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Acute effects of aerobic and two different anaerobic exercises on respiratory muscle strength of well-trained men

ÖZDAL Mustafa

Physical Education and Sport Department, Gaziantep University, Gaziantep, Turkey
Corresponding email: *ozdalm@hotmail.com; mustafaozdal@gantep.edu.tr*

ABSTRACT

The acute effects of aerobic and anaerobic exercises on respiratory muscle strength were examined in 24male subjects using the maximal inspiratory pressure (MIP) measurement in four different trials. The trial 1 was initial level of MIP and did not involve acute exercise. The trial 2 (aerobic exercise), trial 3 (anaerobic exercise for lower extremities), and trial 4 (anaerobic exercise for upper extremities)involved acute exercises before MIP measurement. Repeated measures one way analysis of variance test and Bonferroni correction were used for statistical analysis. Significant decreases in the MIP were found between the trial 1 and the other trials ($p<0.05$). Percent change of the trial 2, trial 3, and trial 4 were by-9.17%, -15.18% and -22.87% respectively, from the trial 1. Percent change of the trial 2, trial 3, and trial 4 of the eight subjects who had higher MIP value were by -6.00% , -7.40%, and -12.87 respectively, from trial 1. Percent change of the trial 2, trial 3, and trial 4 of another selected six subjects who had lesser MIP value were by -11.30%, -17.74%, and -26.10% respectively, from trial 1.These results show that the aerobic and anaerobic acute exercises negatively affect respiratory muscle strength. Nevertheless, it could be said that stronger respiratory muscles show lesser decrement in muscle strength.

Key Words: Exercise, Respiratory muscles, Maximal inspiratory pressure, Strength

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INTRODUCTION

During sportive activity, O_2 amount has to increase when O_2 demand of tissues increase. The respiratory system has to efficiently work for the requirement of tissue[1]. From this perspective, working of the respiratory system is mechanically depending on capacity of the respiratory muscles [2].

Besides, respiratory muscles are vital and affect exercise tolerance [3]. Respiratory work increases during high intensity exercise. This situation creates respiratory muscle fatigue. The respiratory muscle fatigue causes failure to sending adequate O_2 to tissue. When the respiratory muscle exhausted, athlete loses amount of energy capacity by 15% [4-7]. Also, when considering on the respiratory muscles use by 16% amount of O_2 intake during high intensity exercise, significance of the respiratory muscles strength can be explained [8].

Previous studies about of the respiratory muscle strength were carried out with gender aspects [9-11]or/with maximal exhaustive exercises [12-14], but not carried out the aerobic and anaerobic exercise types. It could be hypothesized that acute exercises may negatively affect the respiratory muscle strength, and that anaerobic acute exercise for upper extremity may be has higher effect on the respiratory muscle strength. The present study aimed to investigate the acute effects of the aerobic and anaerobic exercises on the respiratory muscle strength in well-trained men.

MATERIALS AND METHODS

Experimental Design:
This study was designed as a randomized crossover study. The subjects visited the laboratory five times. During their first visit, they were familiarized with the maximal inspiratory pressure (MIP) test and acute exercises. During the second visit (trial 1), a MIP test was performed without acute exercise, and was considered as initial level of MIP. During the third, fourth and fifth visits, the subjects randomly performed acute exercises as aerobic (trial 2), anaerobic for lower extremities (trial 3), and anaerobic for upper extremities (trial 4). MIP test was immediately performed again after the exercise trials. The trials were applied at the same time each day (between 13:00 and 16:00 h). Exercise and high-intensity physical activity were not allowed before the trials.

Subjects:
A total of 24 well-trained athletes voluntarily participated in this study (Table 1). The subjects were included if they had a competitive volleyball history of at least 10 years, were currently volleyball training at least five times per week for a minimum of 2 hours per day. The subjects were informed about of the MIP measure and acute exercises2 days before the study. Ethical approval was obtained from Gaziantep Clinical Research Ethical Committee. Informed consent was obtained from all individual participants included in the study.

Table 1. Descriptive information of subjects (N = 24)

	Means ± SD
Age (years)	25.58 ± 3.80
Height (cm)	193.92 ± 6.57
Weight (kg)	89.08 ± 10.50
BMI (kg/m^2)	23.61 ± 1.60
MIP (cmH$_2$O)	151.75 ± 13.49
$VO_{2\ PEAK}$ (ml/kg/dk)	42.66 ± 9.27
Peak power (W/kg)*	11.69 ± 1.23
Average power (W/kg)*	7.89 ± 0.41
Peak power (W/kg)†	9.51 ± 1.96
Average power (W/kg)†	4.50 ± 0.47

**for lower extremities, †for upper extremities*
BMI: Body mass index, MIP: Maximal inspiratory pressure, $VO_{2\ PEAK}$: Peak oxygen uptake

Procedures:
Maximal Inspiratory Pressure (MIP) Measurement
MIP was measured with the respiratory pressure meter (Micro RPM, CareFusion Micro Medical, Kent, UK), according to the 2002 guidelines of the American Thoracic Society and European Respiratory Society [15]. Measurement started from the residual volume. The nose was occluded throughout the effort. In order to obtain the best value, all subjects performed three to five attempts for not more than a 5% difference between two attempts. An average of three acceptable attempts was used as the MIP value [16].

Aerobic Exercise (trial 2)
Aerobic exercise was carried out with ergoline cycle (Sana Bike 450F, Ergosana GMBH, Bitz, Germany) and ergospirometre (Ergo100 PFT System, Medical Electronic Construction R&D, Brussel, Belgium). Subjects performed warm-up at least 5-10 minutes before exercise. Exercise load was started at 50 W and increased by 25 W/min. The subjects cycled at 60 rpm during the entire exercise time. When the subjects felt exhaustion, the exercise was stopped [17].

Anaerobic Exercise for Lower Extremities (trial 3)
Anaerobic exercise for lower extremities was applied with cycle ergometer (894E Peak Bike, Monark Exercise AB, Vansbro, Sweden) and Wingate test procedure. Before exercise, cycle seat and handle bar was adjusted for each subject. Resistance load was set at 7.50% of subject's body weight. The subjects performed warm-up approximately 5-10 minutes. When subject felt warming up, seated to cycle and pressed to cycle button for drop 7.50% load. After than subject pedaled as fast as possible while seated for 30 seconds. During 30 seconds exercise time, operator provided verbal encouragement to maximal effort of subject [18].

Anaerobic Exercise for Upper Extremities (trial 4)
Anaerobic exercise for upper limb was performed with arm ergometer (891E Cardio Rehab, Monark Exercise AB,

Vansbro, Sweden) and Wingate test procedure. Before exercise, resistance load was set at 5% of subject's body weight. Subject performed warm-up approximately 5-10 minutes. After warm-up, subject seated and started to crank. When subject prepared, operator pressed to button and after than subject arm cranked as hard and fast as possible while seated for 30 seconds. During 30 seconds exercise time, operator provided verbal encouragement to maximal effort of subject [18].

Statistical Analyses:

SPSS version 22.0 (SPSS Inc., Chicago, IL) program was used for statistical analyses. The data were expressed as the mean, standard deviation, and percentage of mean difference. The Shapiro-Wilk test was used for assessing normality. Repeated measures one-way analysis of variance test and Bonferroni correction were used for analyzing the differences in the PFT measurements among the trials. Significance was defined as $p \leq 0.05$.

RESULTS

Table 2. Differences in MIP between trials.

	Means ± SD (cmH_2O)	F	p	Significant difference between trials*
Trial 1	151.75 ± 13.49			
Trial 2	139.00 ± 15.69	**49.529**	**0.001**	1 - 2, 1 - 3, 1 - 4
Trial 3	131.75 ± 18.12			2 - 3, 2 - 4
Trial 4	123.50 ± 19.74			3 - 4

* 1: Trial 1 2: Trial 2 3: Trial 3 4: Trial 4

Comparison of trials in the MIP has presented Table 2.MIP was observed 151.75 ± 13.49 cmH_2O in the trial 1, 139.00 ± 15.69 cmH_2O in the trial 2, 131.75 ± 18.12 cmH_2O in the trial 3, and 123.50 ± 19.74 cmH_2O in the trial 4. There were statistically significance between the trial 1 and other trials, between the trial 2 and the trial 3, trial 4, and between the trial 3 and the trial 4 ($p < 0.05$). When the trial 1 assume as base level of the MIP; percent change of the trial 2 was by -9.17% from the base, the trial 3 was by -15.18% from the base, and the trial 4 was by -22.87% from the base (Figure 1).

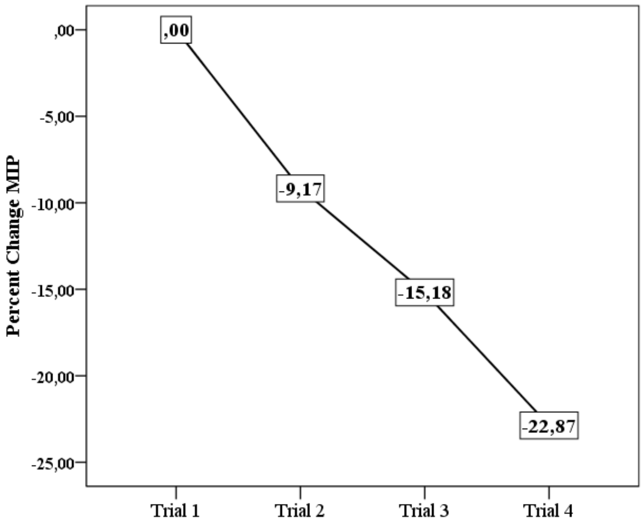

Figure 1. Percent change (%) in maximal inspiratory pressure (MIP) between trials.

Percent change in the MIP parameter between four trials of important sixteen subjects has shown in Figure 2. Eight of them were picked up in the highest MIP values at the trial 1, and presented the dotted line. Other 8 subjects were selected in the least MIP values at the trial 1, and showed the straight line. This selection was preferred for separate subjects to two groups according to their respiratory muscle strength. It means that if a subject has higher MIP value than another, the subject has more respiratory muscle strength than another. According to this decomposition, subjects who had more respiratory muscle strength have respectively decrement of by -6.00% in trial 2, by -7.40% in trial 3 and by -12.87% in trial 4 while other subjects who had less respiratory muscle strength have respectively reduction of by -11.30% in trial 2, by -17.74% in trial 3 and by -26.10% in trial 4.

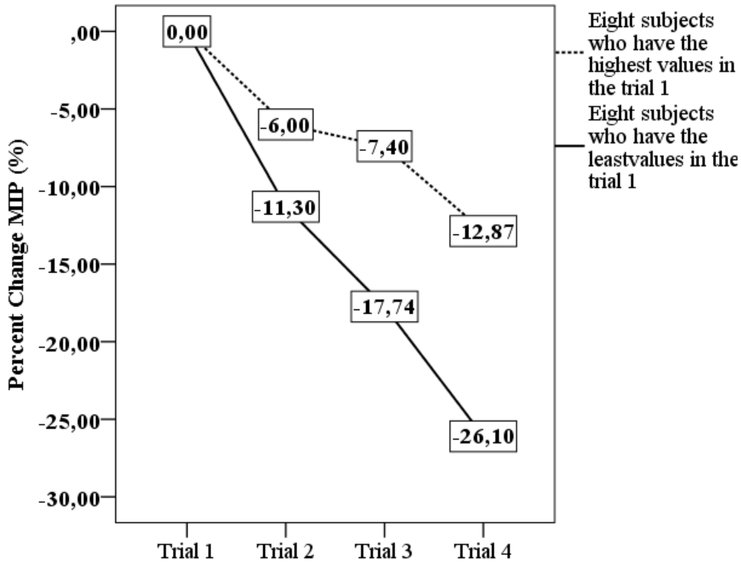

Figure 2. Percent change in maximal inspiratory pressure (MIP) between trials of 8 subjects who had the highest values in the trial 1 (dotted line) and 8 subjects who had the least values in the trial 1 (straight line).

DISCUSSION

Significant decrements were observed in the MIP between initial level and acute exercise trials in the present study ($p < 0.05$). All exercise types caused acute decrease in the MIP from the initial level. It is similar to the previous studies [9-14]. These results are more understandable in Figure 1. Initial level of MIP was trial 1 and it was accepted base. After aerobic exercise, decline by -9.17% was observed in the MIP. The aerobic exercise had smaller effect than the anaerobic exercises. The trial 3, which was anaerobic exercise trial for lower extremity, had medium effect on the MIP, because of trial 3 affected by -15.18% to the MIP. After the trial 4 that was anaerobic exercise trial for upper extremity, decrement was observed by -22.87% in the MIP. It should be noted that the highest decline was observed in the trial 4. On the other hand the aerobic exercise caused the least decrease from the initial.

It is considered that reason of smaller effect of aerobic exercise on the respiratory muscles is about of warm-up effect. The subjects performed general warm-up before aerobic exercise. Also, the aerobic exercise procedure was starting from mild to heavy intensity. It is believed that these reasons created warm-up effect on the respiratory muscles. Warming-up provides increment in blood flow and higher temperature. Thus, the neural activity that affects ability to contracting of muscle may increase, and produced power is efficiently used[19-21]. Furthermore, a previous study reported that the warm-up can remove reflex inhibition of the respiratory muscles, and may positively affect inter-intra muscular coordination[22].

It is believed that the effects of the anaerobic exercises, especially for upper extremities, were sourced some reasons. One of them is the anaerobic exercises had without warm-up effect on the respiratory muscles. It is known that every 1ºC decrease in the muscle temperature may reduce anaerobic power by 5% [23]. Higher temperature may have positive effects on the metabolic reactions, extensibility of connective tissue, muscle viscosity and velocity of action potentials [24]. In this study, subjects performed the general warm-up before the anaerobic exercises with Wingate procedure. The Wingate procedure, by contrast with the aerobic exercise, is very high intensity and suddenly give the intensity. In this situation, rhythmically contracted respiratory muscles [25] contribute trunk muscles as unrhythmically for the peak performance. This new task could stress on the respiratory muscles. The respiratory muscles are specialized for win over elastic load, while other skeletal muscles are specialized to mobility [26]. The effect of the anaerobic exercises on the respiratory muscles may occur from this reason.

Present studies showed that the upper body trunk muscles are responsible for supporting to rising demands of the breathing [27-29].Besides, a recent research reported that the respiratory muscle fatigue can induce fatigue in the trunk muscles [30]. When viewed from this perspective, it could be believed that the reason of the bigger decrement of the respiratory muscle strength in the anaerobic exercise for upper extremity was sudden and extreme fatigue in trunk muscles.

A previous study presented that the aerobic, anaerobic lactic and anaerobic a lactic energy metabolisms contribute exercise during Wingate procedure by 18.6%, 31.1%, and 50.3% respectively [31].Anaerobic exercise with Wingate procedure uses large amount of anaerobic energy metabolism, and causes occurring severe fatigue. The respiratory muscles have resistance to fatigue but have the resistance for oxidative capacity [32] not for the anaerobic glycolytic capacity. This may be another reason of the respiratory muscle strength decrement after anaerobic exercises.

Strong and resistant respiratory muscles can increase exercise capacity, because of delaying fatigue of the respiratory muscles and adequate amount of blood distribution on respiratory muscles. Thus, respiratory functions carry out easier [7,33-35].In the present study, the subjects who had the highest values of the MIP showed lesser decrease in the respiratory muscle strength in all acute exercise trials than subjects who had the least values of the MIP. According to this result, subjects who had stronger respiratory muscles could fall down in respiratory muscle fatigue more delayed.

CONCLUSION

In conclusion, it could be said that aerobic and anaerobic acute exercises negatively affect respiratory muscle strength. But the aerobic exercise has lesser effect than the anaerobic exercises. On the other hand, if an athlete has stronger respiratory muscle strength, decrease of respiratory muscle strength of athlete can be much lesser. At this point, athletes should practice exercises intended for developing their respiratory muscle strength in order to delaying respiratory muscle fatigue.

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