

Physiological responses to HIIT: Enhancing aerobic capacity alongside anaerobic power

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ABSTRACT

Aim: This study was accomplished to find out the effects of HIIT on both anaerobic and aerobic capacities separately. **Method:** Twenty-four healthy individuals between the ages of 18 and 25 participated voluntarily in this study. The volunteers took part in the study were split into two distinct groups as control group ($n = 14$) and experimental group ($n = 10$). A HIIT program, comprised of a single 90-minute session, three days a week was applied to the experimental group for a time period of 8 weeks. The control group, on the other hand, had no exercise intervention and they were instructed to pursue their daily life activities. Before exercises and after training program, the levels of height, body weight, body fat percentage, VO_{2max} , ventilatory threshold, respiratory compensation point, and anaerobic power of both groups were detected as required. **Results:** After relevant training program, a significant increase was observed in the experimental group in terms of the levels of maximum power (w/kg) and average power (w/kg) from Wingate anaerobic testing ($p < .05$). In addition, a significant increase was also observed in VO_{2max} (ml/kg/min) and respiratory compensation point VO_2 (ml/kg/min) values ($p < .05$). **Conclusion:** The results obtained hereby indicate that the practices of HIIT are effective particularly on anaerobic performance, but they also increase the aerobic performance. Employing the high-intensity interval training may be, therefore, beneficial for the athletes who do not have adequate training time as well as for the athletes who desire to reduce the duration and scope of training without experiencing any loss in VO_{2max} and performance levels during the pre-competition period. Furthermore, due to its favourable effects on cardiovascular health resulted from the increases in VO_{2max} , the high-intensity interval training also can be used in exercises of sedentary individuals, paying particular attention to the principles of loading.

Keywords: Cardiopulmonary exercise testing, Wingate anaerobic testing, Athletic performance.

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INTRODUCTION

Aerobic and anaerobic capacity are determining factors for energy utilization and athletic success in daily activities of individuals (McArdle et al., 2015). Aerobic capacity characterizes the efficiency of oxygen-utilizing systems, while anaerobic capacity refers to the efficiency of oxygen-free energy production processes (Brooks et al., 2005). Improving these two capacities plays crucial role in building up athletic performance (McArdle et al., 2015).

Endurance training are applied as a fundamental technique for augmenting the aerobic capacity. Endurance trainings are comprised essentially of aerobic activities that are exercised for a prolonged and at moderate-intensity (Bassett et al., 2000). Relevant training activities increase cardiac output, letting more blood to be circulated, support mitochondrial biogenesis in skeletal muscles, and increase the activities of oxidative enzymes. Aforesaid processes increase the aerobic metabolic capacity and as a result, significant surges are observed in VO_2max levels (Bassett et al., 2000).

The high-intensity interval training, on the other hand, intensely stimulates the anaerobic energy systems in muscles, contributing to the improvement of maximum power production, lactate buffering capacity, and anaerobic endurance (Laursen et al., 2002). It was noted, meanwhile, that the high-intensity interval training is also reported to promote central and peripheral adaptations for aerobic performance, such as mitochondrial biogenesis, increased oxidative enzyme activity, and capillary density (Gibala et al., 2006). Gibala et al. (2006) reported in their study that a protocol of short-term high-intensity interval training employed for a period of only two weeks provided significant increases in VO_2max levels (Gibala et al., 2006). Burgomaster et al. (2008) declared, meanwhile, that the high-intensity interval training program implemented three days a week for a period of six weeks improved oxidative capacity that contributing to the aerobic energy system, and the muscle biopsy data promoted relevant results (Burgomaster et al., 2008).

The high-intensity interval training is an exercise protocol in which short periods of high-intensity exercises and low-intensity recovery periods are consecutively repeated, unlike moderate-intensity aerobic activities (Thum et al., 2017). During exercises, each session ranges between 15 seconds and 4 minutes and aims to reach 80% to 95% of an athlete's maximum heart rate. Recovery time is typically equal to or slightly longer than the intense training interval and is realized through passive rest or low-intense exercises at 40% to 50% of maximum heart rate (Bayati et al., 2011). The high-intensity interval training has been attracting attention as an alternative to the traditional prolonged endurance exercises in recent years (Buchheit et al., 2013).

Fundamental objective of this study was to put forth the level of effectiveness of high-intensity interval training on both aerobic and anaerobic energy systems. This study was conducted herewith to assess the effects on both capacities individually, implementing only the high-intensity interval protocol.

METHODS

Participants and experimental design

Before starting the study, approval needed was obtained from the Sivas Cumhuriyet University Non-Interventional Clinical Research Ethics Committee dated December 14, 2022, with the decision number 2022-12/26. Twenty-four healthy individuals between the ages of 18 and 25 took part in the study as voluntary. Some specific incorporation criteria were applied to in selection of volunteers in order to minimize external variables that might affect relevant levels of physical fitness. In this regard, the participants were required to have not taken part in any regular physical activity in the last 12 months, not to have any

diagnosed chronic disease, and not to be under any ongoing pharmacological treatment. The volunteers participated in the study were separated into two categories namely as control group ($n = 14$) and experimental group ($n = 10$). The volunteers of experimental group were subjected to the high-intensity interval training program consisting, as detailed below, of a single unit 90-minute sessions lasting 3 days a week for a time period of total 8 weeks. The volunteers of control group, on the other hand, received no exercise and were allowed to pursue their routine life activities. Before starting the study, the levels of height, weight, body fat percentage, maximal oxygen consumption capacity (VO_{2max}), ventilatory threshold, respiratory compensation point, and anaerobic power of both groups were settled as required. After the high-intensity interval training program applied to the experimental group for 8 weeks, the measurements aforespecified were taken again from both groups.

Height and body weight measurement

Body weights of the volunteers took part in the study were measured using a brand Tanita BIA device with an accuracy of 0.1 kg, while they were barefoot and wearing only shorts. Their heights were measured by means of a tape measure with a sensitivity of 0.1 cm, while they were barefoot.

Body fat percentage measurement

Body fat percentages were measured using a brand TANITA Body Composition Analyzer. Before taking measurements needed, the volunteers were instructed not to eat anything for at least 4 hours, not to consume any beverages, including alcohol and caffeine-containing drinks, for at least 4 hours, not to enter saunas or take bath and to avoid physical activities during the day. During the measurements, the volunteers were instructed to stand barefoot on metal surface of the device, grasp handles of the device with both hands, and spread their arms parallel to their bodies. The data collected by the device throughout the measurement were recorded accordingly.

Maximal oxygen consumption test

A Maximal Exercise Test was accomplished on the treadmill to detect the levels of maximum oxygen consumption of the volunteers. Throughout the test, the gas exchange measurements of the volunteers were recorded by means of a Quark CPET gas analyser. The test was performed on a treadmill with an inclination of 0% and a starting speed of 7 km.h⁻¹. Then, the speed was increased by 1 km.h⁻¹ every minute, allowing the volunteers to keep exercising till exhaustion. The aspects basically as volunteers' achievement the maximal heart rate during the test, the respiratory exchange ratio (RER), which is the instantaneous ratio of carbon dioxide (VCO_2) and oxygen intake (VO_2) measured during expiration, reaching the levels higher than 1.10, and oxygen intake remaining constant despite increasing exercise intensity were all taken into account as the criteria for reaching VO_{2max} (Poole et al., 2017). The highest 15-second oxygen uptake value, in which at least two of these criteria occurred simultaneously, was accepted as VO_{2max} (ml.kg.min⁻¹). Exhaustion time was determined herewith as the total duration of the test.

Determination of ventilatory threshold and respiratory compensation point

The values of volunteers' ventilatory threshold were determined by means of the non-invasive V-Slope method during a treadmill Maximal Exercise Test (Beaver et al., 2016). The position of the VO_2 curve associated with VCO_2 is examined in accordance with this procedure. When relevant exercise is initiated, VCO_2 and VO_2 increase proportionally to each other, resulting with a slope of the curve representing the correlation between VCO_2 and VO_2 that is approximately equal to 1. However, when a certain level of exercise is reached, the correlation between VCO_2 and VO_2 begins to exhibit a steeper slope due to the nonmetabolic CO_2 released as a result of buffering of lactic acid-derived hydrogen ions accumulated with bicarbonate in addition to the CO_2 produced by aerobic metabolism. After plotting the VCO_2 (y-axis) curve corresponding to

VO₂ (x-axis), two regression lines with a slope equal to (or closest to) 1 and higher than 1 are generated by carrying out the linear regression analysis. The point of intersection of these two regression lines is taken into account as the ventilatory threshold. VO₂ (ml.kg.min⁻¹) value corresponding to the ventilatory threshold point, heart rate, and running speed (km.h⁻¹) are determined at this point. While the VE/VCO₂ ratio begins to increase when assessing the respiratory compensation point, the point at which PETCO₂ level begins to decrease is appointed as the respiratory compensation point. The levels of VO₂ (ml.kg.min⁻¹), heart rate, and running speed (km.h⁻¹) corresponding to the respiratory compensation point are settled accordingly (Hirakoba et al., 2002).

Determining anaerobic power levels

Anaerobic power levels of the volunteers were measured using the 30-second Wingate Anaerobic Test. After adjusting the resistance value on the ergometer to 75 g/kg, the volunteers were instructed to pedal as fast as possible for 30 seconds. The pedal counter recorded the relevant data every 5 seconds throughout the test. When the test was completed, the first 5 seconds of the data collected were taken into account as alactastic capacity and the remaining time was considered as lactacid capacity (Haff et al., 2022). After the test, the values of maximum power (W/kg), minimum power (W/kg), average power (W/kg), and power drop (%) were recorded accordingly.

Table 1. Contents of the high intensity interval training protocol.

Week	Session	Sets	Repetitions × Distance (m)		
1	1	1	5 x 20m sprint		
	2	1	5 x 20m sprint		
	3	1	5 x 20m sprint		
	4	2	5 x 20m sprint	5 x 20m sprint	
2	5	2	5 x 20m sprint	5 x 20m sprint	
	6	2	5 x 20m sprint	5 x 20m sprint	
	7	2	5x 20m sprint	5x 40m sprint	
3	8	2	5x 20m sprint	5x 40m sprint	
	9	2	5x 20m sprint	5x 40m sprint	
	10	2	5x 20m sprint	5x 40m sprint	
4	11	2	5x 20m sprint	5x 40m sprint	
	12	2	5x 20m sprint	5x 40m sprint	
	13	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
5	14	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
	15	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
	16	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
6	17	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
	18	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
	19	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
7	20	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
	21	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
	22	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
8	23	3	5x 20m sprint	5x 40m sprint	5x 60m sprint
	24	3	5x 20m sprint	5x 40m sprint	5x 60m sprint

Training protocol

The high-intensity interval training was applied only to the experimental group, three days a week for eight weeks, with a single unit of 90-minute training session. Before starting the exercises, the volunteers accomplished a 20-minute warm-up, a 50-minute high-intensity interval training session, and finally a 20-

minute cool-down. In the high-intensity interval training protocol applied, the first week covered a single set of 5x20m sprint runs; the second week two sets of 5x20m sprint runs; the third week the first set of 5x20m and the second set of 5x40m sprint runs; the fourth week the first set of 5x20m and the second set of 5x40m sprint runs, and the fifth, sixth, seventh, and eighth weeks the first set of 5x20m, the second set of 5x40m, and the third set of 5x60m sprint runs. The contents of high-intensity interval training program applied were presented in Table 1.

Statistical analysis

Initially, descriptive statistics of the data collected in the study were realized as required. Then, Shapiro-Wilk test, skewness, kurtosis, histogram, Q-Q, and P-P graphs were utilized to find out whether the data were normally distributed. Since the data indicated normal distribution, Paired-Samples T-Test was conducted to compare the values of both pre-training and post-training. The significance level was accepted as $p < .05$.

RESULTS

Age and height (cm) values of the volunteers took part in the study were given in Table 2.

Table 2. Descriptive information of volunteer groups.

	Experimental Group (n = 14)			Control Group (n = 10)		
	$\bar{X} \pm SD$	Min.	Max.	$\bar{X} \pm SD$	Min.	Max.
Age (Years)	21.71 $\pm$ 1.77	19	25	20.80 $\pm$ 1.55	19	23
Height (cm)	180.43 $\pm$ 5.43	172	192	177.60 $\pm$ 7.09	168	188

The results of body weight (kg) and body mass index (kg/m²) measurements the volunteer group were given in Table 3. The measurements revealed no significant difference both before and after the training program for both groups ($p > .05$).

Table 3. Body weight and body mass index measurement results of volunteer groups (n = 14).

		Pre-Training	Post-Training	t	p
		$\bar{X} \pm SD$	$\bar{X} \pm SD$		
Experimental group	Body Weight (kg)	72.42 $\pm$ 7.47	72.58 $\pm$ 7.76	-0.513	.619
	BKI (kg/m ²)	22.47 $\pm$ 1.84	22.52 $\pm$ 1.99	-0.559	.588
Control group	Body Weight (kg)	68.02 $\pm$ 9.36	68.54 $\pm$ 9.35	-1.288	.230
	BKI (kg/m ²)	21.63 $\pm$ 3.38	21.10 $\pm$ 3.58	1.619	.140

Wingate test results of the experimental group were submitted in Table 4. Accordingly, a significant increase was observed in maximum power (w/kg) and average power (w/kg) values of the experimental group after the training program ($p < .05$). On the other hand, there was no significant difference in the values of minimum power (w/kg) and power drop (%) ($p > .05$).

Table 4. Wingate anaerobic test results of the experimental group (n = 14).

	Pre-Training	Post-Training	t	p
	$\bar{X} \pm SD$	$\bar{X} \pm SD$		
Maximum power (w/kg)	13.12 $\pm$ 1.37	14.13 $\pm$ 1.51	-4.094	.002*
Average power (w/kg)	8.53 $\pm$ 0.49	8.78 $\pm$ 0.44	-4.113	.002*
Minimum power (w/kg)	4.88 $\pm$ 0.62	4.96 $\pm$ 0.55	-0.472	.647
Power drop (%)	62.21 $\pm$ 7.13	64.42 $\pm$ 6.03	-1.491	.167

Note. * $p < .05$.

Wingate anaerobic test results of the control group were given in Table 5. No significant difference was obtained between the Wingate test results of the control group both before and after the training program ($p > .05$).

Table 5. Wingate anaerobic test results of the control group (n = 10).

	Pre-Training	Post-Training	t	p
	$\bar{X} \pm SD$	$\bar{X} \pm SD$		
Maximum power (w/kg)	13.02 $\pm$ 1.85	13.11 $\pm$ 1.81	-1.011	.339
Average power (w/kg)	8.54 $\pm$ 0.87	8.69 $\pm$ 1.09	-1.083	.307
Minimum power (w/kg)	8.54 $\pm$ 0.87	8.69 $\pm$ 1.09	-1.083	.307
Power drop (%)	65.77 $\pm$ 7.88	65.29 $\pm$ 7.33	1.692	.125

The cardiopulmonary results for the experimental group were presented in Table 6. After the training program applied to the experimental group, a significant increase was observed in the values of VO_{2max} (ml.kg.min⁻¹) and Respiratory Compensation Point VO_2 (ml.kg.min⁻¹) ($p < .05$). The study revealed no significant difference in other cardiopulmonary test results ($p > .05$).

Table 6. Cardiopulmonary measurement results of experimental group (n = 14).

	Pre-Training	Post-Training	t	p
	$\bar{X} \pm SD$	$\bar{X} \pm SD$		
VO_{2max} (ml/kg/min)	48.55 $\pm$ 4.48	53.27 $\pm$ 5.12	-3.131	.011*
Ventilatory threshold VO_2 (ml/kg/min)	43.13 $\pm$ 6.94	44.85 $\pm$ 3.10	-0.780	.453
Respiratory compensation point VO_2 (ml/kg/min)	47.85 $\pm$ 5.57	52.74 $\pm$ 4.73	-3.172	.010*
Ventilatory threshold time (min)	6.25 $\pm$ 1.84	6.05 $\pm$ 1.44	0.276	.788
Respiratory compensation time (min)	8.24 $\pm$ 1.89	8.84 $\pm$ 1.89	-1.291	.226
Maximum speed (km/h)	16.45 $\pm$ 1.86	16.54 $\pm$ 1.91	-0.219	.831
Ventilatory threshold speed (km/h)	12.90 $\pm$ 1.81	12.81 $\pm$ 1.40	0.126	.902
Respiratory compensation speed (km/h)	14.81 $\pm$ 1.94	15.45 $\pm$ 1.91	-1.295	.224
Exhaustion time (min)	9.98 $\pm$ 1.96	9.96 $\pm$ 2.03	0.033	.974

Note. * $p < .05$.

Cardiopulmonary measurement results of the control group were given in Table 7 above. When the data acquired were examined, no significant difference was observed between the results of cardiopulmonary test measurements of the control group both before and after the training program ($p > .05$).

Table 7. Cardiopulmonary measurement results of control group (n = 10).

	Pre-Training	Post-Training	t	p
	$\bar{X} \pm SD$	$\bar{X} \pm SD$		
VO_{2max} (ml/kg/min)	48.21 $\pm$ 5.93	48.23 $\pm$ 5.71	-0.106	.918
Ventilatory threshold VO_2 (ml/kg/min)	41.41 $\pm$ 4.19	41.52 $\pm$ 4.13	-0.670	.520
Respiratory compensation point VO_2 (ml/kg/min)	46.92 $\pm$ 5.82	46.45 $\pm$ 5.43	1.483	.172
Ventilatory threshold time (min)	4.36 $\pm$ 0.94	4.42 $\pm$ 0.92	-0.701	.501
Respiratory compensation time (min)	6.24 $\pm$ 1.28	6.33 $\pm$ 1.12	-0.804	.442
Maximum speed (km/h)	14.00 $\pm$ 1.49	14.20 $\pm$ 1.13	-1.500	.168
Ventilatory threshold speed (km/h)	11.20 $\pm$ 1.03	11.40 $\pm$ 0.96	-1.500	.168
Respiratory compensation speed (km/h)	13.00 $\pm$ 1.33	13.10 $\pm$ 1.19	-1.00	.343
Exhaustion time (min)	7.35 $\pm$ 1.51	7.60 $\pm$ 1.48	-1.530	.160

DISCUSSION

Athletes take advantage of miscellaneous training techniques to heighten their aerobic and anaerobic capacities. While the prolonged low-to-moderate-intensity exercises that enhance aerobic performance increase the endurance capacity, the high-intensity short exercises that improve anaerobic performance upgrade the explosive strength and speed. It's remarkable, meanwhile, that the high-intensity interval training, applied to improve anaerobic performance, also have efficacious outcomes on aerobic capacity.

Boosting the aerobic capacity requires a long period of time. For an aerobic exercise program to be effective enough, it is advised that each session last at least 45 to 50 minutes and be practiced at least three times a week. This type of endurance training should be sustained for 8 to 12 weeks to achieve prominent improvement. It has been reported, however, that incorporating the high-intensity interval training practices into aerobic training can speed up the adaptation process, support aerobic capacity development, and significantly reduce the time to reach the aerobic capacity aimed (Akgül et al., 2017).

This study revealed no statistically significant difference in body weight and body mass index values of the experimental group after the training program ($p > .05$). Likewise, the study revealed no statistically significant difference in terms of body weight and body mass index values of the control group ($p > .05$). The high-intensity interval training practices cover generally the short-duration, but intense exercises. While these protocols are effective for improving the aerobic and anaerobic capacities, they may not make up a total energy deficit long enough to cause changes in body weight and body mass index (Gibala et al., 2008; Keating et al., 2017). Similar to the results collected in our study, McMillan et al. (2005) conducted a 10-week high-intensity interval training program together with 11 young footballer, exercising twice a week at 90-95% of HRmax and observed no statistically significant change in body mass index levels (McMillan et al., 2005). It was set forth in another study that the high-intensity interval training performed regularly three days a week for a period of eight weeks did not lead to any significant change in the values of body weight and body mass index (Yüksel et al., 2007).

When the Wingate anaerobic test results of the experimental group were analysed, a significant increase was found out in terms of maximum power (W/kg) and average power (W/kg) values collected after the training program ($p < .05$). The study revealed no statistically significant dissimilarity in the values of minimum power (W/kg) and power drop (%) ($p > .05$). No significant difference was observed in the Wingate anaerobic test results of the control group both prior to and after the training program ($p > .05$).

It has been detected that the high-intensity interval training protocol provides increases on the anaerobic performance by leading to significant changes in terms of maximum power (W/kg) and average power (W/kg) values of the Wingate test results. Such an increase observed in the anaerobic performance may be resulted from several reasons. First, the high-intensity interval training effectively stimulate and contribute to improve the glycolytic energy pathway. This process can assist in maintaining power production throughout the Wingate test by increasing lactate production and the muscles' ability to buffer the lactate (MacInnis et al., 2017). In addition, high-intensity interval trainings primarily target the fast-twitch (type II) muscle fibres. Relevant fibres can contribute to, with their talents to produce high force and speed, maximum and average power to be increased in the Wingate test (Tillin et al., 2009).

A study accomplished by MacDougall et al. (1998) reported a significant increase, in parallel with the results in our study, in terms of maximum power and average power values of the Wingate test results of volunteers after applying the high-intensity interval training protocol consisting of 30 seconds of loading and 2.5 to 4

minutes of resting intervals for a time period of 7 weeks (Macdougall et al., 1998). Another study carried out by Rodas et al.(2000), revealed that a 2-week high-intensity interval training protocol comprised of 15 seconds of loading and 45 seconds of resting resulted with a significant increase in the activities of phosphocreatine, glycogen, and anaerobic enzymes (Rodas et al., 2000). Xu and Wang (2025) reported a significant increase in the values of maximum power and average power from Wingate test results after 10 weeks of sprint interval training applied to karate athletes (Xu et al., 2025).

On the other hand, when the results of cardiopulmonary test, which reflects the aerobic performance, were examined, it was determined that the high-intensity interval training program applied resulted with a significant increase in VO_{2max} values of the experimental group ($p < .05$). No significant difference was observed, as expected, in the VO_{2max} values of the control group ($p > .05$).

Favourable effects of high-intensity interval training on VO_{2max} can be expressed by both central (cardiovascular) and peripheral (muscular) physiological adaptations (Buchheit et al., 2013; MacInnis et al., 2017). High-intensity interval trainings allow the heart muscles to contract more powerful and pump more blood (Laursen et al., 2002). Such an attitude leads to increased stroke volume at rest and during exercise, therefore, transferring more oxygen to the tissues and as a result elevating the level of VO_{2max} (MacInnis et al., 2017). Moreover, the high-intensity interval training leads to an increase in left ventricular wall and volume, allowing more blood to be pumped during exercises (Gibala et al., 2012). All of the aforesaid results increase cardiac output and thus amplify the conveyance capacity of circulatory system (MacInnis et al., 2017). Furthermore, it is noted that the high-intensity interval training stimulates some of the similar molecular signalling pathways that arrange the skeletal muscles to be remodelled in response to the endurance training, including transfer of carbohydrates and fats, and changes in the oxidation capacity in combination with mitochondrial biogenesis (Kenney et al., 2022). It is considered that the significant increase observed in VO_{2max} level in this study is due to the reasons aforespecified.

The level of anaerobic threshold is another aspect that influences the endurance performance (Coates et al., 2023). The athletes who reach the anaerobic threshold later have higher endurance capacities (Heuberger et al., 2018). Anaerobic threshold can be assessed by measuring the lactate levels as well as by finding out the ventilatory threshold, which is a non-invasive technique (Beaver et al., 2016; Wasserman, 1984). In addition to the carbon dioxide produced by aerobic metabolism after a certain level of exercise, an increase is observed in carbon dioxide production as a result of buffering of hydrogen ions (H^+) dissociated from accumulated lactic acid with bicarbonate. Ventilation begins to accelerate in reply to the nonmetabolic carbon dioxide released by buffering the H^+ (Wasserman, 1984). The point at which the linearity between minute ventilation (VE) and both carbon dioxide production (VCO_2) and oxygen intake (VO_2) is disrupted is called as the ventilatory threshold. If H^+ overlaps the buffering capacity of circulating bicarbonate, it causes the pH level of blood to deviate toward the acidic side, and resulting acidosis stimulates the carotid bodies, leading to hyperventilation (Wasserman, 1984). In addition, the slope of the curve indicating the correlation between VE and VCO_2 becomes steeper with hyperventilation. This additional ventilatory response is called as the Respiratory Compensation Point (Meyer et al., 2004).

As a result of anaerobic training stimuli, H^+ buffering capacity is expected to improve and due to relevant improvement, the ventilatory threshold levels are expected to boost. However, the study accomplished revealed no significant change in the values of ventilatory threshold VO_2 utilized to invasively determine the anaerobic threshold levels both before and after the high-intensity interval training applied ($p > .05$).

A significant increase was observed, however, in terms of respiratory compensation point VO_2 values of the experimental group after the training program, compared to the pre-training program ($p < .05$). The respiratory compensation point is characterized as the highest exercise point at which the metabolic acidity that proliferates as a result of the anaerobic metabolism starting to become active can be suppressed by the buffering systems of body (Erylmaz et al., 2018). The values in the respiratory compensation point zone represent the highest parameters at which the metabolic, cardiac, and respiratory systems of body demonstrate optimal endurance. The values obtained in this zone are, therefore, the criteria which can maintain significant advantages in analysing the conditions of athletes, sedentary individuals, and individuals with low fitness levels (Keir et al., 2024). At exercise intensities above the respiratory compensation point, metabolic acidosis becomes dominant, causing an athlete to terminate the exercise (Wasserman et al., 2015). Therefore, reaching the respiratory compensation point later means that individuals can continue exercising for longer periods of time and so have higher endurance capacities.

Some researchers have been claiming that the high-intensity trainings that covers anaerobic metabolism can improve the buffering capacity, deflecting the respiratory compensation point toward higher intensities (Chicharro et al., 2000). Accumulation of lactate and H^+ in large quantities during the high-intensity exercises can be a remarkable stimulus for adaptations of the systems responsible for regulating muscle pH (Bishop et al., 2011). Indeed, it has been pointed that the high-intensity interval trainings results with increases in the buffering capacity of muscles (Edge et al., 2006). It has also been indicated that the sprint training increases the buffering capacity of muscles, whereas such an improvement cannot be achieved via the aerobic endurance training (Sharp et al., 1986). The findings collected during our research suggest that the high-intensity interval training applied improves the buffering capacity, leading to an increase in the respiratory compensation point without any change in the ventilatory threshold and consequently prolongs the respiratory compensation point phase.

Another possible explanation for the longer respiratory compensation point phase as a result of the high-intensity interval training may be the percentage of fast-twitch muscle fibres. It has been claimed that the fast-twitch muscle fibres may have a higher buffering capacity, compared to the slow-twitch muscle fibres (Nakagawa et al., 2002).

CONCLUSION

Consequently, the high-intensity interval training applied in this study for a time period of eight weeks resulted with a significant increase in maximum power and average power values, which have remarkable effects on anaerobic performance ($p < .05$). Furthermore, significant increases were observed also in the values of $\text{VO}_{2\text{max}}$ (ml.kg.min^{-1}) and respiratory compensation point, which are crucial indicators of aerobic performance ($p < .05$). The results collected indicate that the practices of high-intensity interval training increase also the aerobic performance, particularly the anaerobic performance.

It can particularly beneficial, due to the favourable effects of high-intensity interval training on athletic performance, for athletes lacking adequate training time and for those who wish to reduce the duration and scope of training practices without experiencing any loss in $\text{VO}_{2\text{max}}$ and performance level throughout the pre-competition period. The practices of high-intensity interval training can, meanwhile, be applied also to the exercise routines of sedentary individuals, taking into account the loading principles, due to the favourable effects on cardiovascular health resulting from the surges in $\text{VO}_{2\text{max}}$.

AUTHOR CONTRIBUTIONS

The authors noted that there was equal participation in the elaboration of this document.

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This study was produced from master thesis of Ardacan Yamen titled "*The effect of high intensity interval training on aerobic and anaerobic capacity*".

ETHICAL APPROVAL

Ethical approval was obtained from the Sivas Cumhuriyet University Non-Interventional Clinical Research Ethics Committee on December 14, 2022, under decision number 2022-12/26. The experiments were conducted in compliance with the applicable laws and regulations of the country in which they were performed. The authors affirm that the manuscript is honest, accurate, and transparent; that no significant aspects of the study have been omitted; and that any deviations from the original study plan have been clearly disclosed. This study adheres to all principles of ethical writing and publication.

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