters, a strong and positive correlation was found between cauda weights and serum testosterone levels of both aerobic and anaerobic exercise groups ($p<0.05$) (Table 1).

DISCUSSION

In the present study, the weight changes of testis, epididymis, seminal vesicle, prostate and cauda tissues in terms of different exercise loads in the metabolic syndrome model induced by high fructose consumption in rats were examined. It has been shown that metabolic syndrome caused a decrease in the weight levels of these tissues and aerobic exercise makes the weight gain in these tissues closer to control group. The situation was at the opposite way in terms of prostate weight. In addition in the weight change in tissues, it has been shown that metabolic syndrome significantly reduced serum testosterone levels and aerobic exercise significantly increased serum testosterone levels compared to the metabolic syndrome group (Figure 2).

If there is no cell apoptosis, the increase and decrease in testicular weight can generally be associated with the change in fluid volume in its content[20]. Fructose, which can also be metabolized by testicular tissue, may contribute to testicular weight loss[21]. There are studies in which a high fructose diet has been associated with weight reduction in rat testicular tissue[22-24]. In a previous study, we showed that the metabolic syndrome induced by high fructose diet leads to a significant increase in oxidative stress of testicular tissue[15]. In addition, it has been previously reported that oxidative stress induced by the experimental diabetes model is the cause of disorders in the rat reproductive system[25]. As it was mentioned in above, the increase in testicular oxidative stress caused by metabolic syndrome can be associated with weight reduction.

Considering the total epididymis and cauda epididymis weights, it can be said that mechanisms cause weight loss in these tissues, similar to the change in testicular weight. Costa et al. (2019) reported in their study that obesity caused by nutrition and sedentary lifestyle reduced total epididymis and cauda epididymis weights[26]. On the other hand, in an experimental diabetes model study we mentioned earlier, decreases in total epididymis and cauda epididymis weights were reported, similar to present study[25]. Navarro-Casado et al. (2010) showed a decrease in the epididymis weights of the diabetes group in the experimental diabetes model[27]. Similarly, in the study by Soudamani et al. (2005), there was a decrease in the epididymis weight of the animals with diabetes[28].

Among the results of the present study, when how the male accessory glands are affected by the metabolic syndrome were examined, a decrease in their weight (Figure 2) can be seen. This weight reduction in seminal

vesicles and ventral prostate is thought to be caused by the same oxidative stress mechanisms mentioned above. When these changes in male reproductive organs are taken together, it is seen that metabolic syndrome has negative effects on male fertility at the level of organ weight. Serum testosterone level was similarly affected by this negative effect of metabolic syndrome (Figure 2). Costa et al 2019 and Türk et al. 2018 reported a decrease in seminal vesicles and ventral prostate weights in line with the present study[25,26]. There are also other studies in the literature reporting the reduction in the accessory glands[29-31]. Although these studies are not related to metabolic syndrome, diabetes studies can also be considered in terms of similarity of reproductive organ weight change mechanisms.

In the present study, it has been showed that high fructose-mediated metabolic syndrome causes a significant reduction in serum testosterone levels. It has been clearly shown in the literature that serum testosterone levels are negatively affected by diseases such as metabolic syndrome and diabetes [32-37].

In terms of exercise interventions, it has been showed that the testis, cauda epididymis weights and serum testosterone levels increased significantly compared to the metabolic syndrome group (Figure 2). Moreover, it was determined that both aerobic and anaerobic exercise interventions had a positive association with the increases in cauda epididymis and serum testosterone levels (Table 1). In a previous study aerobic exercise reduced testicular oxidative stress levels in rats with metabolic syndrome was shown[15]. Furthermore, there was no significant change in reproductive system organ weights and testosterone levels in the group in which anaerobic exercise applied (Figure 2). As mentioned in the previous paragraphs, it is known that increased oxidative stress negatively affects reproductive system organs and hormones. It is known that intensive anaerobic exercise, which includes high-intensity loads, has negative consequences due to exercise-induced oxidative stress[38]. The inability to reduce reactive oxygen species, which are already high due to metabolic syndrome, with such high intensity exercise may be related to this result. Vaamonde et al. (2009) showed in their study that there was a negative relationship between increased exercise intensity and sperm parameters[39]. It was also demonstrated the similarity of this situation in athletes engaged in intense endurance sports although it was not statistically significant[40]. An increase in serum testosterone levels was reported in the study by Grandys et al. (2009) in which a moderate intensity exercise was applied[41]. Moreover, in a study by Wise et al (2011), it was shown that intensive anaerobic exercise negatively affected sperm production[42]. Furthermore, a very comprehensive study reported the negative effects of intense exercise on sperm parameters[43]. Instead of doing high-intensity exercises, doing moderate aerobic exercises rather than physically active contributes to both an increase in sex hormones and improved sperm parameters and sperm morphology[39,44].

CONCLUSION

This study is an experimental study that limited only with male reproductive system organ weights and serum testosterone levels. However, the present study's strongest side is that it examines the effects of exercise interventions with different intensity in the rat metabolic syndrome model. In this context, it has been shown that metabolic syndrome induced by high fructose causes reductions in male rat reproductive system organ weights and serum testosterone levels, and aerobic exercises have positive effects on weight and serum testosterone level reductions. Moreover, it has been tried to emphasize that anaerobic exercise does not have a very effective protective effect in diseases that negatively affect the reproductive system such as metabolic syndrome. In the light of this information, it is thought that the present study has results that will contribute to the role of exercise interventions in terms of different loads in experimental male reproductive system diseases and that these results needs to be clarified by investigating the underlying molecular mechanisms.

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