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The effects of acute interval cycling and blood flow restriction on hematologic factors of beginner cyclists

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Abstract

Blood compositions change as a result of physical activity and an exercise associated with Blood Flow Restriction (BFR) is a new exercise method. This study aims to compare the acute effect of an interval exercise with blood flow restriction on beginner cyclists' hematologic factors. Twenty students of Shiraz Education Cycling Team with an age average of 16.43 ± 1.36 years, weight of 60.07 ± 11.74 kg and height of 175.46 ± 6.14 cm participated voluntarily in this experimental study. The participants were divided randomly into two equal groups of interval cycling with BFR (n=10) and interval cycling without BFR (n=10). Interval exercise consisted of 10 repetitions for one minute and one minute rest between repetitions. BFR was applied by cuff with a width of 15 cm and pressure of 160 mmHg. Before and immediately after the exercise, 5 ml blood sample was taken from a brachial vein. The results were extracted using dependent and independent T-test statistical methods at the significance level of P <0.05 by SPSS 23. The results showed the increasing effect of acute interval cycling with BFR on White Blood Cells (WBC), Red Blood Cells (RBC), Hemoglobin (Hb), Hematocrit (Hct) and Platelets (PLT) as well as the increasing effect of acute interval cycling without BFR on WBC and PLT. No significant difference was observed between the effects of the two exercise methods on hematologic factors (P<0.05). Acute interval cycling with BFR increased five hematologic indexes; however, acute interval cycling without BFR increased two hematologic indexes. It seems that interval exercise with BFR makes wide hematologic changes among beginner cyclists.

Keywords: Blood cells, blood flow restriction, interval exercise.

INTRODUCTION

Blood is a connective heterogeneous tissue with various components and compositions. These components and compositions are affected by body internal and external factors. Various studies suggest that blood compositions change as a result of physical activity (20). Exercise and physical activity makes some changes in the body such as the change of peripheral blood erythrocytes system. On the other hand, inactivity can reduce plasma volume and total volume of red blood cells that ultimately results in the reduction of circulating blood and body performance (7,12). The increase of RBC leads to the increase of the blood oxygen carrying capacity and this increases endurance and sport performance, particularly in long-term events such as running and cycling. That's why researchers and cyclists are trying to find ways to increase red blood cells and hemoglobin to enhance athletic performance (6,10).

The conducted researches about the effect of exercise on hematological indices show inconsistent findings so that the effect of physical activity on RBC, Hb, WBC, Plt, and Hct in previous researches indicates decreasing, increasing, or lack of significant change of these factors (3,20,24,25,37,40). The change of RBC has considerable effects on exercise performance so that anemia makes a negative effect; however, increasing the RBC improves the exercise performance. On the other hand, the exercise itself can make effect on hematologic indices. Different studies have reported the hematological adaptations to endurance exercise (3,29).

Tekin et al. (40) observed a significant increase in WBC after a session of increasing aerobic activity among young and adult athletes. Mohammad Najad Panah Kandi et al. (32) reported significant changes in levels of hemoglobin, leukocytes, erythrocytes and platelets of Physical Education students after completing 7 steps of Bruce protocol. Moreover, Guillo(18) reported a significant increase in Leukocytes, platelets and monocytes in Brazilian Jujitsu athletes after a jujitsu exercise session. Kara et al. (24) stated that submaximal exercise has a significant influence on platelets, hematocrit, red and white blood cells and hemoglobin.

In a study conducted in the form of a session of 5- minute pedaling activity on ergometer bicycle with 90% of maximal oxygen consumption, no significant change was seen in WBC (33). In a comparison made by Natale et al. (33), the relationship between the effect of duration, intensity and type of one-session exercise was studied, but no significant change in red cells variables was reported. In a research conducted by Cakmakci et al. (9), changes in platelets, hematocrit, red and white blood cells were not significant following one session of taekwondo competition.

Hematocrit, hemoglobin concentration, and red blood cell count decrease among endurance athletes. These changes which are mainly made due to the increase of plasma volume, occur during a few days after a long-term exercise (25) since although the amount of absolute hemoglobin increases due to the stimulation of erythrocytes is by the exercise, much higher increase of plasma volume through more fluid retention decreases hematocrit and hemoglobin in endurance athletes (25). Boyadjiev et al. (8) after submaximal exercises as well as Arazi et al. (3) after special session of exercises for preparation and kung-Fu skill realized a significant decrease in RBC variables.

Blood flow restriction– a position as a complementary method of preparation for a set of different sports (for ex: resistive exercises, walking, cycling) - has recently become a popular and interesting issue for researchers. At the time of exercise or sport, BFR includes using pressurized cuffs closed to the proximal portion of each lower (4,27,38) or upper (39,42) limbs. Scientifically, not only cuff pressure should be high enough to block muscle-to- venous return, but also it should be low enough to maintain the circulation of arterial blood in the muscle (4,14,26). According to the evidences, exercise with BFR increases muscle strength (15,27,28,30,36), hypertrophy (1,22,27,28,38), local endurance (11,23,38) and cardiorespiratory endurance (1,34,35). However, the interesting and challenging issue is that: what impact this method may have on athletes hematological variables. However, we found that the impact of BFR in combination with exercise on hematological indices was rarely studied and no report was found.

Regarding the development of BFR as a new exercise method used by professional and amateur athletes and because this kind of exercise cannot be performed continuously and during a long term, studying the impact of this kind of exercise in combination with very applicable exercises of interval kind may be interesting and can help athletes and coaches to be aware of changing in blood compositions through this kind of compositional exercise methods and to adopt necessary measures if required. Therefore, we try to find the response of the following questions in the study: What is the effect of acute interval cycling without BFR on hematological indexes of beginner cyclists? What is the effect of acute interval cycling with BFR on hematological indexes of beginner cyclists? Which of the two exercise methods have more impact hematological indexes of beginner cyclists?

MATERIAL & METHOD

Study design and sample size

This is an experimental study. Twenty students of Shiraz Education Cycling Team with an age average of 16.43 ± 1.36 years, weight of 60.07 ± 11.74 kg and height of 175.46 ± 6.14 cm participated voluntarily in the study.

Pilot study was conducted on 2 subjects before implementing the study. The results suggested that interval cycling and BFR as the independent variables can be implemented among beginner cyclists. Cardiovascular health of students was confirmed by cardiology expert and the written consent of the parents was obtained. Information such as age, sport history, weight and height of subjects were recorded.

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Based on the questionnaire of medical information, none of the participants smoked. They also had no history of blood disease, infection and allergic conditions. Individual characteristics of subjects based on mean and standard deviation are shown in Table 1.

Test procedure

After the subjects became familiar with the whole process of the study, all of them were tested on one kilometer cycling and the maximum time to exhaustion was obtained.

One kilometer cycling test was done by inserting a course bicycle on Technogym trainer device. This test is one of the fields of speed cycling which is conducted in World Championships and Olympic games. At first, the bicycle saddle height was adjusted for each cyclist and then each of them pedaled one kilometer in full force after 5 minutes warming up. One kilometer cycling time was recorded for each subject (2).

In addition, the maximum time to exhaustion test was done through inserting a course bicycle on Technogym trainer device. At first, the bicycle saddle height was adjusted for each cyclist and then they began pedaling with the speed of 20 Km/h and after every minute of pedaling, they increased the speed 2 Km/h so that they reached the speed of 34 Km/H. After reaching this speed, each cyclist increased his speed 1 kilometer per hour after every minute of pedaling so that he exhausted. The whole time of pedaling until exhaustion time was recorded as the index of maximum time of reaching exhaustion (5,10).

Based on the results of these two tests, participants were divided into two homogeneous groups (Table 2) of interval practicing group with BFR and interval practicing group without BFR. After one week without exercise, the two groups performed their exercise protocol. Interval exercise protocol for both groups included 10 repetitions for one minute cycling on stationary bicycle with the intensity of 8 out of 10 according to the Borg scale of perceived pressure and one minute cycling active rest with intensity of 4 out of 10 based on the Borg scale of perceived pressure between iterations. Blood flow restriction of interval exercise group with BFR was applied on highest legs by wind cuff with the width of 15 cm and air pressure of 160 mm Hg at the time of pedaling on stationary bicycle and pedaling intensity of 8 based on the Borg 10 value scale .Then, cuff wind pressure was decreased to 20 mm Hg at rest times (10,26). Naturally, the pedaling speed in this group has been lower than the group without BFR.

In order to obtain information about changes in hematological parameters following the two exercise methods before and immediately after the exercise protocol in the two groups, 5 ml blood sample was taken from the left hand vein basilica in sitting position. The blood sample was poured in EDTA tubes and hematological indices were analyzed in the prestigious clinical laboratory using a cell counter (Sysmex K-1000 IVB=15.20) device made by Japan .The parameters include: red blood cells, white blood cells, platelets, hemoglobin, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC).

Statistical analysis

We used Statistical Packages for the Social Sciences (SPSS), version 23, to analyze the findings of the study. Shapiro – Wilk test was used to determine the normal distribution of data and parametric statistical methods were selected after confirmation. We used dependent T –test and independent T-test to compare the means before and after the exercise and to study the difference of the two groups' means, respectively. In all cases, the level of statistical significance was $P < 0.05$.

RESULTS

General and anthropometric specifications of subjects are shown in Table 1. According to the data analysis, there was no significant difference in hematologic indices measured before the exercise between groups.

Table 1. General and anthropometric specifications of subjects (Mean ± SD).

Variables	All subjects	Interval Cycling	Interval cycling + BFR	p
Age (year)	16.43 ± 1.36	16.37 ± 1.68	16.50 ± 1.06	.862
Height (cm)	175.46 ± 6.14	172.87 ± 6.82	178.06 ± 4.36	.092
Weight (kg)	60.07 ± 11.74	59.63 ± 8.51	60.51 ± 14.92	.887
BMI	19.43 ± 3.11	19.89 ± 2.03	18.97 ± 4.02	.575

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Table 2. Results of the subjects' initial functional test (Mean ± SD).

	Interval cycling + BFR	Interval cycling	P value	t value
Time of 1000m	398.50 ± 21.30	389.70 ± 21.51	0.425	0.822
Time of exhaustion	912.12 ± 163.97	868 ± 64.24	0.496	0.709

Table 3. Results of dependent T-Test on hematological change of beginner cyclists' blood following of acute interval cycling without or with BFR.

Hematologics	Interval	Cycling +	BFR	Interval	Cycling	
Variables	Pre	Post	P Value	Pre	Post	P Value
WBCcount (×10³/μL)	5.62±0.68	7.12±0.59	0.000	6.02±1.08	7.93±1.98	0.002
RBC count (×10⁶/μL)	5.68±0.32	5.87±0.32	0.003	5.58±0.38	5.72±0.43	0.16
Hb g/dL	15.83±1.37	16.35±1.29	0.005	16.25±1.46	16.62±1.69	0.31
Hct %	48.45±2.04	50.13±2.61	0.004	45.95±2.69	47.92±3.25	0.24
PLT count (×10³/μL)	222.75±55.85	253.12±53.19	0.000	223.00±59.10	282.37±74.65	0.001
MCHPg	27.90±2.65	27.85±2.39	0.65	29.13±2.02	29.00±2.13	0.58
MCHC g/dL	32.65±1.89	32.60±1.74	0.66	34.56±1.50	34.63±1.52	0.71
MCV FL	85.43±6.23	85.46±6.36	0.83	84.20±3.31	83.69±3.60	0.15

* WBC=White Blood Cells; RBC= Red Blood Cells; Hb=Hemoglobin; Hct=Hematocrit; PLT=Platelet; MCH=Mean Corpuscular Hemoglobin; MCHC=Mean Corpuscular Hemoglobin Concentration; MCV=Mean Corpuscular Volume; Significant difference between pre and post- test at p<0.05.

Table 4. Results of independent T-test comparing the changes of hematologic indices of the two participating groups.

Hematologic Variables	Interval Cycling	Interval Cycling + BFR	t	df	p
WBC count (×10³/μL)	1.91 ± 1.13	1.50 ± 0.51	-9.29	9.77	0.37
RBC count (×10⁶/μL)	0.13 ± 0.24	0.18 ± 0.11	0.54	14	0.59
Hb g/dL	0.36 ± 0.95	0.51 ± 0.36	0.39	14	0.69
Hct %	0.69 ± 2.17	1.68 ± 1.12	0.83	14	0.42
PLT count (×10³/μL)	59.37 ± 30.78	30.37 ± 10.72	-2.51	14	0.02
MCH Pg	-0.12 ± 0.63	-0.05 ± 0.35	0.28	14	0.78
MCHC g/dL	0.06 ± 0.47	-0.05 ± 0.33	-0.56	14	0.57
MCV FL	-0.51 ± 0.89	0.03 ± 0.40	1.55	14	0.14

* WBC= White Blood Cells; RBC= Red Blood Cells; Hb=Hemoglobin; Hct=Hematocrit; PLT=Platelet; MCH=Mean Corpuscular Hemoglobin; MCHC=Mean Corpuscular Hemoglobin Concentration; MCV=Mean Corpuscular Volume; Significant difference between pre and post- test at p<0.05.

In the group of interval cycling without BFR, the rate of WBC and PLT increased significantly (P <0.05) compared to the pre-exercise (state). Also, in the group of interval cycling with BFR, the rate of WBC, RBC, Hb, Hct, and PLT increased significantly (P <0.05) compared to the pre-exercise (state) (Table 3). Other indices showed no significant change between pre and post-tests (p<0.05).

Results of the independent T-test on comparison of changes pre and post the intervention in both groups specified that in the group of interval exercise with BFR only the PLT index has increased more than the other group, while the other variables had no significant difference between the two groups (Table 4).

DISCUSSION

The results revealed that one session of interval cycling with BFR had an increasing effect on WBC, RBC, Hb, Hct and PLT factors and similarly one session of interval cycling without BFR affected only two indices of WBC and PLT. In comparison, there was no significant difference in the impact of two interventions on hematologic factors, except PLT.

As we mentioned earlier, a significant increase was observed in the count of WBC of both groups. Although this is consistent with the results of Tekin (40) and Kara et al. (24), it does not match with the findings of Cakmakci (9), Natalie et al. (33) and Arazi et al. (3). Moderate to severe exercises rise white blood cells in blood circulation, a change which depends on work intensity (19).Marginal white blood cells (attached to the vascular endothelium) are the major source of circulating white blood cells (19). Separation of white blood cells during an exercise probably occurs due to the increase of cardiac output so that increasing the circulation of white blood cells shows a positive correlation with the increase in heart

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rate (17). The increase of cardiac output via larger mechanical forces releases peripheral white blood cells into the blood circulation (17). Other possible mechanisms affecting the increase of white blood cells during an acute exercise are different effects of hormones on the secretion, margination and migration of white blood cells (16,19).In other words, these changes are likely related to catechol amines, cortisol and some chemotactic factors because temporary immunological disorders occur under such conditions (41). So, both interventions created such stimulation. It was assumed that blood flow restriction in the group of exercise with BFR increases shear stress and cardiac output and makes more obvious changes, though it did not happen.

Erythrocyte measurable variables include Red blood Cells (RBC) count, Hemoglobin (Hb) density, percent of Hematocrit (Hct), Mean Corpuscular Volume (MCH) and mean corpuscular hemoglobin concentration (MCHC). In the present study, RBC, Hct and Hb variables in the group of interval cycling exercise with BFR were significantly increased compared to the pre exercise (state). This is consistent with the results of Kara etal. (24), Najd Panah et al. (32) and Guillo (18); though, it is inconsistent with the findings of Boyadjiev et al. (8), Arazi et al. (3), Natalie et al. (33) and Cakmakci(9). On the other hand, in the interval cycling exercise group without BFR, variables of RBC, Hct and Hb did not increased significantly. This is consistent with the results of Boyadjiev et al. (8), Arazi et al. (3), Natale et al. (33) and Cakmakci (9) inconsistent with findings of Kara et al. (24), Najd Panah et al. (32) and Guillo (18).The difference in exercise protocol, intensity, exercise duration and level of first physical preparation of participants can be the most important factors of difference in the mentioned researches. Reduction of the plasma volume increases the blood viscosity. Therefore, cellular protein parts occupy the greater fraction of total blood volume and this increases the hematocrit. It also leads to the increase of the amount of red blood cells per volume unit even without increasing red blood cells count (25). On the other hand, RBCcount circulating in the blood may be increased during the exercise as a result of releasing the red cells stored in the spleen and this leads to the increase of blood hemoglobin per volume unit (25). Content of blood hemoglobin represents the amount of portable oxygen of the blood. It is better to say that 99% of oxygen is carried in combination with hemoglobin in the blood. Therefore, if in any circumstances, the need for oxygen in tissues and blood portable oxygen content are not balanced, the body will respond to it through increasing the blood oxygen-carrying capacity, i.e. hemoglobin and RBC (21). BFR exercise can increase the local hypoxia and this may lead to a significant increase in RBC, Hct and Hb in the group of cycling exercise with BFR.

MCV index represents the size of red blood cell, or in other words, a measure of average red blood cell volume; MCH index is referred to mean Hb mass in RBC in a sample or certain volume of blood and MCHC is corpuscular hemoglobin concentration index (31).The results in relation with MCH ،MCHC and MCV in both groups did not significantly change which is consistent with the results of Boyadjiev et al. (8), Arazi et al. (3).Platelet is another blood hematologic factor which plays an important role in blood clotting and even in the modulation of inflammatory processes in interaction with white blood cells. In this study, platelet count increased significantly in both groups, but it is assumed that the mechanism for the increase of platelets (independent of changes in plasma volume) are made due to the return of blood from the spleen vascular bed, bone marrow and the accumulation of blood circulation within the lung arteries because of the muscles involved. This is claimed since it has been reported that the injection of epinephrine causes a strong contraction of the spleen - where about one third of platelets stored –and this mechanism might be the reason of a large increase in the amount of this index in the blood circulation after the exercise (13). Moreover, Natalie et al. (33), Cakmakci et al. (9) and Wuet et al. (41) have not reported any significant changes in subjects' blood factors concentration after the exercise. This is consistent with the current research findings based on the lack of significant change of MCH, MCHC, MCV indices after the both exercise methods and the lack of significant change of RBC, Hb and Hct indices in the group of interval cycling exercise without BFR. This can be attributed to the compatibility phenomenon and blood matching of these groups.

Generally, various factors may influence the findings. One of these factors is that the subjects of the current study had not cycling background and

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exercise compatibilities which have been made among beginner cyclists following the exercise method can be effective in fading the differences between the two groups. In addition, other physiological mechanisms which are obscure and not well-known enough may have affected the results beside the limited number of subjects in each group. On the other hand, despite the accuracy of researchers' view, possible errors and limitations beyond the control level of the field activities may affect results of this research and this would certainly indicates the necessity of more studies to achieve a more accurate conclusion.

As a conclusion, acute interval cycling with BFR increased five hematologic indexes; however, acute interval cycling without BFR increased two hematologic indexes. It seems that interval exercise with BFR makes wide hematologic changes among beginner cyclists. Different factors may have influenced the findings. The subjects of the current research had not cycling background and the study of professional cyclists may be different with regard to the attainment of exercise compatibilities and high level of preparation. The lack of controlling the groups is one of the limitations of the present study and conducting future researches can provide more clear results regarding these remarks. Nevertheless, based on the results of the research, it is concluded that if the cyclists use interval cycling exercise combined with BFR, red and white blood cells count and hemoglobin concentration, which are of the most important hematological indicators, will increase following an acute exercise.

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