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The Effects of Match Conditions on the Shaped Elements of Blood And Iron Level of Football Players

Futbolcularda Müsabaka Şartlarının Kanın Şekilli Elemanları ve Demir Düzeyine Etkisi

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ABSTRACT

The conditions of football match and intensive exercise changes the hematological parameters. It is also known that, endurance training causes "sports anemia" which is an athlete specific anemia type. The purpose of our study is to research the effects of pre-match and post-match on the shaped elements of blood and iron level of football players. The study group consisted of 12 volunteer male athletes who are playing football in Turkish A2 League for 'Erciyes Spor Kulübü'. The pulsations, systolic/diastolic blood pressures, vertical/long jumps and elasticity of participating football players are measured and their blood samples were taken before and after the football match. There were statistically significant differences between the values of erythrocyte, leukocyte, thrombocyte, iron and iron binding ($p<0.05$) whereas there weren't any significant differences between PCT (procalcitonin), RBC (red blood cell) and MCH (mean cell hemoglobin) levels ($p>0.05$) in football players before and after the match. According to our results, match conditions and intensive exercise cause serious changes in iron levels and shaped elements of blood. The blood samples which will be taken at the pre-season, mid-season and late-season periods in accordance with the frequencies specified in the current literature can be important to follow the individual blood profile standards of each football players.

Key Words
Hematology, endurance training, iron, performance.

ÖZ

Futbol maçı ve yoğun egzersiz koşulları hematolojik parametreleri değiştirebilmektedir. Dayanıklılık antrenmanlarının sporcuya özgü bir anemi türü olan "spor anemisine" neden olduğu da bilinmektedir. Çalışmamızın amacı, futbolcularda müsabaka şartlarının kanın şekilli elemanları ve demir seviyesi üzerindeki etkilerini araştırmaktır.Çalışma grubu Türkiye A2 Liginde ' Erciyes Spor Kulübü' futbol oynayan 12 gönüllü erkek sporcudan oluşturuldu. Katılan futbolcuların nabızları, sistolik/diyastolik kan basınçları, dikey/uzun sıçramaları ve esnekliği ölçülmüş ve kan örnekleri futbol maçından önce ve sonra alınmıştır. Eritrosit, lökosit, trombosit, demir ve demir bağlanması ($p <0.05$) değerleri arasında istatistiksel olarak anlamlı fark bulunurken, PCT (prokalsitonin), RBC (kırmızı kan hücresi) ve MCH (ortalama hücre hemoglobini) seviyeleri arasında müsabaka öncesi ve sonra anlamlı bir fark yoktu ($p> 0.05$). Sonuçlarımıza göre, maç koşulları ve yoğun egzersiz demir seviyelerinde ve kanın şekilli elemanlarında ciddi değişikliklere neden olmaktadır. Sezon öncesi, sezon ortası ve sezon sonu dönemlerinde mevcut literatürde belirtilen sıklıklara göre alınacak kan örnekleri, her futbolcunun bireysel kan profili standartlarının takibi için önemli olabilir.

Anahtar Kelimeler
Hematoloji, dayanıklılık eğitimi, demir, performans.

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INTRODUCTION

Football (a.k.a. Soccer) is an intermittent and multidisciplinary team sport which involves intensively high and low exercises as well as requires a significant level of endurance. A football player usually wants to show his/her optimal performance during the football match via 150 to 200 powerful movements such as running, dribbling, jumping and tackling in a short span of time [1]. Football player optimal performance depends on many physical and physiological components at the same time the physical demands are also very significant in modern football. Besides technical skills, football also requires strength, agility and endurance. The aerobic capacity of football players cannot be compared with the aerobic capacity of endurance athletes such as long-distance runners, cross-country skiers and professional cyclists. Among the athletes who are playing ball games, football players show the highest maximum oxygen consumption per kilogram of their body weight [2] . Physical activity is an integral function of living systems. It affects many systems including the hematological parameters. Physical activity plays an important role in humans; people can regulate their physical and physiological balance as well as other body factors including hematological levels by adapting exercise habit or in other words cardiovascular activity. Despite being considered as physically normal and healthy, football players could face with homeostatic, biochemical and hematological changes in their results due to intense training, competitions and match-related psycho-physiological stress [3]. Exercising generally has positive effects on body functions, on the other hand, some adverse effects such as increase in hematocrit, blood flow velocity and plasma viscosity have been reported during post-exercise period [4]. In athletes, although the hematological changes derived from endurance training are usually not found clinically relevant and these changes fall within the defined reference range for general population, some difference can be observed. In addition to this, there are significant individual differences in pre-exercise period as well as in responses to the same physical stress. Knowing the reference range of football player's pre-match blood parameters could provide information regarding to the deviations in post-match or post-exercise [4]. For that reason, monitoring the hematological parameters is significant for the determination of imbalances that may potentially affect health status and performance of the football players during training and the season [5]. Hematological parameters are widely used and extremely cheap method for monitoring the athletes performance. In particular, RBC (Red Blood Cell) is an important parameter for evaluating the training efficiency [6]. Although there are several factors that affect aerobic capacity, the most important ones are oxygen transport for the skeletal muscles via cardiovascular system and the body oxygen consumption. These factors are frequently used as an index for evaluating the physical performance of football players. On the other hand, the efficient oxygen transport to the body tissues also related to the size of heart, blood volume and the amount of hemoglobin in the circulatory system [5]. In some of the studies, it is found that the erythrocyte counts, hemoglobin concentrations, mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) of athletes are lower than sedentary (non-athletes) whereas in some other studies it is found that there is slight increase or no difference between athletes and non-athletes [7-9]. These differences in the studies arise from variety of conditions such as intensity of the training, types of training, body mass index (BMI) and anthropometric characteristics of the athletes and different sport disciplines [3-7]. In recent years, the effects of training and physical exercise on the erythrocyte system have been a hot topic and most of the sport anemia studies are primarily centered on endurance training [3]. Decrease in the hematocrit, hemoglobin concentration and erythrocyte count due to endurance training is called sports anemia which is a special medical case seen in sportsmen and explained by plasma volume expansion frequently occurred during and after physical exercise [6-10]. It has been reported that many things can contribute to sports anemia such as plasma volume increase, exercise-induced oxidative stress, increased body temperature, acidosis, gastrointestinal bleeding, acute and chronic inflammation, and damage in red blood cells [11]. It has also been suggested that various exercise types cause changes in circulating numbers thrombocytes and leukocytes. It has been reported that the increase in leukocytes with exercise is similar to that seen during a bacterial infection [12-14].

The aim of this study is to investigate the changes in football players' blood parameters such as erythrocyte counts, hemoglobin, hematocrit, MCV and MCHV values, WBC, PLT, PCT, leukocytes, iron levels and iron binding capacity, before and after the football match.

MATERIALS and METHODS

Individuals and Exercise Protocol: The study group consisted of 12 volunteer male athletes who are playing football in Turkish A2 League for 'Erciyes Spor Kulübü' which is trying to be promoted to the upper league. The volunteers have average age of 19.08±0.36 years old, average height of 1.80±0.02 cm and average weight of 70.16±1.74kg. The study was approved by Erciyes University, Medical Faculty, Ethics Committee. Furthermore, all volunteers who participated in the study were provided with the informed consent form and the research study started after receiving the necessary permits from the relevant university.

Exercise Program: From the male athletes who are playing football in Turkish A2 League for 'Erciyes Spor Kulübü' which is trying to be promoted to the upper league were taken before and immediately after the match pulse, systolic diastolic blood pressure, flexibility, vertical park, long jump measurements and blood samples.

Peripheral Blood Sampling and Analysis: Participating football players' blood samples were taken before and immediately after the match and mixed with 2 ml EDTA in tubes. The samples were sent to the analysis by barcoding within 30 minutes after being taken to ensure that they were not hemolyzed and clotted.These samples (Cell-DYN 3500R (Abbott)) and total iron binding capacity values (Beckman Coulter Unicel DXC 800) were examined in Erciyes University, Central Laboratories.

Statistical Analysis: After the normal distribution compliance of the data was tested the statistical evaluation was done by paired t-test. Significance level was determined as '0.05'. Data were presented with mean±standard deviation.

RESULTS

The characteristics of participating football players and their pulsation, systolic/diastolic blood pressure, vertical/long jump and elasticity values are given in Table I.

DISCUSSION

Match conditions can lead both physiological and metabolic changes in the athletes body. Therefore, the relationship between athletic performance, heavy exercise, physiological and hematological changes must be well known [15]. Football players best performance which they try to show during the football match, depends on many physiological factors and among them the blood parameters have importance. The type and intensity of exercise as well as match conditions, trauma, and stress affect hematological parameters [16,17]. Acute changes in various blood parameters can be seen a few hours of after training. Hemoconcentration which occurred due to sweat loss and fluid shifts in interstitial spaces, is considered to be an important mechanism of changes arise from exercising [18]. Some studies have shown that regular exercise training increases total hemoglobin, red blood cell count and oxygen carrying capacity whereas

Table 1. Physical and Physiological Characteristics of Football Players.

Variables	Group	n	X±Sx	t	P
Pulsation (pulse/min)	Pre-test	12	75.83±3.86	-4.356	0.001**
	Post-test	12	93.75±3.36		
Systolic blood pressure (mmHg)	Pre-test	12	116.25±2.43	2.014	0.069
	Post-test	12	102.42±5.22		
Diastolic blood pressure (mmHg)	Pre-test	12	70.25±3.43	0.227	0.825**
	Post-test	12	68.50±7.00		
Elasticity (cm)	Pre-test	12	15.83±2.00	-3.932	0.002
	Post-test	12	24.25±1.20		
Vertical jump (cm)	Pre-test	12	36.58±1.53	-5.501	0.000***
	Post-test	12	43.42±1.20		
Long jump (cm)	Pre-test	12	222.00±5.40	-0.319	0.755
	Post-test	12	223.83±6.34		

*p<0.05, **p<0.01, ***p<001

Table 2. Comparison of Erythrocyte Values Before and After the Football Match.

Variables	Group	n	X±Sx	t	P
HGB (Hemoglobin)	Pre-test	12	14.925±1.1917	4.094	.002**
	Post-test	12	14.5250±1.15532		
RBC (Erythrocyte)	Pre-test	12	5.1100±.27736	1.795	0.100
	Post-test	12	5.0058±.33069		
HCT (Hematocrit)	Pre-test	12	47.192±3.1303	4.977	0.000***
	Post-test	12	45.0333±3.15719		
MCV (Mean Corpuscular Volume)	Pre-test	12	91.658±5.5049	13.001	0.000***
	Post-test	12	89.5083±5.51815		
MCH (Mean Corpuscular Hemoglobin)	Pre-test	12	29.017±2.2898	1.246	0.239
	Post-test	12	28.9000±2.25630		
MCHC (Mean Corpuscular Hemoglobin Concentration)	Pre-test	12	31.625±.7362	-4.759	0.001**
	Post-test	12	32.2417±.73045		
RDW (Red Cell Distribution Width)	Pre-test	12	14.108±1.0596	9.916	0.000***
	Post-test	12	13.6833±.95806		
HDW (Hemoglobin Concentration Distribution Width)	Pre-test	12	2.6825±.13903	-2.778	0.018*
	Post-test	12	2.7308±.15774		

*p<0.05, **p<0.01, ***p<001

In Erythrocytes; when the pre-match and post-match values are compared, it is observed that there was a decrease in HGB, HCT, MCV and RDW values whereas there was an increase in MCHC and HDW values (p<0.05). On the other hand, there wasn't any difference in RBC and MCH values (p>0.05).

some studies have shown that endurance exercises are useful for blood volume when performed with stretching exercises [5-19].

On the other hand, there are also some studies that indicate heavy endurance exercises are also responsible for the formation of the sports anemia [18]. A potential problem is highlighted in the literature by emphasizing that 12% of the selected footballers have iron depletion, 10% of them have iron deficiency and 6% of them have iron depletion anemia [20]. In our study, when the pre-match and post-match measurement of the football players are compared, it is found out that there was a decrease in their iron levels because of the heavy match conditions (p <0.05). While the absorption of Fe in the body is made in the intestines, the non-absorbed part is excreted through the feces, urine and sweat, in addition to this small amount of Fe is lost via hair and nail growth. Insufficient iron uptake, weak iron absorption, increase in body temperature, gastrointestinal bleeding and red blood cell destruction in other words intravenous hemolysis triggers iron deficiency in athletes [18,19]. It is stated that, hemolysis is increased by the use of athletic shoes which do not have running and shock absorbing functions, on hard grounds that increase soil reaction power, incorrect running techniques and the old erythrocytes in the circulation [11]. The resulting iron deficiency is thought to be caused by defective thermoregulation, intravenous hemolysis, hematuria, sweating, low iron intake or weak intestinal absorption which are developed because of the match conditions. Malcovati et al. [21] observed seasonal hematological parameters and iron levels of elite football players in their study. Although football players' iron levels are showed a different course during the season, they were peaked in the middle of the season and fall with high stress towards the end of the season. This situation shows similarity with our study. On the other hand, the study of Banfi et al. about elite rugby athletes indicated that the iron levels of the athletes remained constant during the season [14]. This situation does not resemble our study. In our study, when we compare pre-match and post-match measurements of the participating football players, we found out that their total iron binding capacity (TIBC) increased after the match (p <0.05) and we think that this increase occurred due to the decrease of iron level throughout the exercise.

Erythrocytes plays an important role in meeting the increased oxygen demand during the exercise [21].

Table 3. Comparison of Thrombocyte Values Before and After the Football Match.

Variables	Group	n	X±Sx	t	P
PLT	Pre-test	12	239.91±11.81	-2.977	0.013
	Post-test	12	265.33±14.41		
MPV	Pre-test	12	7.16±0.14	6.535	0.000***
	Post-test	12	7.58±0.15		
PCT	Pre-test	12	0.18±0.01	-1.086	0.301
	Post-test	12	0.19±0.01		
PDW	Pre-test	12	41.64±1.06	3.365	0.006
	Post-test	12	39.47±1.15		

*p<0.05, **p<0.01, ***p<001

In Thrombocytes; when the pre-match and post-match values are compared, it is observed that there was an increase in PLT and MPV (respectively 239,91±265,33 and 7,16±7,58) whereas there was a decrease in PDW (41,64± 39,47) (p<0.05). On the other hand, there wasn't any difference in PCT values (p>0.05).

Our study showed that HCT (hematocrit), MCV (mean hemoglobin volume), MCH (mean erythrocyte hemoglobin), CH (erythrocyte hemoglobin) and RDW (erythrocyte distribution width) values are decreased compared to pre-match (p <0.05). Hemoglobin is the protein which carries oxygen from respiratory organs to tissues and carries carbon dioxide and protons from tissues to respiratory organs. Because of the critical role of hemoglobin in oxygen transport, sports hematology has been rapidly advancing in recent years and has been identified as a subgroup in athletic health. Hematocrit is significant for the measurement of hemoglobin and erythrocytes in the blood. It is indicated that, decreased hemoglobin and hematocrit values during intense exercise or competitive periods are a well-defined adaptation (characteristics) of sportsmen and professional football players [2] . Hematocrit, MCV, MCH values decrease in intensive anemias but some of the studies indicate that if the body loses water especially in submaximal exercises, the hematocrit value increases due to increased plasma volume with decreased fluid [21]. In some of the studies, hematologic findings of the athletes were examined for 3 years and it is found out that decrease of the erythrocyte, hemoglobin and hematocrit values are maximizing at the end of competition [22]. In addition, Halson et al. [23] prepared a training program for the participating athletes, in which athletes did normal workout for 2 weeks followed by intensive workout for 4 weeks; after the examination of the findings, it is observed that the erythrocyte and hemoglobin parameters showed rhythmic and insignificant declines in the first, second and third weeks whereas they showed regular and meaningful increases in fourth, fifth and sixth weeks. It has been reported that acute swimming exercise decreases ratios of erythrocytes, Hb and Hct in rats compared to pre-swimming values. Banfi et al. [14] have examined the hematological parameters of elite rugby players during a season and stated that hemoglobin and hematocrit values are increased in the first half of the season whereas they decreased towards the end of season; to sum up they recorded two different outcomes for the first and second half of the season. Fallon et al. [24] stated that intensive sportive competition and severe efforts are the sign of hemoglobin and hematocrit reduction. Similar statements made by Rietjens and et al. for cyclists, Schumacher et al. for triathlon and Malcovati et al. for football [20,25,26,]. Therefore, data obtained from the academic literature supports our study and it is thought that decrease of hemoglobin and hematocrit values in erythrocyte parameters are caused by the increased concentration due to maximal exercise, stress, changing metabolic activity and iron deficiency caused by exercise. Also, in our study, we found that there was a decrease in erythrocyte values immediately after the match compared to pre-match values but it was not found to be significant according to p value. Some studies stated that regular and moderate exercises reduce risk of infection compared to sedentary life (non-sportive life) whereas some other studies indicate that prolonged and heavy exercises increases the risk of infection. It is significant to know that how density, duration and type of exercise affect the immune function of body. The changes in the immune function which trigged by exercise can occur both acutely and in the long term [5]. Acute immune response to the exercise is temporary and it can fade away if the person stops or decreases the exercise. Exercises also increase the catecholamine concentration and growth hormo-

Table 4. Comparison of Leukocyte Values Before and After the Football Match.

Variables	Group	n	X±Sx	t	P
WBC (White Blood Cell) (μ/L)	Pre-test	12	6.15±0.33	-5.675	0.000***
	Post-test	12	13.18±1.19		
NE% (Neutrophil)	Pre-test	12	52.10±2.21	-10.211	0.000***
	Post-test	12	80.58±1.70		
EO% (Eosinophil)	Pre-test	12	1.93±0.24	6.241	0.000***
	Post-test	12	0.40±0.05		
LY% (Lymphocyte)	Pre-test	12	35.92±1.86	9.366	0.000***
	Post-test	12	13.56±1.49		
BA% (Basophil)	Pre-test	12	0.49±0.06	4.442	0.000***
	Post-test	12	0.22±0.03		
MO% (Monocyte)	Pre-test	12	7.22±0.43	4.906	0.000**
	Post-test	12	4.44±0.36		

*p<0.05, **p<0.01, ***p<001

According to Table VI, there are statistically significant difference between the pre-match and post-match WBC, NE%, EO%, LY%, BA% and MO% levels of the leukocyte values (p<0.05). When the pre-match and post-match values are compared, it is observed that there was an increase in WBC (6,15±13,18) and NE% (52,10±80,58) whereas there was a decrease in EO%, LY%, BA% and MO% levels (respectively 1,93±0,40, 35,92±13,56, 0,49±0,22 and 7,22±4,44).

ne. These hormones increase the neutrophil in blood due to exercise-induced stress. Some studies show that high cortisol levels are observed after intensive exercise [7]. In our study, Leukocyte (WBC) and Neutrophil values increased immediately after the match compared to the pre-match values but there was a decrease in Eosinophil, Basophil, Lymphocyte and Monocyte values (p<0.005) compared to pre-match values. Neutrophils, Eosinophils, Basophils, Lymphocytes and Monocytes are important leukocytes which are responsible for the defense of the organism. It is stated that, after the strenuous exercise, granulocytes in other words the total WBC percentages increase. It is indicated that, some of the changes in blood parameters (such as hematocrit and RBC counts) returned to resting levels short after the exercise is over, on the other hand some of them lasted for almost 12 hours. Lymphocytes have receptors that sense various stress hormones [21]. It has been reported that leukocyte and lymphocyte amounts in long-term training are not different from resting sedentary people, but maximal exercises lead to leukocytosis and lymphocytosis in both trained and sedentary people, while submaximal exercises cause leukocytosis and lymphocytosis in sedentary without any change in trained people [27]. Moreover, it is stated that WBC activation is closely related to type and level of exercise as well as the athletes' athletic capacity [27]. Neutrophils, Eosinophils, Basophils, Lymphocytes, Monocytes are important leukocytes responsible for the organism defense. Heavy metal overload and stress cause excessive release of the adrenal gland hormones such as adrenaline and cortisone. These hormones negatively affect the production and functions of leukocytes as well as suppress the thymus. Stress stimulates the sympathetic nervous system and stimulated sympathetic nervous system suppresses the immune system. Parasympathetic nervous system controls activities such as resting, relaxing, sleeping, regenerating and curing (regulation) that support the immune system. If this body balance fails in favor of the sympathetic system, the immune system may become worn out due to a constant drive and alarm condition and may suffer from malfunction [28]. Neutrophils are particularly interesting as they increase susceptibility to the infections. In aerobic exercises, the risk of bacterial infection is higher than the anaerobic exercises. In their studies, Heisterberg et al. [29] particularly emphasized the significance of two periods in the performance optimization of professional football players. The first one is the pre-season preparation period. This period usually involves high-intensity endurance training and heavy-resistance exercise training that increases certain immune parameters. The second period is the end of the season. At this period, it has been emphasized that physical constraints are more evident because as the time pass critical indicators such as MCH, MCHC, MCV and hematocrit have been deviated compared to their pre-season values and adverse changes in immune defenses. For that reason,

Table 5. Comparison of Total Iron Binding Capacity Values Before and After the Football Match.

Variables	Group	n	X±Sx	t	P
Fe (Iron)	Pre-test	12	119.92±47.927	3.087	0.010*
	Post-test	12	86.0833±24.32155		
TIBC (Total Iron Binding Capacity)	Pre-test	12	373.75±29.453	-3.273	0.007**
	Post-test	12	383.0000±28.46050		

*p<0.05, **p<0.01, ***p<001

When the pre-match and post-match iron levels and iron binding capacities are compared, it is found out that the iron levels were decreasing (119,92±86,0833) whereas the free iron binding capacity was increasing (373,75±383,0000) compared to the pre-match values (p <0.05).

the coaches and the physical staff must be extra cautious when programming the training schedule for the season [30]. Differences in blood parameters can occur as a result of changes in intensity and type of competition and training.

In conclusion, in our study, it is found out that, at the end of the season, blood samples taken from professional football players who were playing in promotion group, immediately after the match showed significant changes in the shaped element of blood and iron levels compared to the pre-match values. The blood samples which will be taken at the pre-season, mid-season and late-season periods in accordance with the frequencies specified in the current literature can be important to follow the individual blood profile standards of each football players. At the same time, we believe that the blood samples can contribute to the monitoring of elite soccer players' high physical strain and overload as well as following their performance, and ensure early intervention to the deviations.

References

1. D. Draganidis, A. Chatzinikolaou, A.Z. Jamurtas, J. Carlos Barbero, D. Tsoukas, A.S. Theodorou, K. Margonis, Y. Michailidis, A. Avloniti, A. Theodorou, A. Kambas, I. Fatouros, The time-frame of acute resistance exercise effects on football skill performance: The impact of exercise intensity, J. Spor. Sci., 31(2013) 714-722.
2. M.F. Heisterberg, J. Fahrenkrug, P. Krustrup, A. Storskov, Kjaer, J. L. Andersen, Extensive monitoring through multiple blood samples ın professional soccer players, J. Strength. Cond. Res., 27 (2013) 1260-1271.
3. G. Banfi, P.Morelli, Relation between values of haemoglobin, erythrocytes and reticulocytes and bady mass index in elite athletes of different sports disciplines, Int. Jnl. Lab. Hem., 29 (2007) 484-485.
4. R.S. Ajmani, J.L.Fleg, A.A. Demehin, J.G. Wright, F. O'Connor, J.M. Heim, E.Tarien, J.M.Rifkind, Oxidative stress and hemorheological changes induced by acute treadmill exercise, Clin. Hemorheol. Microcirc., 28 (2003) 29-40.
5. E. Varamenti, Z. Nikolovski, M.I. Elgingo, A.Z. Jamurtas, M. Cardinale, Training-ınduced variations in haematological and biochemical variables in adolescent athletes of arab origin throughout an entire athletic season, J. Hum. Kinet., 64 (2018) 123-135.
6. J. Malczewska-Lenczowska, D. Sitkowski, J. Orysiak, A. Pokrywka, Z. Szygula,Total haemoglobin mass, blood volume and morphological indices among athletes from different sport disciplines, Arch. Med. Sci., 9 (2013) 780-787.
7. A.S.R.Silva, V. Santhiago, M. Papoti, C.A. Gobatto, Hematological parameters and anaerobic threshold in Brazillian soccer players throught a training program, Int. Jnl. Lab. Hem., 30 (2008) 158-166.
8. T. Mashiko, T. Umeda, S. Nakaji, K. Sugawara, Effects of exercise on the physical condition of college rugb players during summer training camp, Br J Sport Med, 38 (2004) 186-190.
9. G. Lippi, F. Schena, G.L. Salvagno, R. Aloe, G.Banfi, G.C. Guidi, Foot-strike haemolysis after a 60-km ultramarathon, Blood Transfus, 10 (2012) 377-383.
10. M. Gleeson, A.K. Blannin, D.A. Sewell, R. Cave, Short-term changes in the blood leukocyte and platelet count following different durations of high-intensity treadmill running, J. Spor. Sci. 13 (1995) 115-123.
11. G.G. Wardyna, S.I. Rennarda, S.K. Brusnahanb, T.R. McGuirec, M. L. Carlsona, L. M. Smithd, S. McGranaghana, J. G. Sharpb, Effects of exercise on hematological parameters, circulating side population cells, and cytokines, Experimen. Hematology, 36 (2008) 216-223.
12. V.Cinar, R.Mogulkoç, A.K. Baltaci, Calcium supplementation and 4-week exercise on blood parameters of athletes at rest and exhaustion, Biol. Trace Elem. Res., 134 (2010) 130-135.
13. M.N. Sawka, V.A. Convertino, E.R. Eichner, S.M. Schnieder, A.J. Young, Blood volume: importance and adaptations to exercise training, environmental stresses, and trauma/ sickness, Med. Sci. Spor. Exerc., 32 (2000) 332-348.
14. G. Banfi, M. Del Fabbro, C. Mauri, M.M. Corsi, G. Melegati, Haematological parameters in elite rugby players during a competitive season, Clin. Lab. Haem., 28 (2006) 183-188.
15. S. Meister, K. Aus der Fünten, T. Meyer, Repeated monitoring of blood parameters for evaluating strain and overload in elite football players: is it justified?, J. Spor. Sci., 32 (2014) 1328-1331.

16. M. Hu, W. Lin, Effects of exercise training on red blood cell production: ımplications for anemia, Acta Haematol., 127 (2012) 156-164.
17. S.M Ostojic, Z. Ahmetovic, Weekly training volume and hematological status in female top-level athletes of different sports, J. Spor. Med. Phys. Fitness, 48 (2008) 398-403.
18. S.F. Clark, Iron deficiency anemia, Nutr. Clin. Pract., 23 (2008) 128-141.
19. S.M. Ostojic, Z. Ahmetovic, Indicators of iron status in elite soccer players during the sports season. International J. Labor. Hematol., 31 (2009) 447-52.
20. L. Malcovati, C. Pascutto, M. Cazzola, Hematologic passport for athletes competing in endurance sports: a feasibility study, Haematologica, 88 (2003) 570-581.
21. D.J. Shaskey, G.A. Gren, Sports haematology, Sports Med, 29(2000) 27-38.
22. Y.O. Schumacher, D. Grathwohl, J.M. Barturen, M. Wollenweber, L. Heinrich, A. Schmid, G. Huber, J. Keul, Haemoglobin, haematocrit and red blood cell indices in elite cyclists. Are the control values for blood testing valid?, Int. J. Spor. Med., 21 (2000) 380-385.
23. S.L Halson, G.I. Lnacaster, A.E. Jeukendrup, M. Gleeson, İmmunological responses to overreaching in cyclists, Med. Sci. Spor. Exerc., 35 (2003) 854-86.
24. K.E Fallon, G. Sivyer, K. Sivyer, A. Dare, Changes in haematological parameters and iron metabolism associated with a 1600 kilometre ultramarathon, Br. J. Spor. Med., 33 (1999) 27-32.
25. G.J. Rietjens, H. Kuipers, F. Hartgens, H.A. Keizer, Red blood cell profile of elite olympic distance triathletes. A three-year follow-up, Int. J. Spor. Med., 23 (2002) 391-396.
26. Y.O. Schumacher, R. Jankovits, D. Bültermann, A. Schmid, A. Berg, Hematological indices in elite cyclists, Scand. J. Med Sci Sports, 12 (2002) 301-308.
27. M. Gleeson, C. Williams, Intense exercise training and immune function, Nestle Nutr. Inst. Workshop Ser., 76 (2013) 39-50.
28. S. Meister, O. Faude, T. Ammann, R. Schnittker, T. Meyer, Indicators for high physical strain and overload in elite football players, Scand. J. Med. Sci. Spor., 23 (2013) 156-163.
29. M.F. Heisterberg, J. Fahrenkrug, J.L. Andersen, Multiple blood samples in elite soccer players. Is it worthwhile?, J. Spor. Sci., 13 (2014) 1324-1327.
30. S. Reinke, T. Karhause, W. Doehner, W. Taylor, K. Hottenrott, G.N. Duda, P. Reinke, H.D. Volk, S.D. Anker , The ınfluence of recovery and training phases on body composition, peripheral vascular function and ımmune system of professional soccer, Players. PLoS One, 4 (2019) e4910.