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The acute effects of single football match on whole blood viscosity and hematological variables in female soccer players.

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Abstract

In this study, we aimed to investigate the acute effects of single 90-minute football match on whole blood viscosity and hematological variables in amateur female soccer players.
Ten subjects were selected from the female footballers of an amateur regional football club in Turkey, at the last week of football season. Prior to last seasonal football match venous blood samples were drawn. After 90 minute football match, the researchers stopped the match timely and blood samples were re-drawn from subjects. From the samples, pre- and post-match hematological parameters, lactate level, blood viscosity, plasma Na^+ and K^+ levels were determined.
The results showed that mean corpuscular volume (MCV), Na^+ and K^+ levels were all decreased significantly whereas numbers of white blood cell (WBC) and platelet (PLT) were both increased after the match. We didn't find statistically significant difference in whole blood viscosity after the match. Blood lactate levels were also significantly increased after the match. Our results showed that blood viscosity of female footballers tends to increase by this type of training due to decrease in body waters and increase in WBC and PLT numbers of amateur female footballers.
Increase in blood lactate levels is remarkable and may have adverse effect on blood viscosity of these subjects because some protective mechanisms might not have adequately developed with regular training throughout the season.

Keywords: Soccer, Female footballer, Hematological variables, Blood viscosity, Lactate level.

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Introduction

Football is the most popular sport in the world and it is performed by men, women, children and adults with different levels of expertise [1]. Contemporary sports imply huge training efforts, with thus an increasing danger of overloading [2]. It was previously reported that the early signs of overtraining in elite sportsmen are associated with a hemorheologic pattern [3].

An increase of blood and plasma viscosity, an increased aggregation of erythrocytes and a decreased deformability of erythrocytes are pathogenetically important for a disturbance of the microcirculation. For a series of pictures of a disease, such as polycythaemias, anaemias, paraproteinoses, diabetes mellitus, Raynaud's syndrome, myocardial infarction, degenerative angiopathies, are changes of the blood rheology of clinical relevancy [4].

Blood rheology is one of the determinants of blood flow which becomes important when vasomotor reserve is limited or exhausted. It can be quantified ex vivo by measuring blood and plasma viscosity, hematocrit, red cell deformability and aggregation [5]. The acute increase in whole blood viscosity may unfavorably affect the microcirculatory blood flow and oxygen delivery to the tissues. Recently, limited number of evidence indicates that the viscosities of whole blood and plasma increase in response to a variety of exercise protocols [6,7], it means that long-term exercise attenuates the increase in blood viscosity during the exercise.

Hemorheological alterations during long term exercise depend on hematological parameters, especially hematocrit and plasma protein levels [8]. Previously, it was demonstrated that standard ninety-minute football match did not have adverse effects on blood rheology in regularly trained male footballers [9]. However, it is not known whether standard ninety minute football matches or league matches acutely affect the blood rheology in regularly trained female amateur footballers.

In this study, we aimed to investigate whether single football match affects whole blood viscosity and hematological variables in regularly trained amateur female footballers. Our hypothesis was that the elevated blood lactate levels at the last week of football season and standard 90 minute football match may alter whole blood viscosity and hematological variables in female footballers, and hyperviscosity might occur immediately after the match or sooner at the end of football season.

Materials and Methods

Subjects and study design

Following approval of study protocol by the local Ethic Committee of Inonu University Faculty of Medicine, ten female footballers were selected from the footballers that play in a football club of regional amateur league. Goalkeepers were excluded from the study. Written consent and parent permission for the subjects under 18 years old were taken. These subjects were questioned about the performance and the health problems. Physical parameters such as age, height and body weight were recorded. Informed consent was obtained from all the subjects.

Assays

At the last week of football season, prior to standard league match (pre-training) venous blood samples were withdrawn from the right antecubital vein and 105 minutes (90 minutes playing time plus 15 minutes break time between two periods) after the standard league match (post-training), the subjects stopped the match timely and blood samples were re-withdrawn from the left antecubital vein within two minutes. During the football match, they were allowed to drink spring water at the breaks. Blood samples were immediately transferred into sample tubes that contain different types of anticoagulant. Pre-training and post-training blood samples were separately transported to laboratories in a cooled container as soon as possible. Blood lactate levels were immediately analyzed by lactate strip reader device (ARKRAY INC. Kyoto, JAPAN) as soon as blood samples were withdrawn. Hematological parameters including red blood cell (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), number of platelet (PLT) and number of white blood cell (WBC) were determined by automatic cell analyzer (Beckman Coulter, USA). Na^+ and K^+ were analyzed by blood gas analyzer system (Novbio Medical, Stat-Profile-Ultra, USA).

Whole blood viscosity was determined by a rotational viscometer (modified NDJ-1, Ceti, Liege, Belgium). The rotor numbered zero was used for operation and, measurements were performed by using 60 rpm rotating speed at 37°C. Measurements were repeated at least two times for each sample and average of two subsequent measurements with 0.2 maximum differences was accepted. Shear rate was calculated as 140 s^{-1} on the lateral surface of rotor and not changed.

Statistical analysis

Statistical analyses were done by paired–t test because of the normal distribution of data, and Pearson correlation test was used to investigate correlations. P value was determined as 0.05.

Table 1: *Hematological and hemoreological parameters before and after the match (Mean ± SD).*

	Before the match (n=10)	After the match (n=10)	P value
RBC (× 10^6/mm^3)	4.56 ± 0.25	4.67 ± 0.28	0.203
HGB (g/dl)	12.96 ± 0.80	13.28 ± 0.73	0.182
HCT (%)	38.8 ± 2.23	39.5 ± 2.04	0.241
MCV (μ^3)	85.2 ± 3.28	84.7 ± 3.08	0.028*
PLT (× 10^3/mm^3)	253 ± 41.2	311 ± 50.0	0.005*
WBC (× 10^3/mm^3)	7.89 ± 1.74	11.8 ± 3.80	0.007*
Blood viscosity (mPa.s)	2.61 ± 0.18	2.68 ± 0.31	0.553
Blood lactate (mmol/L)	1.91 ± 0.94	6.27 ± 1.74	0.008*
Plasma Na^+ (mEq/L)	135.2 ± 11.7	128.8 ± 2.5	0.021*
Plasma K^+ (mEq/L)	4.21 ± 1.65	2.75 ± 1.19	0.043*

*Differences are significant at the level of 0.05

Results

Average age of the female footballers was 17.9 ± 1.9 years and their body mass indexes (BMIs) ranged from 17.9 to 22.3 with the average of 19.9 ± 1.2. All subjects were in good health and had no noteworthy health or traumatic problems within the football season. Average time of playing football was found as 3.8 ± 0.9 years. Pre-training and post-training hematological and hemorheological variables and their comparisons were

shown in Table 1. MCV, plasma Na^+ and K^+ contents were all decreased significantly after the match whereas WBC and PLT counts were both significantly increased after the match. It was appeared that whole blood viscosity increased after the match. However, we didn't find statistically significant difference in the elevation of whole blood viscosity. Blood lactate levels were also significantly increased after standard ninety-minute match. As another finding, whole blood viscosity was negatively correlated with plasma Na+ concentration (r= -0.848 and p=0.004).

Discussion

Football is characterized as a high intensity, intermittent, non-continuous exercise [10]. Hemorheological effects of exercise are triphasic phenomenon including short-term, middle- term and long-term effects. In the short-term effects, hyperviscosity occurs mostly due to fluid shifts and alterations of erythrocyte rigidity and agreeability. Middle-term effects include the reversal of acute effects due to plasma volume expansion that decreases both plasma viscosity and hematocrit. Long-term effects involve further improving blood fluidity, parallel with the classical training-induced hormonal and metabolic alterations [11].

It has now been clearly established that blood behaves like a non-Newtonian fluid exhibiting specific features with the probable existence of a plasticity threshold, a viscosity that varies as a function of shear rate and a non-homogeneous nature of the medium during flow. When apparent blood viscosity is represented as a function of shear rate, a high viscosity is observed at low shear rates, mainly due to rouleaux formation or red cell aggregates. At high shear rates, viscosity decreases [12].

In our study, blood lactate levels were significantly increased immediately after the match when compared with their initial values. After the match, blood lactate levels are out of the physiological ranges in these subjects. Similarly, it was reported that high levels of blood lactate (up to 7.2-9.5 mmol/L) may sometimes be observed during a competition match [10]. Lactate removal occurs more effectively during mild to moderate exercise recovery intensities [13]. In these subjects, high levels of blood lactate after the match may be contributed to nature of football match as a high intensity exercise or inadequate adaptation to football.

Contrary to our hypothesis, whole blood viscosity measured at 140 s^{-1} shear rate did not significantly change after the match. The whole blood viscosity might have been balanced by significant decrease in MCV of red blood cell in addition to a little effects of significant increase in WBC and PLT counts. These changes also appeared to be in response to increased shear rate conditions that occurred at the end of the match as well as hemodilution in the middle-term effects of exercise. Although decreases in plasma Na^+ and K^+ contents supported the fluid shift from the intracellular space into plasma (relative hyponatremia and hypopotasemia), increases in WBC and PLT counts may be attributed to the high shear rate conditions in the systemic circulation occurred at the end of the match period in these subjects. On the other hand, volume depletion of red blood cells can limit elevation of blood viscosity against to fluid shift from the plasma into the extra-vascular space. Microcirculatory studies showed a significant increase in the basal perfusion level after exercise when compared to the resting state values [14]. Additionally, it was proposed that exercise-associated hyponatremia is a dilutional hyponatremia occurring during prolonged exercise in athletes, associated with positive fluid balance mediated in part by secretion of arginin vasopressin [15]. This type of hyponatremia may eventually cause acute pulmonary and brain edema.

Increases in WBC counts after the match were reported in some previous studies. Perez et al. [16] showed significant increase in WBC number of children after both the laboratory and field exercise protocols. In another study, WBC and PLT counts significantly increased at the end of single football match period compared with pre-match values of male footballers [9]. Actually, increase in WBC counts in response to exercise in these subjects can be attributed to demargination process caused by exercise or epinephrine administration. Actually half of the blood leucocytes are in marginal pool, i.e., loosely adherent to the vascular endothelium or trapped in the microcirculation. With exercise or epinephrine administration these cells are released into the circulating pool and the leukocyte count raises; this process is called as demargination [17].

Conclusions

Our results showed that whole blood viscosity tends to increase by this type of training due to decrease in body waters and increase in WBC and PLT numbers in amateur female footballers. Increase in blood lactate levels is remarkable and this may have adverse effect on blood viscosity of these subjects because some protective mechanisms are not adequately developed with regular training throughout the training. Notwithstanding, possible increases in whole blood viscosity may have been prevented by some protective mechanisms occurring by regular training and increased shear rate during football match. The ultimate conclusion is that ninety-minute football playing may not suitable in that lactate elimination for female players who do not have well developed adaptive mechanisms and this playing time may be shortened for female players. Risk of hyponatremia may be prevented by supplying element-enriched beverages during and after the long-term matches.

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