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Effects of Aerobic Exercise on Oxidant/Antioxidant Status in Obese Boys: A Controlled Trial

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Abstract

It is unclear how the aerobic exercise program effects oxidative stress and antioxidant defense parameters in obese children; therefore, our objective is to examine the effects of aerobic exercise on parameters of oxidative stress and antioxidant in obese boys. Our study included 10 obese boys, aged from 13 to 15, and 10 healthy boys as a control group. Before and after exercise, 10 ml blood specimens were taken from the obese boys, who exercised 3 days/week for 12 weeks. 10 ml blood specimens were also taken from the healthy control group. The oxidative stress and antioxidant defense parameter levels in blood samples were measured for both groups. In our study, it was found that the control group and obese children after aerobic exercise had significantly higher superoxide dismutase, catalase, glutathione peroxidase, and paraoxonase-1 values than those of obese boys before aerobic exercise. On the other hand, it was found that after aerobic exercise, the control group and obese children had significantly lower malondialdehyde, nitric oxide, and carbonyl values than those of obese boys before aerobic exercise. When these findings are taken into account, it may be suggested that aerobic exercise regulated oxidative stress and improved the state of antioxidant status in obese boys.

Key words: *Childhood obesity, Oxidative stress, Antioxidant, Regular exercises, Carbonyl*

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Introduction

Obesity, resulting from excessive fat storage in the body, is an unresolved clinical condition affecting the health of children and adults. Childhood obesity prevalence has increased all over the world recently, especially in the developed countries. The lack of physical activity, which has a negative effect on maintaining a healthy lifestyle, and high-calorie food intake are among the reasons for obesity (1).

The effect of oxidative stress and oxidants, which occur due to various reasons, has proven to be causing the development of various complications in obese individuals (2). Reactive oxygen species (ROS) creates oxidative damage in carbohydrates, proteins, and lipid molecules. The lipid peroxidation and carbohydrate oxidation products, formed by the action of ROS, constitute modifications in the amino acid content of protein and cause an increase in carbonyl content of plasma protein (3).

Genetic studies have found some enzyme genes affected by exercises and physical fitnesses (4). One of them is the serum paraoxonase-1 (PON-1) enzyme, which proved to have an antioxidative function in humans. HDL-related PON-1 enzyme, formed under oxidative stress, has an effect to reduce hydrogen peroxide (H_2O_2). Previous studies examining the effect of exercise on oxidative stress and antioxidative defense system mostly focused on aerobic exercise form. Aerobic exercise has been shown to strengthen the antioxidative defense system and inhibit damage caused by oxidative stress (5).

The primary components of the physiological antioxidative defense are catalase (CAT), glutathione peroxidase (GPx), and superoxide dismutase (SOD). Antioxidative protection of skeletal muscles in humans is weak; therefore, skeletal muscles may easily be subjected to oxidative stress (6). Acceleration of energy in metabolism during aerobic exercise increases the concentration of free oxygen radicals in cells, so this situation increases lipid peroxidation rate causing muscle damage (6). Nitric oxide (NO) is the most important molecule in the human body. It penetrates almost all organs from the heart to the lungs. It relaxes the vessels, decreases the risk of stroke or heart attack, and lowers blood pressure (7).

Several *in vitro* and *in vivo* human and experimental investigations demonstrated that exercise increases the production of lipid peroxidation, ROS and whole-body oxygen consumption. On the other hand, regular physical training leads to an increase in antioxidant enzyme activities (8).

The examination of benefits and arrangement of exercise programs will provide practical data for the literature to prevent heart disease, which is quite common all over the world, and strengthen antioxidant metabolism. Regular exercise is known to empower antioxidant metabolism. Although the impacts of exercise on antioxidative and oxidative stress parameters in obese adult individuals have been investigated before, in terms of these parameters, there is no satisfactory study on the effects of exercise in obese children. However, how regular exercise affects the oxidant/antioxidant status is still not completely obvious in obese children. Considering these aspects, the present investigation was conducted to evaluate the impacts of a 12-week aerobic activity program on serum levels of SOD, CAT, GPx, malondialdehyde (MDA), C=O, NO and PON-1, on 13-15 years old obese boys.

Materials and methods

Study Design

The study group consisted of 10 boys, diagnosed with obesity (aged 13-15) and receiving education in a private middle school in Nevsehir province, Turkey. Ten healthy children, who were students at the same school, gender and age-matched, were also included in the research as the healthy control group.

Data Collection

This study was carried out in Erciyes University, Faculty of Pharmacy, Biochemistry Department Laboratories and Nevşehir Special Versa Hospital. The study protocol was approved by the Ethics Committee of Medical Faculty of Erciyes University (approval number and date: 684-2012/06.11.2012). Before starting the research, GPx activity results from previous studies (9), which conduct on obese children, were taken into consideration. A sample size of 7 reaches 95% power to detect a mean of paired differences of 4.7(0.25) with a known standard deviation of differences of 3 (0.15) and with a significance level (alpha) of 0,05000 using a Wilcoxon test (A paired t-Test) assuming that distribution is normal (10). As a result of these calculations, it started to work in groups of 20 children in both groups in priority, but then some of the individuals who did not work regularly and do not fully comply with the exercise instructions were excluded from the study and finally, the examination was terminated with 10 children in both group who complied with the working procedures. No restrictions were imposed on the dietary regulation of children, and they were able to continue their eating habits.

The body weights and heights of the children included in the study were measured with G-TECH brand and GL-150 model electronic weighing and stadiometer. Specific BMI percentile curves prepared for children and adolescents, and adjusted according to their ages and sexes, were used (11).

Exercise protocol and training arrangement

The fitness levels of obese children were determined according to physical activity readiness inventory, physical activity index, and physical fitness (Table 1). In order to increase the level of physical fitness, the training intensity must be 130 beats/min and above. For this reason, moderate aerobic exercises were applied on a running band by following polar brand pulse counting time between 130-150 beats/min. The maximal oxygen using (Max VO_2) levels of obese children were determined by 20 m shuttle running test (12). It was built at optimum level of exercise in order to obtain the targeted level of fitness. For each obese child, the optimal fitness status was determined using the Karvonen formula (13).

With the help of the obtained results, a personal exercise prescription for each obese boy was created using a personal exercise protocol chart (12). In each training unit, 400 kcal of energy loss was targeted, and participants tried to reach 1200 kcal of energy loss per week. These calculations are based on the mentioned graphics, tests, and the fitness scores of obese boys (12, 13).

An exercise session consists of the following sections:

1. Warm-up (5-10 min.)
2. Condition (20-60 min) (aerobic exercises, muscle strengthening, and endurance exercises)
3. Cooldown (5-10 min.)

Table 1: Physical activity readiness inventory and physical fitness (Score = Violence x time x frequency)..

Questions	
1-Did your doctor tell you that you have a problem with your heart and that you can only do physical activity with a doctor's check?	If ones has given all the answers to no questions, ones can start training in physical activity with coach control. If ones answer yes to a question, ones can start training by consulting your doctor and your coach at the check of your doctor. If ones say yes to two or more questions, ones can only start the exercise with the supervision of your doctor.
2-Do you feel pain in your chest during physical activity?	
3-Did you feel chest pain in case you did not physical activity last month?	
4-Have you lost your balance due to dizziness or loss of consciousness?	
5-Do you have a bone or joint problem that will change your physical activity?	
6-Did your doctor recommend medication for your blood pressure or your heart?	
7-Do you have any reason not to participate in physical activity?	

Evaluation of physical activity index and physical fitness		
Intensity	**Continuance**	**Frequency**
(5) Continuous Deep Breathing and Sweating	(4) 30 min or over	(5) Everyday
(4) Intermittent Deep Breathing and Sweating (Tennis)	(3) 20-30 min	(4) 3-5 times a week
(3) Normal (Cycling)	(2) 10-20 min	(3) 1-2 times a week
(2) Normal (Volleyball)	(1) 10 min or less	(2) Several times a month
(1) Light walking etc.		(1) Less than one month

Laboratory measurements

The fasting blood specimens were also taken from the exercise group in the morning of the first day after the end of the exercise. Afterward, blood samples were allowed to clot and centrifuged at 4000 g as usual. Yellow and clear serum specimens were selected and both lipemic or haemolysed specimens were excluded. The serum specimens were kept at −70°C for evaluation of oxidative stress and antioxidative defense parameters.

Determination of SOD, CAT, GPx, and PON-1

Obese children were given aerobic exercise for 3 days a week for 12 weeks, and 10 ml blood samples were taken twice (pre-test and post-test). SOD activity was measured using the method described by Sun et al. (14). The activity of CAT was measured using the technic described by Yasmineh et al. (15). The activity of glutathione peroxidase was determined using the technic described by Paglia et al. (16). The activity of PON-1 was determined using the technic described by Eckerson et al. (17).

Measurement of Carbonyl, MDA, and NO

The levels of the protein carbonyl group were measured using the technic described by Evans et al. (18). Malondialdehyde was determined using the technic described by Yoshoiko et al. (19). Nitrite and nitrate measurements were measured using the method described by Smarason et al. (20).

Statistical Analysis

Statistical analyses were conducted using SigmaStat 3.5 and SPSS software version 15.0 statistical packages. For calculate sample size in this study, a power analysis was performed with GPower software 3.1 (Düsseldorf University, Germany). The normality of the data was evaluated by the Kolmogorov-Smirnov Test. The values of the groups were compared with the independent sample t-test. The Mann-Whitney U test was used for intergroup comparisons of continuous data. Wilcoxon test was used for pre-and post-exercise

comparison in obese children. The chi-square test was used for the evaluation of difference in the distribution of categorical variables. Statistical significance was determined as 0.05.

Results

Sociodemographic data and biochemical parameters of study groups are shown in Table 2. We found that there was no significant difference between the groups in terms of gender, age, educational status, and socio-demographic data. The ages of healthy volunteers and obese children were 13-15 (mean: 14±1.0 years), and all were male.

Table 2: Comparison of study groups in terms of sociodemographic data and biochemical parameters.

Parameters	Study Groups			Comparisons		
	Control (*n*=10)	Pre-exercise (*n*=10)	Post-exercise (*n*=10)	Control/ pre-exercise *p*	Control/ post-exercise *p*	Pre-exercise / post-exercise *p*
Age	14±1.0	14±1.0	14±1.0	1.000	1.000	1.000
Gender (G/B)	0/10	0/10	0/10	1.000	1.000	1.000
Height (cm)	170±3.45	170±2.90	170±2.90	0.985	0.985	1.000
Education time (year)	7.00±2	7.00±2	7.00±2	1.000	1.000	1.000
Weight (kg)	68±2.75	90±2.87	84±2.02	<0.001	<0.001	<0.001
BMI (kg/m^2)	23.5±2.06	31.1±1.05	29.2±1.02	<0.001	<0.001	0.059
SOD (U/ml)	9.17(9.19-9.21)	7.21(7.22-7.25)	8.88(8.93-8.95)	<0.001	0.034	<0.001
CAT (U/ml)	3.17(3.18-3.19)	2.5(2.53-2.55)	3.01(3.04-3.07)	<0.001	<0.001	<0.001
GPx (U/ml)	142.3±1.31	132.2±1.44	140.5±1.76	<0.001	0.034	<0.001
PON-1 (U/ml)	130.6±3.61	106.0±3.90	111.4±2.41	<0.001	0.004	<0.001
Carbonyl (µmol/L)	92.44±0.96	101.5±2.41	93.4±2.40	<0.001	0.547	<0.001
MDA (nmol/ml)	3.79(3.81-3.87)	4.91(4.97-4.98)	3.71(3.74-3.75)	<0.001	0.001	<0.001
NO (µmol/L)	41.8(42.4-42.7)	52.6(53.3-54.1)	39.6(40.2-41.7)	<0.001	0.055	<0.001

The data are presented as mean±standard deviation or median (25th-75th percentil) for continuous variables. BMI: Body Mass Index, CAT: Catalase, GPx: Glutathione Peroxidase, MDA: Malondialdehyde, NO: Nitric oxide, PON-1: Paraoxonase-1, SOD: Superoxide Dismutase.

The median (25^{th}-75^{th} percentile) levels of SOD and CAT of the controls were significantly higher than pre-exercise and post-exercise SOD and CAT levels of obese children ($p<0.001$). Nevertheless, the median level of (25^{th}-75^{th}percentil) SOD and CAT in obese children after exercise was found to be closer to those of the control values. The median (25^{th}-75^{th} percentile) level of SOD and CAT in obese children after exercise was shown to be significantly higher than those of pre-exercise ($p<0.001$; Table 2).

The mean levels of GPx and PON-1 in the control group were significantly higher than pre-exercise and post-exercise GPx and PON-1 levels of obese children ($p<0.001$; Figure 1). Nevertheless, the mean post-exercise GPx and PON-1 levels of obese children were found to be closer

to those of the control values (p=0.034 and p=0.004, respectively). The mean GPx and PON-1 levels of obese children after exercise were shown to be significantly higher than those of pre-exercise (p<0.001; Table 2).

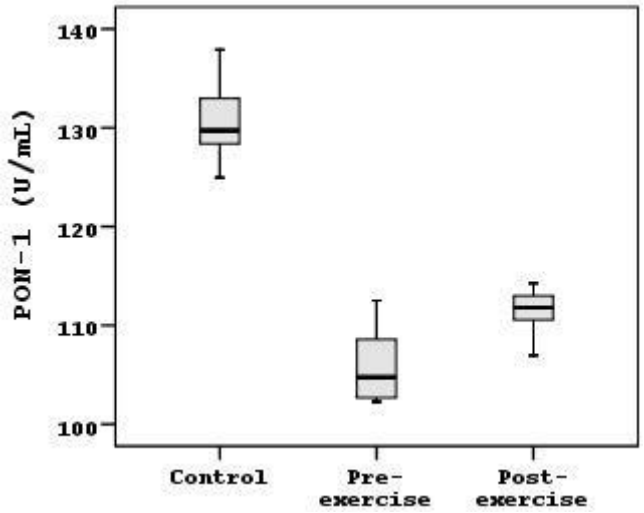

Figure 1. Comparison of study groups in terms of PON-1 levels. PON-1: Paraoxonase-1.

The mean level of carbonyl and median (25^{th}-75^{th} percentile) NO level of the control group was significantly lower than pre-exercise carbonyl and NO levels of obese children (p<0.001). On the other hand, there was no significant difference between the control group and post-exercise in terms of the carbonyl and NO levels (p=0.547 and p=0.055; Figure 2 and Figure 3, respectively). Moreover, the median (25th-75^{th} percentile) level of NO in post-exercise was lower than those of the control group (p=0.055). The mean level of carbonyl and median (25^{th}-75^{th} percentil) level of NO in obese children after exercise was found to be significantly lower than those of pre-exercise. The median (25^{th}-75^{th} percentile) MDA level of the controls was significantly lower than pre-exercise MDA levels of obese children. On the other hand, the median (25^{th}-75^{th} percentile) post-exercise MDA levels of obese children were significantly lower than those of the control group and pre-exercise obese children (p<0.001; Table 2; Figure 4).

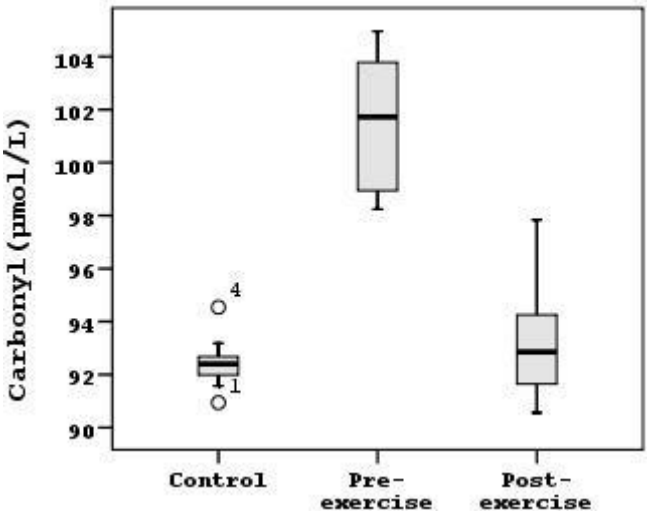

Figure 2: Comparison of study groups in terms of carbonyl levels.

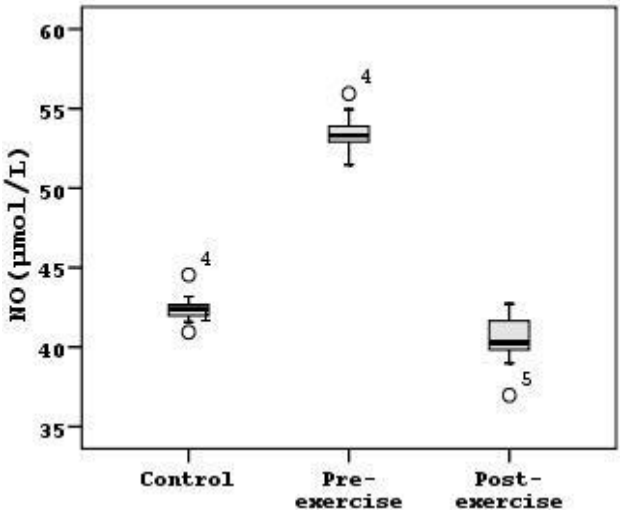

Figure 3: Comparison of study groups in terms of NO levels. NO: Nitric oxide.

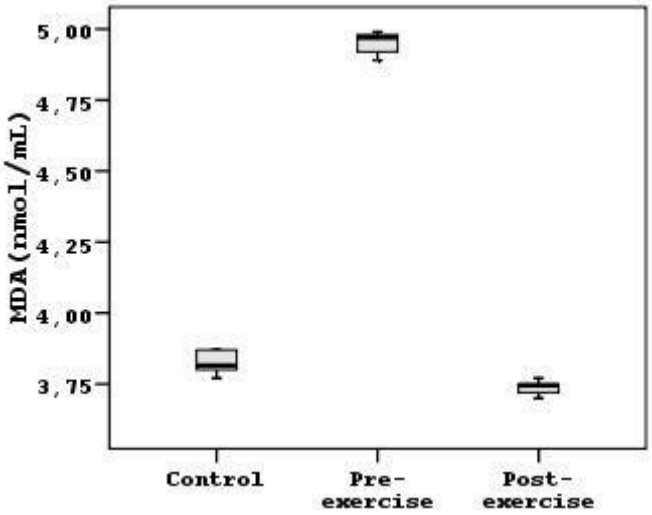

Figure 4: Comparison of study groups in terms of MDA levels. MDA: Malondialdehyde.

Discussion

The findings of the present investigation provide a demonstration of reduced oxidative stress status for obese children after 12 weeks of physical exercise as shown with an increase in activity of antioxidant enzymes but a decrease in levels of oxidative stress markers.

In the first measurements of our study, we found that the levels of SOD, CAT, GPx, and PON-1 in obese boys were significantly lower than the control group, and consistent with these findings; and we found out that obese boys had significantly higher carbonyl, MDA and NO levels than controls.

Oxidative stress occurs under physiological conditions and in pathological processes including obesity and damage to different organs (2). Similar results with our findings were reported in the group of prepubertal obese children who had a significant decrease of GPx and SOD activities, and antioxidant/oxidant status was significantly altered in obese children. Analogously, it was reported that previous studies on oxidative stress established significantly higher concentrations of MDA, ox-LDL, carbonyl, advanced oxidation protein products, and lower concentrations of enzymes with antioxidative activities, such as SOD, CAT, and GSH in children with obesity than non-obese ones (21). Rowicka et al. showed that prepubertal children with obesity already have a greater intensification of oxidative processes measured by total oxidant capacity concentrations and oxidative stress index values, while they simultaneously have lowered antioxidant defense measured by total antioxidant capacity concentrations compared with non-obese children (21). They also found a positive correlation between obesity duration and total oxidant capacity concentration, and they suggested that these findings may confirm the intensification of oxidative processes along with the duration of obesity occurrence not only in adults but also in children (21). This is concordant with the findings of Kilic et al. (22). They showed that oxidative stress markers and antioxidant activities were significantly higher in the obese group compared to the control while oxidative stress index was not distinct between the groups.

Considering these aspects, it may be suggested that our results confirm previous findings in which oxidative/antioxidant activities are altered due to obesity in children.

The second most important finding of our study is that the demonstration of the increased levels of SOD, CAT, GPx, and PON-1 in obese children after exercise is higher than those of pre-exercise.

Anaerobic and aerobic exercises in association with weight loss have been shown to be beneficial in the improvement of oxidative stress. It has been reported that oxidative stress has decreased in healthy obese adults following 24 weeks of resistance exercise (23), potentially due to decreases in total fat mass and/or increases in fat-free mass and maximal oxygen consumption (24).

Oh et al. reported that activity of the GPX enhanced following 6 months of regular exercise in obese women, while 12 weeks from moderate to high-intensity aerobic exercise reduced thiobarbituric reactive acid substances in obese individuals (25). Moreover, following regular training, acute exercise-induced increasing MDA levels were extenuated, while GPX and SOD enhanced levels than acute exercise-induced responses of pre-training.

In the present study, in compliance with the antioxidant enzyme findings, we determined that decreased levels of carbonyl, MDA, and NO were present in obese children after exercise when compared to those of pre-exercise.

To our knowledge, there is no similar study conducted on the effect of regular exercise on carbonyl, MDA and NO in obese children. Therefore, we think that our study findings will have great contributions to the literature.

Growing evidence demonstrated that regular training enhances the repair system and improves antioxidant status to recover from oxidative damage. When there was a weight loss, what caused significant skeletal and muscle-specific oxidative stress reduction in sedentary healthy obese adults was aerobic training for 3 months (26). It was exhibited by Youssef et al. that it was also adequate to have a moderate 3 months of regular exercise in the absence of weight loss to reduce training-induced increases of myeloperoxidase just after an acute bout of maximal aerobic training in obese and overweight adolescent girls when compared with pre-exercise girls (27). On the contrary, training without weight loss was not enough to enhance any oxidative stress markers in adolescents with obesity at the end of 3 months training course, in spite of making use of exercise in higher intensities (28). When handled together, powerful evidence supports a positive influence of aerobic training on redox balance. The training-induced adaptations of oxidative stress enhance the efficiency of the enzymatic antioxidant defense systems, after they lead to a greater mitochondrial capacity to scavenge free radicals.

In spite of all these, it can be suggested that regular exercise training have beneficial effects on reducing oxidative stress in our study. We can emphasize the fact that the results of this study demonstrate the positive effects of a correct exercise to be even more advantageous than the control group in terms of some oxidant parameters. In the present study, similar to oxidative stress parameter levels, the mean weight of obese children of post-exercise was significantly lower than pre-exercise obese children. On the other hand, it was stated that the antioxidant state shows differences depending on the type, size, and direction of exercise (29). Furthermore, the characteristics of the participants (gender, clinical disease status, and fitness or training levels) can affect the resultant amount of oxidization that occurs (30).

As far as we know, for the first time in this study, it was found that exercise can improve health in obese children including decreased lipid levels and protein oxidation markers, and increased antioxidant enzyme levels. However, this study has several limitations. Since this is a pilot study, we did not obtain any data about the nutritional status of study groups, and we did not make any arrangements about their diets. Moreover, the study population was small, for this reason, many more subjects are needed for the follow-up study, which should include the nutritional modification to examine the association between oxidative stress and exercise benefit.

In conclusion, the findings of this study are very interesting because it was performed strictly with obese children, who could have more oxidative stress conditions than lean subjects. Long-term exercise training regulated oxidative stress, however, improved the state of antioxidant status in obese boys. Nevertheless, examining the effect of regular exercise between different

gender groups of obese children having similar nutritional forms might be more precious and deserves further investigation.

Conflict of interest

The authors declare that no conflict of interest exists.

Acknowledgement

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