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# *Acute Hematological Profile Response to One Session of Aerobic and Anaerobic Exercise among Young Male Kickboxers*

## *Genç Erkek Kick-Boksörler Arasında Tek Seans Aerobik ve Anaerobik Egzersize Cevaben Akut Hematolojik Profil*

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### Abstract

**Objective:** The aim of this study is to investigate the effects of a one-session aerobic and anaerobic exercise on some hematological variables in young men kickboxing.
**Material and Methods:** Thirteen young male kickboxers were randomly separated in two control and experimental groups. The experimental group performed anaerobic (running based anaerobic test: RAST) and aerobic exercise (running 1 mile) on separate days. Blood samples were taken before and immediately after exercise, during 45 min and 90 min of recovery. Leukocyte [white blood cell Count (WBC), lymphocytes (LYM)] and erythrocyte variables [red blood cell count (RBC), hemoglobin (HGB) and hematocrit (HCT)] and platelets (PLT) were measured.
**Results:** After correcting plasma volume, results showed that WBC, LYM, and PLT significantly increased while PLT decreased immediately after exercise. However, RBC, HGB, and HCT did not change significantly.
**Conclusion:** According to the obtained results, it can be advised that one-session anaerobic RAST can cause more changes in hematological profiles of kickboxers. Therefore, it may be a reason that kickboxing relies on anaerobic power.
**Key Words:** Leukocytes, erythrocytes, kickboxing, RAST

### Özet

**Amaç:** Bu çalışmanın amacı, genç erkek kick-boks yapanlarda tek seans aerobik ve anaerobik egzersizin bazı hematolojik değişkenler üzerine etkilerini araştırmaktır.
**Gereç ve Yöntemler:** On üç genç erkek kick-boksör rastgele iki kontrol ve deney grubuna ayrıldı. Deney grubu ayrı günlerde anaerobik (koşmaya dayanan anaerobik test: RAST) ve aerobik egzersiz (bir mil koşu) yaptı. Kan örnekleri egzersizin öncesinde ve hemen sonrasında, dinlenmenin 45. dakikasında ve 90. dakikasında alındı. Lökositler [Beyaz kan hücresi sayımı (WBC), lenfositler (LYM)] ve eritrosit değişkenleri [kırmızı kan hücresi sayımı (RBC), hemoglobin (HGB) ve hematokrit (HCT)] ve trombosit (PLT) ölçüldü.
**Bulgular:** Plazma hacmini düzelttikten sonra sonuçlar, egzersizden hemen sonra PLT azalırken, WBC, LYM ve PLT'nin belirgin olarak arttığını gösterdi. Ancak, RBC, HGB ve HCT önemli bir değişiklik göstermedi.
**Sonuç:** Elde edilen sonuçlara göre, tek seans anaerobik RAST'ın kick-boksörlerin hematolojik profillerinde daha fazla değişikliğe neden olabildiği söylenebilir. Dolayısıyla, bu kick-boksun anaerobik güce dayanmasının bir nedeni olabilir.
**Anahtar Kelimeler:** Lökositler, eritrositler, kick-boks, RAST

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## Introduction

The effect of physical activity in various patterns on different physiological systems, particularly blood cells, has been clearly investigated (1-3). Like any physiological tissue, blood does not provide the same response concerning every exercise, either. The human body reflects appropriately in special circumstances, based on the type of physical activities, intensity, and duration.

The cooperation and efficiency of body tissues, especially blood ones, are required to supply the required energy for efficient body tissues. Blood compositions, according to a vast number of studies, change due to different physical activities. Physical activities are actually considered a physiological stimulus to release blood cells through bone marrow (4,5). Endurance exercises, based on recent findings, lead to decreases in hemoglobin (HGB) concentration, the number of erythrocytes, and hematocrit (HCT) percentage, which, in itself, reflects anemia originating in physical activities and exercises (6-8).

Regarding the essential role of white blood cells (WBC) in the immune system as well as their capability of gene expression due to one or several nuclei, a number of studies have focused on the effect of physical activities and exercise (2,9,10). McCarthy et al. (11) found that exercising on an ergometer for 30 minutes with 48%-84% Vo2 max could increase the average number of WBC, and the number of lymphocytes and neutrophils also increased by 117%. Furthermore, the neutrophil number could increase to 154% after a 165-min exercise on an ergometer.

Morci et al. (5) reported that rowing with the highest speed (28-32 rowing movements per minutes) causes an increase in the total number of WBC and its components. Absolute number of lymphocytes and neutrophils increased, respectively, 53% and 74%, whereas the increase in platelet number was reported to be 29%. Exercise physiology experts took into account not only WBCs but also responses to a couple of physical activities and exercises, especially the effect of various kinds of activities, on erythrocyte components.

It was reported that in comparison with non-athletes and anaerobic athletes, endurance athletes have higher blood volume, hemoglobin concentration, red blood cells (RBC), and plasma volume. Despite these findings, Silva et al. (3), in a football training program (20-24 sessions, 14.66-16.63 hours per week), RBC, HGB, and HCT concentration increased during the second week, while HCT decreased during the third week. Additionally, they showed that mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) were significantly lowered and raised, respectively.

Yalcin et al. (12) investigated the effect of one session of anaerobic intensive exercise on hematologic responses among 10 male volunteers and concluded that RBC immediately increased to 8%-10%, a return to the base level, and decreased in number during a time span of 15 minutes and 2 hours, after exercising. However, there was no significant modification in MCV. RAST, measuring the anaerobic performance of athletes indicates a high coefficient correlation with the winget test but has not been utilized as a training program in order to evaluate hematologic changes by such athletes.

As a type of martial art, kickboxing can be considered highly similar to taekwondo and boxing due to skill conception and its functioning (i.e., using the arm and leg). However, regarding the time (2 minutes) and break (between two intervals of the competition), it looks like taekwondo and wrestling. Among some features of kickboxing are fast and tense performance and the emphasis on anaerobic power. Based on these features, we can assume that this tense, challenging, and intensive field of sport is reliant on the anaerobic energy system while paying attention to the total match time and relaxing break, making clear that the aerobic system is also involved to continue certain activities.

It has been reported that physical activities directly influence the performance and distribution of blood cells. In addition, different types of training can influence the immune system temporarily and permanently, so that various responses of blood cells have been seen concerning short- and long-term activities in various intensities and the effect of these activities on the increase, decrease, and occasionally no change in trend of blood variables. Based on the administered studies, a comparison of two different types of exercises dealing with blood factors has not been investigated in any particular field of sports. Based on the foregoing, the researcher has tried to answer these questions:

What is the effect of the RAST anaerobic test on hematological parameters (white blood cells, red blood cells, and platelets) of kickboxing athletes?

What is the impact of an aerobic test (a mile running) on hematological parameters (white blood cells, red blood cells, and platelets) of kickboxing athletes?

## Material and Methods

**Participants**

Among 30 volunteers, 13 kickboxers who were in the range of 18-24 years old and had a history of championship in provincial and national competitions were selected and gave written consent for this study, which was approved by the Human Studies Committee of Mazandaran University, IRAN. Then, six of them were randomly left in the control group, while the rest of them (i.e., 7) were in the experimental one.

The pre-requisite factors to choose these volunteers were as follows: not taking any drugs and supplements, individual health, no background suffering from hematological diseases, or any disease that influenced hematological factors. These subjects have practiced kickboxing at least 2 to 10 years while they practiced their field 8-12 hours per week. General characteristics of these participants have been presented in Table 1. All of these competitive participants are national or state champions. They have been completely clarified about the objectives of the study and investigation protocol.

**A one-session aerobic and anaerobic activity**

On the exact day of the test, subjects were asked to run for an anaerobic competition-free activity, including a 35-meter run six times with a 10-second break among each one, at maximum speed. According to this exercise, subjects tried to have a warm-up exercise dealing with running, stretching, and jogging for

5 minutes and then did the test. They were asked do an aerobic exercise after a 1-week break. On the test day, on the predetermined test day, the subjects first warmed themselves up through some controlled exercises (i.e., having all joints slowly warmed and jogging and stretching movements). The selected aerobic test consisted of running a mile with maximum speed; the average for every mile was 7.04 minutes, and the control group was at rest and had no activity.

**Blood Sampling**

Ten cc of blood was collected from the participants' arm vessels while they were sitting before, immediately after, and 45 and 90 minutes after exercise. Moreover, in order to homogenize the athletes' nutrition schedule, 10 hours before doing the test, participants were asked not to eat anything due to the probability of the nutritional impact on several variables, such as plasma volume.

**Hematological Measurements**

Having collected all blood samples, they were sent immediately to a biochemical laboratory to measure on a hematology analyzer automatic system (Sysmex KX-21). The Dill and Costill equation was used to evaluate the possible changes in plasma volume thanks to a one-session activity. In this formula, blood volume (BV) and red cell volume (RCV) before (b) and after (a) the exercise will be taken into account.

$BV_a = BV_b * (HGB_b / HGB_b)$
$RCV_a = BV_a * HCT_a$
$PV_a = BV_a - RCV_a$
$BV_b = 100mt$
$RCV_b = HCT_b$
$PV_b = [1- (HCT / 100) *100]$

**Table 1. Physical characteristics of the participants (mean±standard deviation)**

| | Experimental Group (n=7) | Control Group (n=6) |
|---|---|---|
| Age (years) | 21±14 | 19.66±1.40 |
| Height (m) | 175.85±1.24 | 175.00±1.15 |
| Body weight (kg) | 67.67±1.57 | 67.50±2.83 |
| Body mass index (kg/m²) | 21.69±0.64 | 22.06±1.02 |

**Statistical Analysis**

All individual features and hematological characteristics were illustrated based on mean and standard deviation. Kolmogorov-Smirnov test was administered to make sure of the fact that the data distribution was normal. Two-factor ANOVA for repeated variables (4 times and 2 groups) was employed. The difference detected by ANOVA was located with an LSD (with Bonferroni correction) post hoc test. A significant level was considered $p \leq 0.05$, and the SPSS computer program was used for statistical analysis.

## Results

The information available in Table 2 shows there was no significant difference in the control group regarding any measured factors.

The number of WBC, immediately after an aerobic exercise, showed a significant increase of 48.12 and 36.66, respectively. In addition, during the 90-minute recovery, the highest increase occurred in aerobic exercises (i.e., 42.1% vs. 26.78%) (Figure 1). The number of RBC had a significant decrease only during the 45-minute recovery period in comparison with immediately after the exercise ($F=3.2$, $p=0.04$). The number of platelets had a significant decrease (5.54%) during the 45 and 90 minutes of recovery, in comparison with the base level during the 90 minutes of recovery after anaerobic exercise, whereas its number increased to 8.4% during aerobic exercise (Figure 2).

In addition, hemoglobin changes were not significant. The number of hematocrits during the immediate time, in comparison with the time before the activity, and the 90-minute recovery, respectively, showed a significant increase and decrease (Figure 3). The changes in the number of LYM after aerobic exercise and anaerobic exercise, respectively, increased by 51.02% and 90%, while during the 90-minute recovery decreased to 33.9% after aerobic exercise and 43% after anaerobic exercise (Figure 1, 4). Based on the obtained data, there was a significant increase in WBC during the immediate time of the anaerobic exercise and 45 and 90 minutes of recovery. The number of RBC did not have any significant changes (Figure 4). There was a significant decrease at 45 and 90 minutes in comparison to the immediate time (Figure 5).

A significant decrease was reported in hemoglobin and hematocrit changes in 45 minutes in comparison to the time devoted to the pre- and post-periods (Figure 6).

**Table 2. Hematological profiles of control group**

| | 30 min before | Immediately | 45 min after | 90 min after | F | P |
|---|---|---|---|---|---|---|
| WBC (10³/mL) | 8.06±1.59 | 7.82±2.13 | 7.93±2.35 | 7.96±2.25 | 0.19 | 0.89 |
| RBC (10³/mL) | 5.71±0.71 | 5.57±0.56 | 5.66±0.55 | 5.69±0.64 | 0.79 | 0.51 |
| HGB (g/dL) | 14.98±1.46 | 14.91±1.89 | 14.98±1.65 | 15.21±1.73 | 0.45 | 0.71 |
| HCT (%) | 46.36±2.27 | 45.26±2.95 | 45.88±2.40 | 46.2±2.83 | 0.94 | 0.94 |
| LYM (10³/mL) | 2.35±0.78 | 1.97±0.37 | 1.97±0.31 | 1.95±0.38 | 2.12 | 0.14 |
| PLT (10³/mL) | 196.5±34.41 | 200.1±32.73 | 196.32±30.61 | 193.59±32.33 | 0.68 | 0.57 |

Blood samples were taken before and immediately after exercise, during 45 min and 90 min of recovery. Leukocyte [white blood cell Count (WBC), lymphocytes (LYM)] and erythrocyte variables [red blood cell count (RBC), hemoglobin (HGB) and hematocrit (HCT)] and platelet (PLT) were measured. After correcting plasma volume, results showed that WBC, LYM, and PLT significantly increased while PLT decreased immediately after exercise. However, RBC, HGB, and HCT did not change significantly

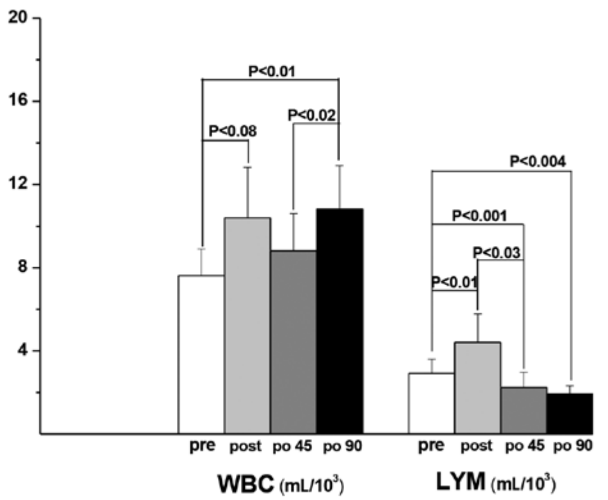


Figure 1. Total changes of lymphocytes (LYM) and blood cell count (WBC) after aerobic exercise in the experimental group

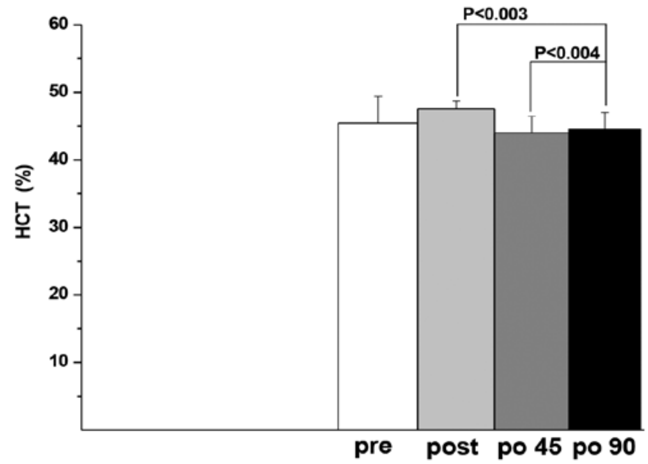


Figure 3. Total changes of hematocrit (HCT) after aerobic exercise in the experimental group

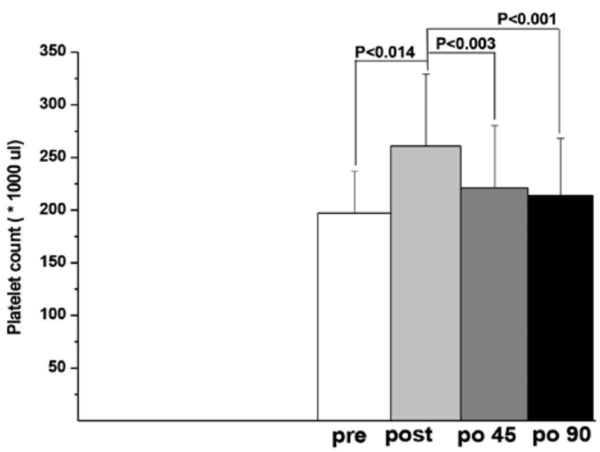


Figure 2. Total changes of platelet (PLT) after aerobic exercise in the experimental group

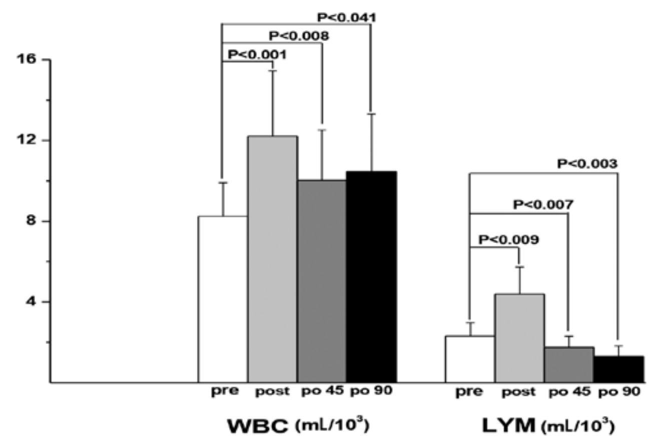


Figure 4. Total changes of lymphocytes (LYM) and white blood cell Count (WBC) after anaerobic exercise in the experimental group

## Discussion

The findings of the present study reflected that one session of aerobic exercise (running one mile three times with 3 minutes rest between each one) and anaerobic exercise (RAST test) caused a significant increase in the number of WBC, LYM, and PLT right after the exercise.

Zhang et al. (13) maintained a significant increase of 15.8 and 19.4 in the number of WBC and LYM when they conducted exhaustive exercise of less than 30 minutes. They asserted that WBC (after 12 hours) and LYM (after 1 hour) could return to the base level.

The simplest reasons, which can be introduced to justify the increase in WBC concentration after exercise, can be attributed to the decrease in plasma volume. In contrast, in this study, there were no significant differences. Consequently, there are some other factors that are worth paying attention to through WBC changes. During any sports event, some WBC go toward damaged muscular fibers, and WBC can function as a defensive system, while there are some kinds of disturbances in the natural functioning of body tissues (14). The number of WBC increases after those activities, which cause muscular exhaustion. Its accurate mechanism during any kind of exercise is not actually clear. Most likely, some mechanical factors can be involved in this process, such as an increase in cardiac output, and cause some changes in capillary endothelial cells (15,16).

It is clear that some hormones, such as epinephrine and cortisol, influence the distribution of WBC in blood circulation and different parts of the body, such as liver, spleen, and bone marrow. Epinephrine increases the number of WBC during exercise.

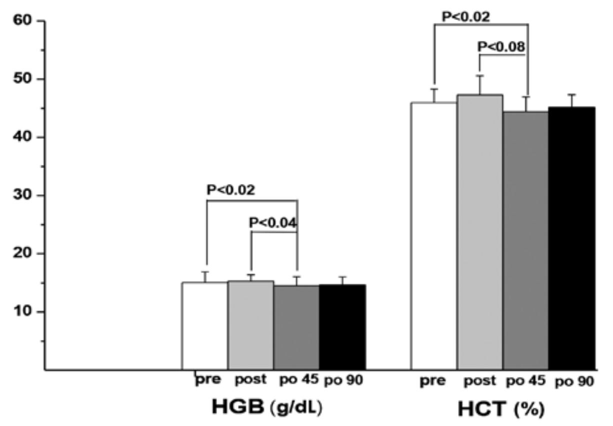


Figure 5. Total changes of hemoglobin (HGB) and hematocrit (HCT) after anaerobic exercise in the experimental group

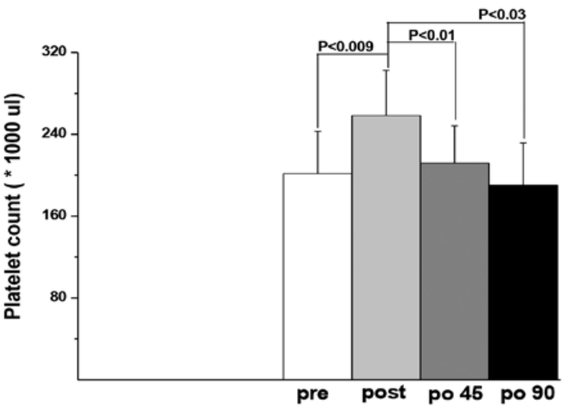


Figure 6. Total changes of platelet (PLT) after anaerobic exercise in the experimental group

Based on the McCarthy and Dale method, the changed increase in the number of WBC during short-term activities (less than an hour) can be derived from the increase in epinephrine, because there is a very slow increase in cortisol in response to the activity. Furthermore, the increase in the number of cells, which is the result of cortisol, occurs 1 hour right after exercise. During long-duration activities, catecholamine and cortisol cause a decrease in WBC (16).

Although the concentration of catecholamine and cortisol was not measured, based on the quality of the present study, its concentration seemed to increase. Lymphocytosis, which takes place in anaerobic and resistance exercises more than any other sports activities, can be attributed to sympathetic and beta-adrenergic pathway activation, since sympathetic nerves can directly provide nerves with lymphoid issues, such as spleen, thymus, and lymph nodes (17,18).

In this study, the number of HGB and HTC was quite insignificant after both exercises. However, during 45 minutes of recovery, in both kinds of exercises, there was a decrease in HTC to 3%. The number of changes in RBC showed a significant decrease of 2.93% after 45 minutes of anaerobic exercise. Wardyna et al. (19) reported a significant increase in the concentration of HTC, HGB, and PLT percentages. In the non-exercising group (young male and female non-athletes), along with an exhaustive aerobic exercise, there was no significant change in the number of WBC, while all other studies reported significant increases in the number of PLT (20-23). The platelet cycle was heterogeneous in size, density, and reflectivity. Therefore, it can be concluded that the age and size of platelet are independent determinants.

Platelets are made in controlled, stimulated production conditions. The number of platelets will be increased during sports, which is why such an increase happens because of fresh platelet release originating in spleen vessels, bone marrow, and some other platelet supply in the body. Epinephrine release will cause strong contraction of the spleen, where there is nearly one-third of all saved platelets of the body. This mechanism can justify the reasons of the affluent increase of platelets in sports. In addition, in extreme steps of platelet activation, such kinds of increases can be caused by formation changes in megakaryocyte components of the cytoplasm (21-23). There is no consensus on the effects of exercises on platelet concentration and symptoms of platelet activation. However, it has to be mentioned that short-term training causes activation of blood clotting, as well as an increase in fibronolize, and maintains the balance between formation of blood clotting and its analysis in a natural level (10,15). Based on the finding of the present study, it can be concluded that even though PLT and LYM had dropped down to their lower levels during the 45- and 90-minute recovery, WBC, at the same time, showed a significant increase, which manifests the partial weakening of the immune system of the body. To sum up, according to the obtained results, it can be advised that comparing aerobic exercises, one-session anaerobic RAST can cause more changes in hematological profiles of kickboxers; so, it may be a reason that kickboxing relies on anaerobic power. This finding approves the fact that the response of the hematological and immune system depends on some types of physical activities.

**Ethics Committee Approval:** The design of this study approved by Ethics Committee of Faculty of Physical Education and Sport Sciences Islamic Azad University Central Tehran Branch.

**Informed Consent:** Subjects gave written informed consent to participate in this study as approved

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## References

1. Ahmadizad S, El-Sayed MS, MacLaren DP. Effects of water intake on the responses of haemorheological variables to resistance exercise. Clin Hemorheol Microcirc 2006;35:317-27.
2. Ghanbari-Niaki A, Saghebjoo M, Rashid-Lamir A, Fathi R, Kraemer RR. Acute circuit-resistance exercise increases expression of lymphocyte agouti-related protein in young women. Exp Biol Med 2010;235:326-34. [CrossRef]
3. Silva AS, Santhiago V, Papoti M, Gobatto CA. Hematological parameters and anaerobic threshold in Brazilian soccer players throughout a training program. Int J Lab Hem 2008;30:158-66. [CrossRef]
4. Möbius-Winkler S, Hilberg T, Menzel K, Golla E, Burman A, Schuler G, et al. Time-dependent mobilization of circulating progenitor cells during strenuous exercise in healthy individuals. Appl Physiol 2009;107:1943-50. [CrossRef]
5. Morici G, Zangla D, Santoro A, Pelosi E, Petrucci E, Gioia M, et al. Supramaximal exercise mobilizes hematopoietic progenitors and reticulocytes in athletes. Am J Physiol Regul Integr Comp Physiol 2005;289:1496-503. [CrossRef]
6. Shaskey DJ, Green GA. Sports Hematology. Sports Med 2000;29:27-38. [CrossRef]
7. Schumacher YO, Schmid A, Grathwohl D, Bultermann D, Berg A. Hematological indices and iron status in athletes of various sports and performances. Med Sci Sports Exerc 2002;34:869-75. [CrossRef]
8. Convertino VA. Blood volume: its adaptation to endurance training. Med Sci Sports Exerc 1991;23:1338-48. [CrossRef]
9. Connolly PH, Caiozzo VJ, Zaldivar F, Nemet D, Larson J, Hung SP, et al. Effects of exercise on gene expression in human peripheral blood mononuclear cells. J Appl Physiol 2004;97:1461-9. [CrossRef]
10. El-Sayed MS. Effects of Exercise and Training on Blood coagulation, fibrinolysis and platelet aggregation. Sports Med 1996;22:282-98. [CrossRef]
11. McCarthy DA, Macdonald I, Grant M, Marbut M, Watling M, Nicholson S, et al. Studies on the immediate and delayed leucocytosis elicited by brief (30-min) strenuous exercise. Eur J Appl Physiol Occup Physiol 1992;64:513-7. [CrossRef]
12. Yalcin O, Erman A, Muratli S, Bor-Kucukatay M, Baskurt OK. Time course of hemorheological alterations after heavy anaerobic exercise in untrained human subjects. J Appl Physiol 2003;94:997-1002.
13. Zhang X, Matsuo K, Farmawati A, Higashi Y, Ogawa K, Nagata K, et al. Exhaustive exercise induces differential changes in serum granulysin and circulating number of natural killer cells. Tohoku J Exp Med 2006;210:117-24. [CrossRef]
14. Smith LL, Mc Common M, Smith S, Chamness M, Israel RG, O'Brien KF. White blood cell response to uphill walking and downhill jogging at similar metabolic loads. Euro J Appl Physiol Occup Physiol 1989;58:833-7. [CrossRef]
15. El-Sayed MS, El-Sayed Ali Z, Ahmadizad S. Exercies and training effects on blood haemostasis in health and disease: an update. Sports Med 2004;34:181-200. [CrossRef]
16. McCarthy DA, Dale MM. The leukocytosis of exercise. A review and model. Sports Med 1988;6:333-63. [CrossRef]
17. Murray R, Paul GL, Seifert JG, Eddy DE. Responses to varying rates of carbohydrate ingestion during exercise. Med Sci Sports Exerc 1991;23:713-8. [CrossRef]
18. Mazzeo RS, Rajkumar C, Rolland J, Blaher B, Jennings G, Esler M. Immune response to a single bout of exercise in young and elderly subjects. Mech Ageing Dev 1998;100:121-32. [CrossRef]
19. Wardyna GG, Rennarda SI, Brusnahanb SK, McGuirec TR, Carlsona ML, Smithd LM, et al. Effects of exercise on hematological parameters, circulating side population cells, and cytokines. Exp Hematol 2008;36:216-23. [CrossRef]
20. Ahmadizad S, El-Sayed MS. The effects of graded resistance exercise on platelet aggregation and activation. Med Sci Sports Exerc 2003;35:1026-32. [CrossRef]
21. Satoshi F. Effect of 12 week of strenuoouse physical training on haemorheological change. Malitari Medicine 2005;590:170-7.
22. Wu HJ, Chen KT, Shee BW, Chang HC, Huang YJ, Yang RS. Effect of 24h ultra-marathon on biochemical and hematological parameters. World J Gastroenterol 2004;10:2711-4.
23. Karakoc Y, Duzova H, Polat A, Emre MH, Arabaci I. Effect of training period on ham rheological variables in regularly trained footballers. BR J Sports Med 2005;39:4. [CrossRef]