Comparative analysis of hematological parameters in well-trained athletes and untrained men

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Abstract

Purpose:	The purpose of current study was to investigate the hematology parameters of male athletes who had exercised regularly for five years and sedentary male university students.
Material:	The sample consisted of 18 well-trained and 18 sedentary male university students aged between 20 and 22 years old. The peripheral fasting blood samples were collected from each participant. Laboratory analysis was made to determine the red and white blood cells counts and their concentration percentage.
Results:	The means of white blood cell, lymphocyte, monocyte counts, and lymphocyte and monocyte percentages were significantly lower in the well-trained group while the means of hemoglobin count, mean cell hemoglobin, red blood cell distribution width were significantly lower in sedentary group (p > .05). However, no statistically significant difference between groups was found in red blood cell counts, granulocyte counts, and granulocyte percentages (p > .05).
Conclusions:	Our findings show that athletes participating in the long-term regular exercise have the high level of the concentration of red blood cells subtypes and the low level of the concentration of white blood cells subtypes when compared to their sedentary peers. Because their hematologic values remain within the reference range for healthy people, these differences do not pose any serious clinical problems for athletes. The high RBC and low WBC subtypes values of athletes may be explained by chronic adaptation to long-term exercise.
Keywords:	blood, exercise, hematology, sports, athletes.

Introduction

Nowadays, it is the known fact that physical activity through regular exercise had positive effects on physical, physiological, psychological, and other health outcomes. Scientific evidence exists that these are positive effects caused by the acute and chronic effects of regular exercise on different body systems. Regular exercise leads to increase of physical capacity by improving the efficiency of the cardiovascular, muscular, respiratory and neural systems. Blood is widely used as an indicator to evaluate the effect of exercise on the function of body systems such as the cardiovascular, immune, and endocrine system. Blood is composed of three main cell types including red blood cells (RBCs) or erythrocytes (99%), platelets (< 1%) and white blood cells (WBCs) or leukocytes (<1%) [1, 2]. These cells play an important role in maintaining a homeostatic balance. RBCs have a primary role in the transport of respiratory gases. Hemoglobin (HGB) that contained in the red blood cells carries oxygen from the lungs to the tissues and thereby provides needed oxygen in efficient energy production for muscle contractions and sustained contractions during the prolonged physical activity and exercise. Also, RBCs enable the transport of carbon dioxide out of tissues, normalization of blood pH and they carrier metabolites such as lactate released from skeletal muscles during high-intensity exercise [2, 3]. It has been considered that a reduction in the count of

RBCs, HGB concentration, or oxygen-binding capacity of HGB may negatively impact on physical performance. WBC is important components of the immune system [4]. Their primary role is to protect against pathogenic bacteria, viruses, other foreign materials entering the body, infections and damaged cells that threaten the normal function of tissues in the body [5].

Regular exercise and physical activity are considered as an important regulator of blood cells and their functions [6,7]. On the other hand, physical inactivity and sedentary lifestyles is often accompanied by hematologic disorders such as hypovolemia, hematocrit (HCT) and Ph imbalance [8-10]. It was reported that there are different findings that emerge with regard to hematologic parameters in the peripheral blood during and after exercise and physical activity [11]. However, intensity, type, frequency, and duration of exercise, genetic factors, the physiologic characteristics and lifestyle of subjects are closely related to acute and chronic differences in hematologic parameters [12,13]. In scientific researches, these factors might account for the inconsistent results in blood parameters of athletes. In order to make an accurate inference about the effect of physical activity through regular exercise on blood parameters, it should be investigated the long-term effect of regular exercise and physical activity on these parameters for different ages and population groups. In the literature, the many of studies have usually focused the acute and short-term effect of exercise and physical activity on hematologic

parameters [11,14-17]. The studies conducted in this field dictated an increase in WBC count and a decrease in RBC count as a result of regular exercise [14,15]. On the other hand, some researchers reported opposite or contradictory findings [18-20]. In summary, there are controversial about how exercise affects the hematology. Therefore, it should be investigated in more detail and in different population over different time periods. To this end, the present study compared hematology parameters of male athletes who doing regular exercise for five years and sedentary university students in the same age group and gender. We hypothesized that regular exercise caused the permanent changes in the hematologic parameters of athletes in long-term.

Materials and Methods

Subjects

Eighteen well-trained male athletes from basketball, handball, and volleyball and 18 healthy and sedentary male university students volunteered to participate in this study. Participants' age ranged from 20-22 (mean 21) years old. Trained athletes (TA) were regularly trained at least 5 years, three times a week for about 3-5 hours per session while sedentary students (SS) did not have a history of regular exercise or physical activity. Written informed consent was obtained from each participant.

Procedure

All data were collected in Turkey during the year 2014. The participants were fully informed about the study procedures. Age of participants was determined from the date of birth recorded on their national identification cards. This research was performed in accordance with tenets of Helsinki Declaration.

Data Collection

The peripheral fasting blood samples were collected from both TA and SS. All subjects were given morning appointments and instructed not to eat or drink anything after 22:00 p.m. Their blood samples were taken from the antecubital vein in the at least eight hour period of fasting. 10 ml of blood sample was collected from each participant by using sterile EDTA vacuum tubes. Blood analysis was immediately performed included: RBC, HGB, HCT, mean cell hemoglobin (MCH) and red blood cell distribution width (RDW), WBC, lymphocyte count, lymphocytes (%), granulocyte count, granulocyte percentage, monocyte count and monocyte percentage (%).

Statistical Analysis

Data analysis was performed through the SPSS (SPSS Inc., Chicago, IL, USA) trial version 17.0 statistical package. Means and SD were computed for all quantitative variables and percentages were computed for categorical variables. The Shapiro-Wilk test was used to inspect for the distributions of the variables. Independent samples t-tests were used to test for group differences. Statistical significance defined at $p < .05$.

Results

A comparison of the mean RBC parameters for the TA and SS groups is shown in Table 1. An independent-samples t-test was performed to compare of RBC parameters between the groups. The results of the t-tests revealed that there were significant differences on the HGB (t (34) = 3.27, p = .002, 95% CI [0.44, 1.87], d = 0.10), HTC (t (34) = 2.56, p = .015, 95% CI [0.61, 5.24], d = 0.16), MCH (t (34) = 3.50, p = .001, 95% CI [-0.072, 2.70], d = 0.27), and RDW (t (34) = 5.99, p = .00, 95% CI [1.23, 5.50], d = 0.51). The means of these parameters in the TA group were statistically higher than the SS group. However, the mean of RBC were not significantly different between the two groups (p > .05).

A comparison of the mean WBC parameters for the TA and SS groups is shown in Table 2. An independent-samples t-test was performed to compare of RBC parameters between the groups. The results of the t-tests revealed that there were significant differences on the WBC (t (34) = -2.77, p = .010, 95% CI [-1.50, -0.23], d = 0.18), lymphocyte count (t (34) = -4.55, p = .000, 95% CI [-0.95, 0.36], d = 0.39), lymphocyte percentage (t (34) = -5.21, p = .000, 95% CI [-13.66, -5.99], d = 0.44), monocyte count (t (34) = -4.36, p = .000, 95% CI [-0.28, 0.10], d = 0.36), and monocyte percentage (t (34) = -6.19, p = .000, 95% CI [-2.79, -1.41], d = 0.53), The means of WBC, lymphocyte count, lymphocyte percentage,

Table 1. Comparison of RBC parameters for TA and SS groups.

Variables	Group TA (n= 18) M (SD)	SS (n= 18) M (SD)	95% CI for Mean Difference	t(34)	p	Cohen's d
RBC (10^6/uL)	5.41 (0.62)	5.10 (0.35)	[-0.03, 0.66]	1.87	.070	0.10
HGB (g/dL)	15.83 (1.25)	14.68 (0.83)	[0.44, 1.87]	3.27	.002*	0.24
HCT (%)	46.04 (4.30)	43.13 (2.13)	[0.61, 5.24]	2.56	.015*	0.16
MCH (pg)	29.32 (1.16)	27.61 (1.72)	[-0.72, 2.70]	3.50	.001*	0.27
RDW (%)	13.77 (0.73)	11.90 (1.10)	[1.23, 2.50]	5.99	.000*	0.51

Note: *; p < .05

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Table 2. Comparison of WBC parameters for TA and SS groups.

| Variables | Group | | 95% CI for Mean Difference | t(34) | p | Cohen's d |
	TA (n= 18) M (SD)	SS (n= 18) M (SD)				
WBC (x10^9 L^{-1})	6.35 (0.85)	7.21 (1.02)	[-1.50, -0.23]	-2.77	.010*	0.18
LC (x10^9 L^{-1})	2.11 (0.43)	2.77 (0.43)	[-0.95, -0.36]	-4.55	.000*	0.39
LP(%)	30.11 (6.00)	39.94 (5.30)	[-13.66, -5.99]	-5.21	.000*	0.44
GC (x10^9 L^{-1})	3.71 (0.80)	3.39 (0.72)	[-0.21, 0.83]	1.22	.229	0.04
GP (%)	56.45 (7.17)	52.33 (5.17)	[-0.12, 8.35]	1.98	.056	0.10
MC (x10^9 L^{-1})	0.39 (0.15)	0.58 (0.10)	[-0.28, 0.10]	-4.36	.000*	0.36
MP (%)	5.68 (1.19)	7.78 (0.81)	[-2.79, -1.41]	-6.19	.000*	0.53

Note: LC; lymphocyte count, LP; lymphocyte percentage, GC; granulocyte count, GP; granulocyte percentage, MC; monocyte count and MP; monocyte percentage and *; p < .05.

monocyte count and monocyte percentage in the SS group were statistically higher than the TA group. However, there was no statistically difference between the two groups in but no statistically significance difference in granulocyte count (t (34) = 1.22, p = .229, 95% CI [-0.21, 0.83], d = 0.04) and granulocyte percentage (t (34) = 1.98, p = .056, 95% CI [-0.12, 8.35], d = 0.10).

Discussion

The hematological response to acute and chronic exercise has recently been reviewed. Although it is commonly accepted that both acute and chronic exercises induce many hematological changes in humans [13], it is unclear how the long-term effect of regular exercise on hematologic parameters of athletes. To date, however, little attention has been paid to the long-term effect of exercise on hematological parameters in athletes. In this study, we investigated the differences in the hematological parameters between TA group who had a history of basketball, handball and volleyball training for a minimum of 5 years and SS group who did not regular exercise except for daily activity. Our findings partially support our hypothesis and show significant differences between the in HGB, HTC, MCV, RDW, WBC, lymphocyte count, lymphocyte percentage, granulocyte percentage monocyte count, and monocyte percentage between the TA and SS groups. In contrast with what would be expected, there were no significant differences in RBC, granulocyte count, and granulocyte percentage between the groups.

Long-term regular exercise had a significant impact on the physical performance in human [22]. Hematological parameters including RBCs and WBCs are associated with the physical performance of athletes. It is thought that an increase in the concentration of the RBCs indicates an improvement in aerobic performance [23]. The findings from this study demonstrated that RBCs values of both TA and SS groups were within normal range for Turkish people [24,25]. The comparison of the mean RBCs values between the TA and SS groups show the means of HGB, HCT, MCH, and RDW values significantly differed in favor of TA group. However, the mean of RBC values did not differ statistically between the groups. Researches within the past few years have demonstrated that exercise stimulates erythropoiesis and tends to increase the RBCs after competition or training [15,26]. Also, Hu et al., (2011) also addressed exercise have a positive effect on RBCs indices in human [22]. These statements support our findings of RBCs except for the mean of RBC values. On the other hand, some studies have reported results contrary to the results of this research. In two studies have revealed that athletes have a lower HCT percentage than sedentary subjects. [27,28]. Novosadova indicated that the ratio of hemoglobin to hematocrit remained unchanged during and after moderate (67 % VO_{2max}) and low (40 % VO_{2max}) intensity aerobic exercise. The results of these studies are inconsistent with our study. In this study, the mean of RBC values did not differ statistically between the groups [29]. The non-significant difference in RBC counts in between groups may be related to several factors. First, it is possible that exercise programs performed to athletes are not as effective for improving RBC outcomes as other forms of exercise.

In this study, hematologic variables including WBC, lymphocyte count, lymphocyte percentage, monocyte count, and monocyte percentage were significantly lower in TA group. Although the granulocyte count and percentage were higher in SS group, these parameters did not differ significantly between the groups. Scientific evidence exists that WBCs play a crucial role in the immune system [7,11]. The high circulating levels of WBCs and their subtypes is closely associated with increased infection or inflammation as well as coronary heart disease and type 2 diabetes [30,31]. All mean values in both groups were within normal range for Turkish people despite the statistically significant differences between the

groups [24,25]. In literature, previous research has shown that there are the inter-relationships between exercise and immune function [32]. Some researcher indicated that the lymphocyte concentration increases during exercise bouts but it may fall baseline values found before exercise after exercise [11]. In addition, other researchers addressed decreased or no changed in WBCs values of athletes both during exercise and after [14,33]. Taken together, these reports and our results revealed that regular exercise has no adverse effect on the immune system in the long term.

Conclusion

In summary, our findings show that athletes participating in the long-term regular exercise may have the high level of RBC subtypes concentration and the low level of WBC subtypes concentration when compared to their sedentary peers. Because their hematologic values remain within the reference range for healthy people, these differences do not pose any serious clinical problems for athletes. The high RBC and low WBC subtypes values of athletes may be explained by chronic adaptation to long-term exercise. As a result, to participate in long-term regular exercise training affects positively the hematological parameters. Future large scale research is needed to further confirm these results in both athletes and other populations.

Highlights

• Regular exercise has no adverse effect on the immune system in the long term.

• Long-term training can effects on concentration of hemoglobin, percentage of hematocrit, mean cell hemoglobin, and red blood cell distribution width.

• White blood cells count, lymphocyte count, lymphocyte percentage, monocyte count and monocyte percentage in sedentary men are higher than well-trained men athletes.

Acknowledgment

Conflict of interests

The authors declare that they have no conflict of interest.

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