Research Article

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Effects of different exercise loads on serum betatrophin (ANGPTL-8/lipasin) and cartonectin (CTRP-3) levels in metabolic syndrome

Metabolik sendromda farklı egzersiz yüklenmelerinin serum betatrofin (Angptl-8/Lipasin) ve kartonektin (Ctrp-3) düzeylerine etkisi

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Abstract

Objectives: The number of studies examining the circulating level change of betatrophin and cartonectin in metabolic syndrome applying different loads of exercise is limited. The purpose of the present study was to investigate how different loads of exercises regulate the betatrophin and cartonectin levels in metabolic syndrome induced rats.

Methods: A total of 24 Wistar-Albino male rats were used in the study. Rats were divided into four groups as follows; G1: control group (fed with standard diet and tap water), G2: metabolic syndrome group (without exercise application), G3: metabolic syndrome + aerobic exercise group (aerobic exercise applied), G4: metabolic syndrome + anaerobic exercise group (anaerobic exercise applied). Betatrophin and Cartonectin levels were determined by ELISA method in serum samples.

Results: There was a statistically significant difference in betatrophin levels between the groups and this differentiation

was caused by G2 ($p < 0.05$). Cartonectin levels were not significantly different between groups ($p > 0.05$).

Conclusions: It can be concluded that anaerobic exercises have more positive effects on glucose balance in metabolic syndrome than aerobic exercises, and by regulating betatrophin levels, anaerobic exercises indicate this effect.

Keywords: aerobic exercise; anaerobic exercise; betatrophin (ANGPL-8); cartonectin (CTRP-3); metabolic syndrome.

Öz

Amaç: Metabolik sendromda farklı egzersiz yüklenmeleri uygulanarak dolaşımdaki betatrofin ve kartonektin düzeylerini inceleyen çalışmaların sayısı sınırlıdır. Sunulan çalışmanın amacı, farklı egzersiz yüklenmelerinin metabolik sendrom oluşturulan sıçanlarda betatrofin ve kartonektin düzeylerini nasıl düzenlediğini araştırmaktır.

Yöntem: Bu çalışmada toplam 24 adet Wistar-Albino erkek sıçan kullanıldı. Sıçanlar şu şekilde dört gruba ayrıldı; G1: kontrol grubu (standart diyet ve su ile beslenen), G2: Metabolik Sendrom Grubu (egzersiz uygulanmayan grup), G3: Metabolik Sendrom + Aerobik Egzersiz Grubu (aerobik egzersiz uygulanan grup), G4 Metabolik Sendrom + Anaerobik Egzersiz Grubu (anaerobik egzersiz uygulanan grup). Serum örneklerinde Betatrofin ve Kartonektin düzeyleri ELISA metodu ile belirlendi.

Bulgular: Gruplar arası betatrofin düzeylerinde G2'den kaynaklanan istatistiksel olarak anlamlı bir farklılaşma vardı ($p < 0.05$). Kartonektin düzeyleri gruplar arasında anlamlı olarak farklı değildi ($p > 0.05$).

Sonuç: Anaerobik egzersizlerin metabolik sendromda glukoz dengesi üzerine aerobik egzersizlere göre daha olumlu etkilerinin olduğu ve anaerobik egzersizlerin betatrofin

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düzeylerini düzenleyerek bu etkiyi gösterdiği sonucuna varılabilir.

Anahtar Kelimeler: aerobik egzersiz; anaerobik egzersiz; betatropin (ANGPL-8); kartonektin (CTRP-3); metabolik sendrom.

Introduction

One of the consequences of consuming convenience food and lack of physical activities, metabolic syndrome is defined as a pathological condition characterized by abdominal obesity, insulin resistance, hypertension, and dyslipidemia by the World Health Organization (WHO) [1]. Although the number of people affected by metabolic syndrome is thought to be parallel to the number of people affected by obesity and type 2 diabetes, the prevalence of metabolic syndrome is three times higher than obesity and type 2 diabetes, according to the American National Center for Health Statistics [1, 2]. According to the International Diabetes Federation (IDF) data, while the global diabetes prevalence for 2019 was 463 million people, it is predicted that this figure will rise to 700 million people by 2045 [3]. Metabolic syndrome is diagnosed as the presence of three or more of the following factors which; hypertriglyceridemia, reduced high-density lipoprotein cholesterol (HDL-C), total cholesterol, dysglycemia, increased waist circumference, and elevated blood pressure [4]. Additionally, circulating changes of some peptide hormones such as betatrophin have been reported to play a role in the development of the metabolic syndrome risk factors [5, 6].

Betatrophin (ANGPTL-8, lipasin) hormone is a peptide hormone secreted from the liver and adipose tissue, which is a member of angiopoietin-like proteins that are thought to be effective in glucose and triglyceride metabolism [5]. It has been reported that betatrophin levels are generally associated with triglyceride and very low density lipoprotein (VLDL) levels, and serum betatrophin levels increase in diseases such as diabetes, obesity, and metabolic syndrome [7]. It is also called lipasin due to its regulatory effects on lipoprotein lipase activities [8]. Although betatrophin levels have been investigated in studies in which aerobic and resistance exercises are applied, involving individuals with type 2 diabetes and obesity [8, 9], there is not enough research on how betatrophin responds to different loads of exercises in individuals with metabolic syndrome.

Cartonectin (CTRP-3), a member of the C1q/TNF-related proteins family, has been identified as an anti-inflammatory adipokine secreted from adipose tissue. It is reported that

cartonectin, which has been shown to trigger the release of adipokine and resistin from mice adipocytes, behaves similarly to adipokine [10]. When the studies on cartonectin are examined, it is found that there is a limited number of studies investigating both exercise applications and metabolic syndrome. To the extent of our knowledge, cartonectin and exercise were only discussed together in the study of Choi et al. [11] in the case of a metabolic disease. Additionally, Hasegawa et al. [12] investigated cartonectin and exercise together in case of arterial stiffness. Since the results of studies on cartonectin in the literature are limited, the response of this adipokine to exercise is an essential research topic. The present research is a novel study which investigates betatrophin and cartonectin together with two types of exercise applications in metabolic syndrome.

Exercise applications as treatment methods gain importance in terms of severity, duration, and frequency to people who are affected by chronic diseases such as metabolic syndrome, diabetes, and obesity [13, 14]. Exercises in general are divided as aerobic and anaerobic exercises depending on the energy metabolism they use. Briefly, aerobic exercises 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. In high-intensity and short-term loads that continue above the anaerobic threshold, the oxygen required for resynthesis of ATP is insufficient, and ATP is resynthesized anaerobically by the ATP and phosphocreatine (PC) energy metabolism called the phosphogen system [15, 16]. Exercises that continue in this way and include short-term high-intensity loads are defined as anaerobic exercises [16]. Both types of exercises are accepted practices that have positive effects on reducing the increase in adipose tissue, preventing complications of chronic diseases, and making the person feel better physically and psychologically [13, 14].

In the light of this knowledge, the purposes of the present study are to investigate the effect of aerobic and anaerobic exercises on the levels of betatrophin and cartonectin secreted from adipose tissue and to determine the most effective exercise type to be applied to individuals with metabolic syndrome.

Materials and methods

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) with project number BSY.19.02.

Experimental animals

A total of 24 male Wistar-Albino rats, six weeks old and weighing an average of 182.82 g, were used in the study. The rats were supplied from Firat University Experimental Research Center. Firat University Experimental Research Center, where the temperature and humidity was controlled for 12 h light and 12 h dark, was used for the accommodation of the experimental animals during the study and for the exercise applications. Experimental animals were divided into four groups 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.

In the procedure, experimental animals were fed *ad-libitum* for 14 weeks with 30% fructose solution, which is freshly and daily prepared with drinking water [17] (except control group), in addition to standard cow diet. The amount of feed and water consumed by the animals in all groups were controlled and recorded every day between 9:00 and 10:00 am. Additionally, the weight of the animals was recorded at the end of each week. In order to detect whether metabolic syndrome was induced in the animals, at the 8th week of the study, two animals from the control group and six animals from the fructose-fed groups were selected randomly and one ml of blood samples were taken from jugular vein. In these samples, glucose, triglyceride, and HDL-C values were analyzed using an auto analyzer (Siemens ADVIA 2400 Chemistry System, Siemens Healthcare Diagnostics Ltd., USA).

In our previous study, serum glucose, HDL-C, and triglyceride levels were evaluated in samples taken from the jugular vein of animals after eight weeks, and metabolic syndrome was diagnosed as a result of the presence of at least three of the NCEP ATP III metabolic syndrome diagnostic criteria [18, 19].

Exercise protocol

After inducing the metabolic syndrome, the rats in G3 and G4 were run for 5 min 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 min and the animals were adapted to the device during the first week. Following the adaptation process, the

maximum running capacity of the groups to be exercised was determined using a method similar to Koch and Britton's method [20] by making each animal run at a gradually increasing speed on the treadmill. The test was terminated on condition that the animal stays on the wires with electric shock for 5 s. In this case, the final speed was recorded to calculate the intensity of the exercise. The 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 min three days in a week during six weeks. The animals in G4 did anaerobic exercise with zero incline on the Treadmill Exercise device for 20 min three days in a week during six weeks. In the first part of anaerobic exercise, which consists of four parts, the animals were run at 50–60% of their maximum running capacity for 5 min for warming up. In the second part, the animals were run at 85–90% of their maximum running capacity for 3 min, in the third part, animals were run at 50–60% of their maximum running capacity for 2 min and for the last part animals were run at 85–90% of their maximum running capacity. These four parts lasted 20 min in total (see Figure 1).

Sample collection

At the end of the study, blood samples were taken from all animals by decapitation in aprotinin tubes between 09:00 and 10:00 in the morning to be used in the analysis. After the blood samples were centrifuged at 1,500 g for 10 min, the obtained serum samples were stored at –80 °C until the study day. In serum samples, betatrophin (ANGPTL-8) and cartonectin (CTRP-3) were measured by ELISA method.

Betatrophin levels in serum samples were determined following the steps in the catalog of the ELISA kit (Rat ANGPTL-8; Catalog number: 201-11-1796 Sunred Biological Technology Co., Ltd., Shanghai, China). The measurement range of the Rat ANGPTL-8 ELISA kit was: 2.5–700 ng/L, sensitivity was: 2.436 ng/L, Intra Assay was: CV <8% and Inter Assay was: CV <11%.

Cartonectin levels in serum samples were determined following the steps in the catalog of the ELISA kit (Rat Cartonectin; Catalog number: 201-11-5893 Sunred Biological Technology Co., Ltd., Shanghai, China). The measurement range of the Rat Cartonectin ELISA kit was: 0.5–40 ng/mL, sensitivity was: 0.136 ng/mL, Intra Assay was: CV <8% and Inter Assay was: CV <11%. The test results were reported by using the automatic washer Bio-Tek ELX50 (Biotek Instruments, USA) in well washes and ChroMate, Microplate Reader P4300 devices (Awareness Technology Instruments, USA) for absorbance readings.

Glucose, low density lipoprotein cholesterol (LDL-C), total cholesterol, HDL-C, triglyceride, and uric acid measurements in serum samples were analyzed at Firat University Hospital Central Biochemistry Laboratory by using an auto analyzer (Siemens ADVIA 2400 Chemistry System, Siemens Healthcare Diagnostics Ltd., USA).

Statistical evaluation

Normality tests (Kolmogorov–Smirnov, histogram, kurtosis-skewness) were applied to the obtained data and it was determined that the data did not show normal distribution. Kruskal–Wallis, Mann–Whitney U, and Spearman–Rank Correlation non-parametric tests were used for the statistical evaluations in the IBM SPSS 22.0 package program.

Results

When the weight changes of the groups at the end of the study were examined in Table 1, it was seen that the mean of G2 was the highest and the mean of G4 was the lowest. There was a significant difference between these groups ($p < 0.05$). In glucose levels, it was seen that there was a significant differentiation and this differentiation was due to the lowest level of G4 ($p < 0.05$). In triglyceride levels, it was seen that there was a significant differentiation and this differentiation was between G1–G2 and G2–G4 ($p < 0.05$). In HDL-C levels, it was seen that there was no statistically significant difference between the groups ($p > 0.05$). In LDL levels, it was seen that there was a significant differentiation and this differentiation was caused by G4 ($p < 0.05$). It was determined that there was no statistically significant difference in total cholesterol levels ($p > 0.05$). It was seen that there was a statistically significant difference between groups in uric acid levels and this differentiation was due to G2 ($p < 0.05$). In betatrophin levels, it was seen that there was a statistically significant difference between the groups and this differentiation was caused by G2 ($p < 0.05$). HDL-C levels of G3 were negatively correlated with betatrophin levels ($p < 0.05$) (Table 2). Uric Acid levels of G2 were positively correlated with betatrophin levels ($p < 0.05$) (Table 2). In cartonection levels, it was seen that there was no statistically significant difference between the groups ($p > 0.05$). Total cholesterol levels of G3 were positively correlated with cartonection levels ($p < 0.05$) (Table 3).

Table 2: Significant correlations with betatrophin in all groups.

Betatrophin	Control (G1)	MetS C. (G2)	Aerobic E. (G3)	Anaerobic E. (G4)
HDL, mg/dL	Ns	Ns	$r = -0.901$ $p = 0.014$	Ns
Uric acid, mg/dL	Ns	$r = 0.897$ $p = 0.039$	Ns	Ns

MetS C, metabolic syndrome control; Aerobic E, aerobic exercise group; Anaerobic E, anaerobic exercise group; Ns, not significant; HDL, high-density lipoprotein. Bold values indicate the significant correlation.

Table 3: Significant correlations with cartonection in all groups.

Cartonection	Control (G1)	MetS C. (G2)	Aerobic E. (G3)	Anaerobic E. (G4)
Total cholesterol, mg/dL	Ns	Ns	$r = 0.876$ $p = 0.022$	Ns

MetS C, metabolic syndrome control; Aerobic E, aerobic exercise group; Anaerobic E, anaerobic exercise group; Ns = not significant. Bold values indicate the significant correlation.

Discussion

Considering the weight changes as a result of the research, it was seen that the weight level of G2 was statistically significantly higher than the control group (G1), G3, and G4. It is seen that the weight levels of G3 and G4 decreased statistically compared to G1 and G2 as a result. This suggests that exercise may have a positive effect on weight control. As for which type of exercise is more effective, the

Table 1: Descriptive data of the groups.

Variable	Control (G1)		MetS C. (G2)		Aerobic E. (G3)		Anaerobic E. (G4)		p-Value
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Weight, g	418.85 ± 56.92 ^b		502.80 ± 5.49 ^c		440.50 ± 67.89 ^b		414.83 ± 32.16 ^b		0.017 ^a
Glucose, mg/dL	107.42 ± 7.04 ^b		120.11 ± 12.74 ^b		121.84 ± 3.84 ^b		93.64 ± 13.77 ^c		0.002 ^a
Triglyceride, mg/dL	69.97 ± 9.22 ^b		152.64 ± 1.56 ^c		102.4 ± 27.01 ^d		90.00 ± 9.80 ^d		0.001 ^a
HDL-C, mg/dL	35.14 ± 1.77 ^b		31.68 ± 4.84 ^b		35.60 ± 7.64 ^b		36.00 ± 3.94 ^b		0.42
LDL-C, mg/dL	10.78 ± 2.52 ^b		13.27 ± 2.62 ^c		11.62 ± 2.68 ^b		7.96 ± 2.68 ^c		0.048 ^a
Cholesterol, mg/dL	54.68 ± 10.41 ^b		66.00 ± 8.27 ^b		55.80 ± 9.44 ^b		51.80 ± 7.17 ^b		0.098
Uric acid, mg/dL	0.67 ± 0.18 ^b		1.15 ± 0.37 ^c		0.72 ± 0.13 ^d		0.56 ± 0.25 ^d		0.011 ^a
Betatrophin, ng/L	5.41 ± 0.21 ^b		6.79 ± 0.73 ^c		6.48 ± 0.87 ^c		6.00 ± 1.12 ^b		0.03 ^a
Cartonection, ng/mL	0.89 ± 0.20 ^b		1.09 ± 0.14 ^b		0.99 ± 0.14 ^b		1.05 ± 0.16 ^b		0.56

MetS C, metabolic syndrome control; Aerobic E, aerobic exercise group; Anaerobic E, anaerobic exercise group; HDL-C, high-density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; S.D, standard deviation. ^aSignificance, S.D, different letter on the same line indicates the differentiation between groups. Italic values indicate the significance.

Figure 1: The process of study.

finding that the weight level of the anaerobic exercise group was lower than the aerobic exercise group suggests that short-term high-intensity anaerobic exercises may be more effective for weight control.

Er [21] reported in her study that statistically significant decreases were observed in weight levels of the rats compared to the weight levels of rats that received only fructose. Dal [22] reported a statistically significant decrease in the weight levels of patients diagnosed with metabolic syndrome after eight week mild-moderate exercises. Additionally, Özçelik [23] reported that there were decreases in weight levels in the exercise groups in the study which calorie restriction and exercise were applied to metabolic syndrome induced rats.

The statistical analysis of the research groups' glucose levels in the present study has shown that G3's glucose levels were almost the same as G2, while G4's glucose levels were statistically significantly lower than the other groups. Considering the research results, it can be inferred that anaerobic exercises have more positive effects on glucose balance in metabolic syndrome than aerobic exercises.

Machado et al. [24] reported that exercises, applied at both intensities and periods, decreased glucose levels in their study, in which treadmill exercises were applied to obese rats with metabolic syndrome at 60% and 80% of two intensities and for two different periods for 3–5 days in a week. Koç [25] reported a statistically significant decrease in glucose levels in the exercise groups in the study which examine the effects of exercise and calorie restriction in fructose-induced metabolic syndrome. Additionally, Dieli-Conwright et al. [26] reported that the glucose levels of individuals diagnosed with metabolic

syndrome decreased significantly after the exercise applications and did not increase to the basal level during the three month follow-up period in their study, in which aerobic exercise and resistance exercises were applied in a combined manner.

The statistical analysis of the triglyceride levels of research groups in the present study, it was seen that the triglyceride levels of G2 were significantly higher than the other groups. When the results of the exercise groups were examined, it was found that the triglyceride levels of both exercise groups decreased significantly compared to the level of G2 and there was no significant difference between the groups that were exercised. The greater decrease in G4 suggests that anaerobic exercises are more effective methods for regulating the lipid profile.

When the statistical analysis of the HDL-C levels of our research groups is considered, while there was no statistically significant difference between the groups, it was seen that the HDL-C levels of G2 were low and the HDL-C levels of the exercise groups were similar to the G1. In the study by Earnest et al. [27] which aerobic and resistance exercises were applied to individuals with metabolic syndrome and type 2 diabetes, it was reported that the triglyceride, LDL-C, and total cholesterol levels of the groups that were exercised after nine months of practice were lower than the control group. Considering HDL-C levels in the same study, there was no statistically significant difference, but exercise practices increased HDL-C levels, as it was in the present study. Similarly, in another study held by Moholdt et al. [28], in which aerobic interval exercises and continuous moderate intensity exercises were applied to individuals with metabolic syndrome for

16 weeks, it was reported that triglyceride levels of both exercise groups were lower than the control group, although there was no statistically significant decrease in their basal status. Additionally, it was stated that there was an increase in the HDL-C levels of the same participants after the exercise applications, although it was not statistically significant, similar to the present study.

When the statistical analyzes of serum betatrophin levels of our research groups were examined at the end of the six week exercises, it was seen that betatrophin levels of G2 and G3 are significantly higher than betatrophin levels of G1. While no statistically significant difference was found among the groups that were exercised, it was seen that betatrophin levels of G4 are at the lowest level among the metabolic syndrome induced groups. In the light of these results, it can be said that, anaerobic exercises are more effective to reduce the increased betatrophin levels in metabolic syndrome and preventing the complications that may arise from the increase of betatrophin, and creating exercise programs to be applied to individuals with metabolic syndrome using anaerobic exercises would be a more effective treatment or a prevention method of metabolic syndrome. Betatrophin, a protein originated from liver and adipose tissue, can be predicted as a biomarker that its levels should be kept under control in order to prevent dyslipidemia in individuals with metabolic syndrome due to its effects on triglyceride and glucose metabolism. Besides, a positive correlation between increased uric acid levels and betatrophin levels were determined in G2. This positive relationship suggests that betatrophin increases in circulation as a complication of fructose metabolism. However, a negative correlation in HDL-C levels and betatrophin levels were determined in G2. It is possible to associate the deterioration in the lipid profile of the same group with the increase in betatrophin in the circulation. Considering the changes in lipid profile and betatrophin levels of exercise groups, it can be said that anaerobic exercises are a more effective method in the treatment of dyslipidemia caused by the role of betatrophin in metabolic syndrome. In the same vein, Sertogullarindan et al. [29] stated that high levels of betatrophin have a central role in dysregulating serum lipid levels.

Abu Fahra et al. [30] reported in their research that the betatrophin levels of the individuals with metabolic syndrome were higher than the control group and that high betatrophin levels were associated with C-reactive protein and metabolic syndrome components; moreover, the role of betatrophin in metabolic and inflammation pathways were reported in the study. On the other hand, Wang et al. [31] argued that the disease occurs by increasing the level of metabolic syndrome components by decreasing betatrophin

levels, unlike our study. In another study held by Hu et al. [32], in which aerobic exercises were applied to individuals with type 2 diabetes and obesity for six months, five days a week and for at least 30 min a day, it was reported that the betatrophin levels of the exercise group decreased significantly at the end of six months of exercise compared to the pre-exercise levels.

When the statistical analysis of the serum cartonectin levels of our research groups was examined at the end of the six week exercises, it was determined that there was no statistically significant difference between the groups. However, it was seen that the cartonectin levels of G2 and G4 were higher than the other groups. The correlations in the levels of cartonectin and total cholesterol in G2 can be related to the anti-inflammatory effect of cartonectin. Similarly, Tan et al. [33] also reported a correlation between cartonectin and total cholesterol levels. Furthermore, in the study held by Yoo et al. [34] it was reported that serum cartonectin was significantly negatively associated with total cholesterol levels.

As for the cartonectin levels, Hasegawa et al. [12] reported that the cartonectin levels of the exercise group increased statistically significantly at the end of the applications in their study, in which aerobic exercises were applied to middle-aged and elderly individuals, three days a week and 55 min a day for eight weeks. In the study held by Choi et al. [11], in which a combined exercise program including three month aerobic and resistance exercises were applied to obese women, the levels of cartonectin were examined. The participants performed aerobic exercise on the treadmill for 45 min a day, five days a week, with loads of 60–75% of their heart rate. In addition, 20 min of strength training was applied in combination with aerobic exercise. It was reported that there was no statistically significant difference in cartonectin levels of obese and non-obese women, while a statistically significant decrease was reported in obese women with combined exercises. However, it has been reported that cartonectin levels correlate with age, gender, triglyceride, LDL-C, and adiponectin levels.

The strongest aspect of this research is that it is a novel study in which betatrophin and cartonectin are discussed together in terms of metabolic syndrome and changes in exercise practices. In particular, analyzing aerobic and anaerobic exercises comparably is an important feature of the study. Additionally, it is one of a limited number of studies involving different exercise types and metabolic syndrome, especially in terms of cartonectin.

As the number and the gender of the animals used in the study could be a limiting factor, it might be suggested to involve more subjects and both genders for further

studies. It might also be suggested that the longer the duration of exercise applications, the better the effects could be understood. The presented research focused on changes after six weeks of exercise, three days a week. Studies in which exercise durations are designed differently might provide results that show different aspects of the changes in betatrophin and cartonectin levels.

Conclusions

As the findings of the present study indicates, it could be thought that anaerobic exercises are more effective in reducing glucose and triglyceride levels than aerobic exercises, and this effect is shown by regulating betatrophin levels. When the literature is reviewed, the number of studies examining the change in betatrophin with exercise in metabolic syndrome is limited. Especially in terms of anaerobic exercises, our research will contribute to the literature on this subject.

When the effects of two different loads of exercises in terms of levels of cartonectin, which is known as an anti-inflammatory adipokine were analyzed, it was found that the cartonectin levels increased with anaerobic exercises and decreased with aerobic exercises. Moreover, it was found that the group with metabolic syndrome, which did not do exercise, also had high levels of cartonectin. The present study is one of the distinctive studies investigating cartonectin levels with metabolic syndrome and exercise applications together.

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Author contributions: Muhammed Emre Karaman, Cengiz Arslan, and Mehmet Ferit Gürsu 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.

Competing interests: Authors state no conflict of interest.

Informed consent Not applicable.

Ethical approval: The research related to animal's use has complied with all the relevant national regulations and institutional policies for the care and use of animals (Firat University Animal Experiments Local Ethics Committee (Meeting Number: 2018/05, Decision No: 60, Protocol No: 2108/27)).

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