Original Article

On the effect of a single intense resistance exercise session on some cardiovascular indices in professional cyclists

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Abstract

Research done in most societies has confirmed that high blood pressure or hypertension increases various cardiovascular diseases in a person by about 2 to 3 times. This study aimed to recognize the effect of an intense resistance training session on some cardiovascular indices in professional cyclists. The subjects of this semi-experimental study consisted of 30 cyclists participating in this study voluntarily. They were selected via convenience methods and randomly divided into two experimental (15 people) and control (15 people) groups. The experimental group performed intense resistance training for one and a half hours. The control group did not receive any steady-state sports activities during this interval. The variables intended by the subjects in both groups were evaluated some 24 hours before the training started and 24 hours after the training ended. Data analysis was performed using dependent and independent t-test using SPSS16 statistical software at a significant ($\alpha \leq 0.05$) level. The results suggested that one single intense resistance training session could have an effect on some cardiovascular indices among professional cyclists. This is while, after one hour of inactive recovery, its levels declined in both groups, whereas in the group receiving steady-state training, the levels remained above the baseline after one hour of recovery. However, after plasma volume was corrected, fibrinogen levels in the interval group decreased significantly compared to the baseline levels. Therefore, a single session of intense resistance training was found to reduce systolic and diastolic blood pressure and resting heart rate ($p \leq 0.05$).

Keywords: Intense resistance training, cardiovascular indices, Professional cyclists.

INTRODUCTION

Today, high blood pressure or hypertension, as the most important risk-making factor for the progress of cardiovascular diseases, is becoming a growing crisis in the global community which affects people of various ethnicities. Researchers have reported that hypertension is out of control across the world such that in the last 20 years the number of people with the disease has exceeded the one-billion mark. Hypertension is associated with obesity, especially central or abdominal obesity. Abdominal obesity is one of the factors causing coronary heart disease, stroke and congenital heart failure. The epidemic of obesity and obesity-related hypertension are associated with an increased risk of high cholesterol, insulin resistance, the prevalence of diabetes, and chronic renal disease. Systolic and diastolic blood pressure increase linearly in both women and men as waist circumference increases, where this increase, independent of age, represents body mass index, and other factors related to systolic blood pressure in women and diastolic blood pressure in men. Various studies have demonstrated a strong link between bodily activity and reduced risk of developing chronic diseases such as stroke, diabetes, osteoporosis, and cardiovascular diseases. Resistance and endurance activities lead to various cardiovascular responses in individuals. Resistance activities lead to pressure overload, while aerobic activities lead to volume overload on the heart. Total vascular resistance may increase or decrease depending on the muscle mass involved and the type of resistance. Once resistance activity rises, sympathetic stimulation plasma catecholamines increases and parasympathetic activity decreases. Aerobic sports activities are effective in lowering resting blood pressure and can also be a non-pharmacological factor to control hypertension. Based on studies, blood pressure usually decreases after one session of aerobic exercise, which is called anemia. Each of the variables in this article can be an important and predictive factor to the risk of developing cardiovascular diseases and cardiovascular health. On the

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other hand, today more attention has been focused on resistance training and an increasing number of people are turning to such training to enjoy the varied benefits it entails (such as preventing osteoporosis, especially in women, preventing physical weakness and sarcopenia, etc.). As well, resistance training has become an integral part of the training program for various athletes, including cyclists. However, most studies focusing attention on resistance training have been carried out on non-athletes or athletes who train as amateurs. The type of exercise, level of physical fitness and many other factors can affect adjustment as a result of exercise; this leads to different responses in the face of resistance exercise in athletes considering the adjustment of cycling exercises in the long term.

Generally, concerning cycling and the subsequent adaptation on blood pressure, heart rate, myocardial oxygen cost, and hs-CRP are lower than in studies on non-athletes and amateurs, with contradicting results ensuing. Some studies have demonstrated a fall in these factors after activity, while other studies reported these variables to have remained constant or increased. In any case, more studies are needed in this area as well [1].

Studies in recent years have suggested that many diseases, ranging from cardiovascular diseases to cancers, all arise from a series of physiological stages called inflammation which are closely related to immune responses. Studies have shown that regular exercise can bring about a variety of anti-inflammatory impacts and thus protect against cardiovascular disease. It is worth mentioning that the conflicting research results obtained in the last decade on the response of new and traditional cardiovascular indices to exercises have necessitated the need for conducting new research with a human model and investigating the effect of resistance training to examine new and traditional cardiovascular indices.

Many studies have emphasized the desired effect of physical activity on reducing cardiovascular risk factors and fibrinogen [2]. Meyer et al. (2006) reported the development of arterial atherosclerosis is associated with cardiovascular risk factors, mass body index, body waist-hip ratio, systolic blood pressure, insulin levels, triglycerides, low-density lipoprotein to lipoprotein ratio, and plasma fibrinogen. Besides, a significant correlation was noted between body mass index and levels of reactive protein C and fibrinogen in obese girls, with an insignificant relation was seen between normal and slim girls.

According to the suggestions by the Centers for Disease Control and Prevention and the American University of Sports Medicine, the intensity of exercise is seen as the first factor in prescribing an exercise program to protect people against cardiovascular diseases. Therefore, for people subject to the risk of developing cardiovascular diseases, a lifestyle of moderate activity can be associated with useful benefits such as lower blood pressure, prothrombotic factors, lipid peroxidation and increased lipoprotein, fibrinolytic activity, and lower blood pressure. This is while they are more important goals than increased maximum oxygen consumption [2]. However, conversely, clinical trials have indicated that intense exercises can increase the risk of developing thrombotic events in important arteries thus, temporarily increasing the incidence of primary phlebitis [3]. The prevalence of these complications is higher in cardiovascular patients during exercises. Large-scale studies have illustrated that more than 1 million exercise tests have been carried out with fatal and non-fatal complications on athletes such that the rate of morbidity and mortality in coronary heart patients was reported about 1.4 and 0.2 respectively in every ten thousand tests. Thus, according to reliable reports, although exercise activity protects individuals against cardiovascular diseases, it also increases the risk of sudden cardiac death [2]. Hence, though exercise may prevent risk, exercise-induced platelet activation could stimulate acute vascular events.

However, results from a meta-analysis research demonstrate the application of steady-state exercise with an average intensity of 40 to 80% of the maximum oxygen consumption in most researches [4]. Failure to pay attention to the results of new research in the area of exercise physiology can partially justify using unchanged and fixed rehabilitation exercise protocol. High Intensity Interval Training is another form of exercise which is only often used in rehabilitation exercises and include repetitive steps of 30 to 300 seconds of aerobic exercises in range of 95 to 100% of maximum oxygen consumption along with equal, shorter or longer recovery intervals. High Intensity Interval Training has significant effects on improving health and coronary heart diseases. In a study on blood homeostasis in exercise and sports activities, it was concluded that intense exercise had contradictory results on fibrinogen. Moderate level exercise leads to strengthened fibrinolytic activity without the necessary activity in the blood coagulation mechanisms, while highly intense exercise activates fibrinolysis and blood coagulation simultaneously.

Given the significance of the subject of this research, attempts are made to answer the question: What is the effect of an intense resistance training session on some cardiovascular indices in professional cyclists?

Research Methods

This study was a semi-experimental research as it involved independent and dependent variables, pre-test and post-test and experimental and control groups. The researcher seeks to investigate the case results by considering both control and experimental groups (intense resistance exercises).

The study is comprised by 30 cyclists who were members to the national cycling team of the Islamic Republic of Iran via purposive and available sampling and then they were randomly divided into two groups.

Data collection method

The required information in the present study was collected by library and field methods.

Data collection tools

1. Scales and height gauges
2. Abnova laboratory kit developed in Germany
3. Plastic syringes and tubes to collect blood samples and to transfer them to the laboratory.
4. Laboratory equipment, special devices such as GT collet, iron biochemistry kit and spectrophotometry to measure blood factors as used by laboratory experts.
5. Blood pressure monitor developed in Japan
6. One session of one and a half hours of intense resistance training.

Administration procedure:

Research subjects had voluntarily and purposefully participated in this research project and were randomly divided into two groups: experimental (n = 15) and control (n = 15) groups.

The inclusion criteria for selecting the subjects were no history of exercise during the last six months and no taking of hormonal drugs.

Subjects entered the research stage after confirming the absence of any blood and heart disorders, necessary examinations and obtaining of permission to participate in sports activities by the physician, as well as full knowledge of the research conditions, filling in of personal consent.

Before the consent form was completed, the subjects were given information about the nature and manner of cooperation in research and the way the necessary issues about exercise, nutrition, drug use, smoking, consumption of supplements and energy substances were to be observed. Then a questionnaire on personal characteristics and sports medicine status was completed by way of self-declaration.

Before the study started, anthropometric indices such as height (cm), weight (kg) and subjects were measured.

Data analysis method

Data analysis was done using descriptive statistics including mean and standard deviation. Tables and graphs were applied to describe the research specifications and inferential samples such as Kolmogorov-Smirnov test (to determine the normality of data distribution), Levene's test (to examine the homogeneity of variances), and independent and dependent student t-test were performed to analyze the research hypotheses.

Results

Descriptive findings

Table 1. Mean and standard deviation of age, weight and height of experimental and control groups

Variables	Experimental group	Control group
Age (in years)	60.07 ± 2.66	62.27 ± 4.15
Weight (in kilograms)	76.27 ± 5.89	75.9 ± 6.57
Height (in centimeters)	167.47 ± 4.15	168.27 ± 4.82

According to the data in Table 1, the standard deviation of the variables of height, weight and age indicates that the subjects in the experimental and control groups are in the same position from the point of view of the mentioned variables.

Inferential findings

Kolmogorov-Smirnov test

Table 2: Sample distribution normalcy test (Kolmogorov-Smirnov test)

Variable \ Group and stage		Experimental group		Control group	
		Pretest	Posttest	Pretest	Posttest
Systolic blood pressure	Z	1.22	0.763	1.35	1.36
	Sig.	0.1	0.61	0.051	0.53
Diastolic blood pressure	Z	0.55	0.38	1.35	1.02
	Sig.	0.91	0.99	0.51	0.28
Resting heart rate	Z	0.69	0.74	0.85	0.63
	Sig.	0.72	0.63	0.47	0.82

After analyzing the research variables via Kolmogorov-Smirnov test, and according to the Z value obtained and the significant level observed, one can conclude concerning all research variables, in two experimental and the control groups that the sample has been taken from a population with a normal distribution (Table 2).

Testing the hypotheses

First hypothesis: A single intense resistance training has a significant effect on systolic blood pressure in professional cyclists.

A dependent t-test was used to assess the effects of an intense resistance training session on systolic blood pressure in professional cyclists. The results are provided in Table 3.

Table 3. The effect of an intense resistance training session on systolic blood pressure in professional cyclists

	Mean and standard deviation (mm Hg)		Level of change (%)	Dependent t value	Sig.
	Pre-test	Post-test			
Intense resistance training	149.33 ± 3.19	142.67 ± 3.2	- 4.46	10.58	0.0001
Control group	147.67 ± 2.58	147.33 ± 2.6	- 0.23	0.37	0.72
Independent t value	5.73				
Significance level	0.0001				

Concerning the intense resistance training group, a comparison of pre-test and post-test data suggests that the subjects' systolic blood pressure significantly decreased by 4.46% before and after training ($p \leq 0.0001$). A comparison of pre-test and post-test of the control group indicated no significant difference between the two stages ($P = 0.72$). A comparison of changes in the control and experimental groups indicated a significant difference between the two groups ($p \leq 0.0001$). Thus, by rejecting the null hypothesis, one can conclude that a session of intense resistance training has a significant effect on systolic blood pressure.

Second hypothesis: A session of intense resistance training has a significant effect on diastolic blood pressure.

Dependent t-test was used to assess the effects of a session of intense resistance training on diastolic blood pressure. The results are provided in Table 4.

Table 4. The effect of a single session intense resistance training on diastolic blood pressure

	Mean and standard deviation (mm Hg)		Level of change (%)	Dependent t value	Sig.
	Pre-test	Post-test			
Intense resistance training	89.33 ± 2.58	82.67 ± 4.57	- 7.45	5.29	0.0001
Control group	85.33 ± 5.16	86.67 ± 4.88	+ 1.57	-1	0.33
Independent t value	4.36				
Significance level	0.0001				

Concerning the exercise group, a comparison of pre-test and post-test data indicates that the subjects' diastolic blood pressure decreased significantly by 7.45% before and after exercise ($p \leq 0.0001$). A comparison of pre-test and post-test of the control group indicates that there is no significant difference between the two stages ($P = 0.33$). A comparison of changes in the control and experimental groups indicated a significant difference between the two groups ($p \leq 0.0001$). Therefore, by rejecting the null hypothesis, one can conclude that a session of intense resistance training has a significant effect on diastolic blood pressure.

Third hypothesis: A session of intense resistance training has a significant effect on resting heart rate.

Dependent t-test was used to assess the effects of one session of intense resistance training on resting heart rate. The results are provided in Table 5.

Table 5. The effect of a single intense resistance training session on resting heart rate in professional cyclists

Stage and value Group	Mean and standard deviation (number)		Level of change (%)	Dependent t value	Sig.
	Pre-test	Post-test			
Experimental	79.47 ± 3.2	78.33 ± 2.84	- 1.43	6.86	0.0001
Control	78.73 ± 1.71	78.4 ± 1.99	- 0.42	1.58	0.14
Independent t value	2.99				
Significance level	0.006				

Concerning the exercise group, a comparison of pre-test and post-test data indicated that the subjects' resting heart rate significantly decreased by 1.43% before and after exercise ($p \leq 0.0001$). A comparison of pre-test and post-test of the control group indicates that there is no significant difference between the two stages ($P = 0.14$). Comparison of changes in the control and experimental groups indicated a significant difference between the two groups ($P \leq 0.05$). Therefore, by rejecting the null hypothesis, one can conclude that a session of intense resistance training has a significant effect on the resting heart rate of professional cyclists.

Discussion

In the present study, the effect of an intense resistance training session on some cardiovascular indices was evaluated in professional cyclists. The findings demonstrated that one session of intense resistance training had an effect on some cardiovascular indices in professional cyclists and after one hour of inactive recovery, its levels saw a decline in both groups, while in the steady-state group level training, an hour recovery remained at the baseline at higher levels. However, after plasma volume was corrected, fibrinogen levels in the interval group decreased significantly compared to baseline levels. Plasma fibrinogen is viewed a significant combination of coagulation cascade and a major determinant of viscosity and blood flow. According to epidemiological studies, higher plasma fibrinogen levels are associated with increased risk of cardiovascular disorders, including ischemic heart disease, brain stroke, and other vascular occlusion diseases; this is while regular aerobic exercise leads to a reduced level of fibrinogen by decreasing catecholamine stimulation and increasing blood flow. In the present study, despite the fact that fibrinogen levels after rose in both steady-state and interval exercise, its levels in the steady-state group were significantly higher than those in the baseline group. Thus, after plasma volume was corrected, a significant difference was noted between the interval and steady-state groups in fibrinogen levels immediately after exercise (in the interval group, its levels were significantly lower). These findings suggested improved coagulation and anticoagulant status following a session of intense interval exercise. In these activities, more time is allotted to high-intensity exercise than to steady-state exercise, thus incurring fatigue more suddenly, which can lead to stronger cardiovascular adaptation stimulation. According to Batga et al. (2009), the change in fibrinogen levels after exercise depends on its baseline values before exercise.

In this connection, Faramarzi et al. (2012) demonstrated that a resistance training session was effective in reducing systolic and diastolic blood pressure in menopausal elderly women. Hosseini Boroujeni et al. (2007) conducted a study entitled "the effect of low-intensity aerobic exercise on blood pressure" on 36 employees with primary hypertension presenting to health centers in Borujen, which revealed a significant decrease in MDA and diastolic. Bayat et al. (2011) stated that three weeks of aerobic exercise on blood pressure in type 2 diabetic patients with hypertension had a positive effect. Delshad et al. (2011) reported that 12 weeks of resistance exercise at 85, 80 and 100% of the maximum recurrence were found to be 50% positive and significant among women of higher than 0 years old (a type of hypertension). In their study, Nourshahi et al. (2009) reported a significant decline in blood pressure after mountaineering in elderly men. Wildman et al. (2004) concluded in their study that physical activity at leisure time significantly reduced MDA and diastolic menopausal women at 44 to 50 years [5]. Fluraz et al. (2006) observed hypotension in women who had received swimming training. Hillston et al. (2006), while studying men 40 to 76 years old, found that relatively -intense exercise also helped blood pressure come down. In a study on 131 people in South Australia over 10 to 16 weeks, Smith et al. (2007) found out that regular aerobic exercise was effective in lowering blood pressure. The result of the present study a consistent line the results obtained from the above research.

As age rises, the thickness of the arterial wall increases, which is mainly because of increased collagen fibers and the destruction of elastin fibers in the middle layer of arteries and its calcification. As a result, vascular compliance decreases, leading to the dilated artery, increased pulse pressure, and increased pulse wave velocity. This condition predisposes the elderly to isolated systolic hypertension (ISH), which is the most prevalent type of hypertension in the elderly. Increased intima-media thickness of the vessel's wall shows a significant risk of atherosclerosis, and the predictive value of increased IMT for future acute cardiovascular incidents is equal to or greater than the classical cardiovascular risk factors.

Studies by Franklin et al. (2007) have demonstrated that systolic blood pressure has seen an ascending trend with rising ages in all age ranges; however, diastolic blood pressure increases until the age of 50, remain constant during the 50s and 60s, thus decreasing after the age of 60. Isolated systolic hypertension (ISH) is the most prevalent form of hypertension in people over the age of 50, and even its mild cases are associated with a significant rise in the risk of cardiovascular events. In the elderly, pulse pressure is also regarded a stronger predictor of future acute cardiovascular events than systolic or diastolic blood pressure. On the other hand, in the elderly, pressure receptors which maintain normal blood pressure, become weak when changing position from a lying to sitting status, predisposing the individual to hypotension. Pressure receptor function in the elderly who train is much better than the sedentary elderly and these people are less likely to have postural hypotension. As well, the elderly who are physically fit and exercise regularly undergo lower pulse pressure and lower pulse wave velocity. Regular exercise in the elderly improves endothelial function. Low-salt diet also reduces the process of hardening of the arteries in older age. Thus, regular exercise and proper diet in the elderly help prevent cardiovascular diseases and improve mental accuracy.

The exact mechanism of how exercise lowers blood pressure is still unknown. However, this is likely because of a reduction in catecholamines generated by exercise. This reaction contributes to reduced peripheral resistance to blood flow and subsequent hypotension. Also, exercise can facilitate renal sodium excretion, thereby reducing fluid volume and blood pressure. Sports exercises appear to increase the number of capillaries in active skeletal muscles, increase progress, reduce dilated vascular resistance, reduce blood flow resistance, improve neural blood vessels regulation, reduce environmental resistance and reduce resting heart rate and lower blood pressure. Researchers maintain that after exercise, an enzyme called dopamine beta hydroxylase is reduced in the hypothalamus. A reduction in the amount of this enzyme reduces the environmental activity of epinephrine in response to emotions and other stimuli and helps lower blood pressure.

The findings also suggested that the subjects' resting heart rate after exercise significantly decreased. The effect of strenuous (aerobic) exercises on the walls of the heart shows that such exercises lead to volumetric overload on the heart, increase the cavities of the heart, especially the left ventricle, and increase the walls of the heart by making changes to its thickness. The walls of the heart are probably due to an increase in the left ventricular mass index. Various studies have demonstrated that the left ventricle is more affected by exercise than other parts of the heart.

During exercise, cardiac output increases with a dramatic increase in heart rate and stroke volume. As a result, with tachycardia and reduced diastolic time, there will be less time available for left ventricular diastolic filling. Therefore, left ventricular diastolic function should increase during exercise to maintain the increasing trend of trauma volume. Increased sympathetic stimulation, catecholamines, and venous return lead to increased cardiac contractile function and decreased left ventricular systolic volume [8]. As well, according to Han Zheng et al. (2008), exercise strengthens the left ventricular systolic function by improving the balance between the sympathetic and parasympathetic nervous systems. This increases the volume of the heartbeat and the heart rate during exercise and following occurrence of fatigue while decreasing the heart rate during the resting period. Akashi et al. (2002) observed that exercise reduces regular vascular resistance as it increases vasodilatory capacity [9]. Reduced arterial dilatation could causes arterial hypertension, a process that can lead to left ventricular hypertrophy and reduced coronary blood flow. Besides, reducing dilated small arteries increases the risk of acute cardiac complications [10]. According to Mourot et al. (2009), dilation increases coronary artery disease [10]. According to previous studies, increased vasodilation is associated with changes in endothelial function and nitric oxide production [9]. All of these changes can increase heart function, lower blood pressure, increase left ventricular volume, and reduce resting heart rate.

Considering the nature of intense resistance training and its application to all ages, it is recommended to carry out such exercises to increase all kinds of capabilities. The results demonstrated a significant reduction in systolic and diastolic blood pressure as a result of aerobic exercise, thus it is suggested to do such exercises.

Because of resting heart rate decreases following exercise, such exercises can be recommended for people with high blood pressure and people with chronic heart palpitations.
Finally, to better examine the issue, it is suggested that future researchers be done in different geographical areas in terms of altitude and temperature conditions, in order to determine the effect of altitude on blood factors. It is also suggested that two types of exercises with different intensities be compared in future research.

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