The Relation between Performance Values with Different Characteristics and Hematological Results of Professional Soccer Players

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Abstract: Purpose: Soccer which is the most popular sports in the world requires various factors such as technical/biomechanical, tactical, mental and physiological aspects for success. In this study, the relations between the results of performance tests coming from different energy transfer systems depending on intensity and time and hematological results occur in a soccer game of 90 minutes were investigated. **Methods:** 24 soccer players with age of 22.2 ± 2.0 years, height of 177.0 ± 4.7 cm and body mass of 71.9 ± 6.4 kg joined this study. After measuring the hematological results of the subjets the loss (decrease) in their maximal aerobic (20 m shuttle run test), anaerobic (wingate test) capacities, sprint ability (30 m) and repeated sprint (6 x 30 m sprint) performances were determined. **Results:** After the findings were evaluated, it was determined that the relation between maximal oxygen consumption (VO_2max) and mean power is 0.01 and relation between VO_2max and percentage decrement in repeated sprint ability is 0.05, the relation between peak power and fastest sprint value is 0.01, the relation among each hematological values was 0.01. **Conclusion:** The fuel required in soccer game for motions performed with or without ball is supplied by different energy systems depending on intensity and time. These energy systems are in an interaction in different levels among themselves independent from hematological values.

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1. Introduction

Soccer performance depends on various factors such as technical-biomechanical, tactical, mental and physiological aspects (Stølen et al., 2005). Physiological demands require the players to be sufficient in various areas such as aerobic and anaerobic power, muscle strength, elasticity and agility. In soccer game consisting of exercise periods of high intensity interspersed among exercise periods of low intensity the energy required (Svensson & Drust, 2005) is supplied both by aerobic and anaerobic metabolism (Foss & Keteyian, 1998; Bompa, 1999; Guyton & John, 2011). The energy systems do not activate separately one by one manner but in a scrolling manner depending the time and intensity characteristics of the activity (Åstrand & Rodahl, 1986; McArdle, 2000). There is a need for energy for the formation of body movements and muscle contractions. This need is fulfilled by the energy that arouses after degrading the last bond in the "adenosine triphosphate" (ATP) combination which has high energy phosphate bonds stored in skeleton muscular tissue (Scott, 2005; Guyton & John, 2011; McArdle, 2000; Foss, 1998; Åstrand & Rodahl 1986). The ATP amount needed for the contraction of skeleton muscles at the physical activities is supplied by three different energy systems. The selection of which energy system to be activated is determined by duration and intensity of the activity. The immediate energy is supplied by ATP-PCr system, the short term energy is supplied by glycolytic system and the long term energy is supplied by aerobic system (Guyton & John, 2011; McArdle, 2000; Foss, 1998). The aerobic capacity is linked with the ability of body to use existing oxygen (Svensson & Drust 2005) and it is the highest oxygen utilization that could be reached during maximal or intense exercise program. It is stated that the aerobic capacity can be limited depending on the lack of oxidative enzymes in the cell mitochondria or the O_2 amount carried to active tissues with ability of cardio vascular system (Wilmore & Costill, 2005). The anaerobic capacity is the work capacity created by skeleton muscles during maximal and supramaximal physical activities of less than 90 seconds with the lack of oxygen (Jonathan & Euan, 1997). It is stated that the elite soccer players repeat sprints of 2-4 seconds in average with intervals of 90 seconds (Stolen et al., 2005). Also it is indicated that aerobic way is used as main energy source in soccer games (Bangsbo, 1994; Krustrup et al., 2003) and soccer players at elite level run nearly 10 kms with a power close to the aerobic threshold (80-90 % of maximal heart rate) during a game of 90 minutes (Stølen et al., 2005). According to the literature on this field the positive relation between maximal oxygen consumption capacity (VO2max) and distance covered in the soccer matches and (Hoff, 2005; Krustrup, 2003; Drust, 1998; Reilly, 2003; Franco, 2005) technical-tactical performance of players is stressed (Apor, 1988; Wisløff, 1998; Helgerud et al., 2001). Integrity could not be identified at the studies on the relation between hematological values and exercises. Linstedt (2001) has shown that maximal oxygen consumption amount has been limited by the central circulatory system during the exercises in which the large muscle groups took part. There are numerous studies that stimulation of the hematological parameters are attributed to the sportive activities on the characteristics of the specific styles such as strength and power training. It has been stated that the hemoglobin concentration has increased erythrocytosis (erythrocyte increase) stimulation mainly with the effect of exercise but this mechanism has been suppressed by the very large increase of the plasma volume (Schumacher et al., 2002). In this study the relations between different energy transfer systems that needed for performing the actions with or without ball during a soccer game and activate according to intensity and duration and the hematological values have been observed.

2. Materials and Methods

The measurements are performed at 4 different days in second week of soccer league preparation season. In the first day measurements of height and body composition and taking of blood samples have been done. In the 2nd day Wingate anaerobic power test (WAnT) application at the soccer fitness saloon, in the 3rd day 6 x 30 m repeated sprint test and in the 4th day 20 m shuttle run test have been performed. 30 m sprint and 20 m shuttle run tests have been carried out at the environment that 1067 meter of altitude, at an outdoor area, on dry natural turf and temperature of 25°-26° C. Performance tests have been started 2.5 hours later after breakfast.

3. Participants

24 soccer players from the Turkish 2nd professional soccer league participated to this study.

4. Experimental Procedures

Measurement of body composition and heigh

The measurement of body composition (body mass, fat mass, fat free mass) has been performed by Tanita TBF 410 Japan, height measurements have been performed by a Holtain brand (England) stadiometer with a sensitivity of ± 1 mm. The measurement of body composition was performed before taking of blood samples in fasting state.

Taking of blood samples

Erythrocytes (RBC) and hemoglobin (HGB) measurements at the blood samples taken after 9 hours of fasting period have been done with a Coulter T-890 USA device.

Wingate anaerobic power test (WAnT)

WanT test consists of pedaling for 30 seconds with a maximal speed against a constant force. Test has been performed in 5 intervals as preparation, recovery period, acceleration, wingate test and cooldown phases respectively. At the preparation phase (5 minutes) 5 low resistance maximal pedaling speed sprints with 4-6 seconds intervals and at the recovery phase (3 minutes) pedaling with a minimal resistance (10-20 rpm 1kg) and very low speed were performed. At the acceleration phase resistance was increased incrementally and after 9-10 seconds it was raised to the pre-determined level. The participant pedaled for 30 seconds with maximum effort at the wingate test phase and at the end of the process came the cooldown phase. This phase included of pedaling with maximum resistance for 2-3 minutes. The load subjected to cycling pedal was determined as 75 grams for each kgs of body mass during the test (Adams, 2002; Inbar et al., 1996; Bar-Or, 1987).

20 m Shuttle Run Test

Equipments for this test are a CD including 20 m shuttle run test audio warnings, a CD player, a tape measure, cones and individual forms. The test process consisted of preparation phase, application phase and cooldown phase after the end of test. During the preparation phase, to catch a standard all soccer player groups participating the test have been subjected to a warm-up phase of 10 minutes that has a content prepared before (jog, low run, flexibility, stretching). During the test period soccer players were expected to determine their running tempo between the cones in accordance with the voice (ton and bleep) they heard automatically from the CD player. It was previously stated that the time interval between voices would decrease after each minute so tempo would increase (according to the voices the running pace was 8.5 km/h at the beginning and it increased 0.5 km/h in every minute. The tests of participants who could not reach to the place that they had to be twice after the audio warnings were finalized (Léger et al., 1988).

30 m ve 6 x 30 m Repeated sprint test

This test was applied in three phases consisting of warm-up, testing and cooldown periods. At the warm-up phase (25 min.) each participant subjected to various activities (containing jog, low run, submaximal /maxsimal run, flexibility, stretching and jump) in accordance with the predetermined number, duration or pace in order to catch the standard. The participants began the sprint when they are ready at high start position without accelerating and ended at 30 meters. 30 m test measurements of the players passing between start and stop divisions of photocell were taken after photocell automatically stopped. The measurement was performed by using new-test 2000 in Finland photocell device with milliseconds sensitivity. After the best degree was determined at the 6 x 30 m repeated sprint test percentage decrement at the velocity performance due to fatigue (Percentage decrement; % PD) was measured as below: Fatigue % or the percentage decrement (% PD); = 100 – [(fastest sprint time x 6 / total repeated sprint time) x 100] (Glaister, 2004).

Statistical Analysis

Mean and standard deviation measurements regarding the total data were performed. Test of normality for data was done with Sample K-S test and the values were calculated more than 0.05. The relation between each datum that shows normal distribution was researched with the help of Pearson product moment correlation analysis. For the statistical analysis, a package program was used and significance level was accepted as 0.05.

5. Results

The demographical specifications of soccer players like age, height, body weight and body mass index (BMI) were determined as 22.2 ± 2.0 (years), 177.0 ± 4,7 (cm), 71.9 ± 6.4 (kg) and 22.9 ± 1.5 (kg/m^2) respectively (Table 1).

After the 20 m shuttle run test to determine the aerobic capacity, the maximal oxygen usage (VO_2max) was calculated as 53.3 ± 3.6 ($ml.kg^{-1}.min^{-1}$), with wingate test to determine the aerobic strength the peak power (PP) was calculated as 11.1 ± 0.9 (watt/kg) and the mean power (MP) was calculated as 7.7 ± 0.6 (watt/kg) (Table 2). The fastest sprint (FS) degree in 30 meter sprint test was recorded as 4.2 ± 0.1 (sec.) and percentage decrement (PD) or fatigue was recorded as 2.9 ± 1.3 (Table 2).

The relations between performance tests with different characters of soccer players were given at Table 3. According to this, it had been determined that there was a positive meaningful relation between maximal oxygen usage and mean power ($P<0.01$) and there was a negative meaningful relation between maximal oxygen usage and the ability of maintaining sprint power ($P<0.05$). Also it had been seen that there was a negative relation between peak power (PP) and the fastest sprint (FS) ($P<0.05$) and for hematological values there is a positive relation only between themselves ($P<0.0$) (Table 3).

Table 1. Demographic characteristics and body composition of soccer players; mean ± standard deviation (SD), minimum and maximum values.

n = 24	Mean ± SD	Minimum	Maximum
Age (years)	22.2 ± 2.0	21.00	28.00
Height (cm)	177.0 ± 4.7	170.00	185.00
Body mass (kg)	71.9 ± 6.4	60.80	84.20
Body mass index; BMI (kg/m^2)	22.9 ± 1.5	19.85	25.42

Table 2. Aerobic and anaerobic power, fastest sprint, sprint power maintenance, hematological of soccer players; mean ± standard deviation (SD), minimum and maximum values.

N = 24	Mean ± SD	Minimum	Maximum
Maximal oxygen consumption ($ml . kg^{-1} . min^{-1}$)	53.3 ± 3.6	47.40	60.60
Peak power (watt/kg)	11.1 ± 0.9	9.90	13.2
Mean power (watt/kg)	7.7 ± 0.6	6.80	9.1
Fastest sprint (sec.)	4.2 ± 0.1	4.05	4.53
Percentage decrement	2.9 ± 1.3	1.22	6.03
Erythrocytes (10^{12} / L; M/mm^3)	5.03 ± 0.3	4.39	5.62
Hemoglobin (g/dL)	15. 7 ± 0.9	13.90	16.70
VO_2max;, RBC;, HGB; Hemoglobin,			

Table 3: The performance test results of soccer players with different characteristics and the relation between hematological values.

		VO2max	PP	MP	FS	PD	RBC	HGB
VO2max	**r**	1	.216	**.605 (**)**	-.416	**-.560 (*)**	.435	.297
	P		.375	.006	.076	.013	.063	.218
PP			1					
	P			.179	.009	.266	.493	.977
MP				1				
	P				.409	.000	.369	.234
FS					1			
	P					.398	,589	.590
PD						1		
	P						.872	.827
RBC							1	
	P							.000
HGB								1
	P							

VO2max: Maximal oxygen consumption, PP: Peak power, MP: Mean power, FS: Fastest sprint, PD: Percentage decrement RBC; Red blood cells or erythrocytes, HGB; Hemoglobin,

* Correlation is significant at the 0.05 level (2-tailed),

** Correlation is significant at the 0.01 level (2-tailed),

6. Discussion

In soccer physical demands requires the players to be adequate on the aspects such as aerobic and anaerobic power, muscle strength, flexibility and agility (Svensson & Drust, 2005). In this study that performed with the participation of national level professional players it has been seen that different energy transfer systems depending the intensity and time are interacting with each other in some level independent from the hematological values (aerobic and anaerobic) (Table 3). Here the aerobic capacity represents metabolic parameter and VO2max in figures is a significant performance indicator individually in soccer (Bangsbo, 1994). The VO2max value for elite male players was reported by Wisloff et al., (1998), Reilly (1994) and Hoff (2005) is between 55 – 68 $ml/kg^{-1}/min^{-1}$, between 54 – 64 $ml/kg^{-1}/min^{-1}$ by Wilmore and Costill (2005) and between 55 – 65 $ml/kg^{-1}/min^{-1}$ by Gore (2000). The reason for the VO2max results in this study is lower than the values stated at the literature can be attributed to the reality that these soccer players are just at the beginning of the pre-season preparation phase (Table 2). The strong, positive relation found in this study between MP value which is the indicator of the lactasid section of wingate anaerobic test (Inbar & Bar-Or, 1986; Wilmore & Costill, 2005) and aerobic capacity ($r = .605$; $P < 0.01$) (Table 3) can be considered as a supporting data for the knowledge that higher aerobic capacity will be transferred to the anaerobic capacity positively. WAnT is a performance test that performed with the contribution of different energy transfer systems (Spencer et al., 2005). It was reported that the aerobic system has contributed to the total energy production with a percentage of 13-44% during this test (Gastin, 2001 The negative relation between peak power (the power produced per kg in 5 seconds) value with alactacid quality belonging to Wingate test and the fastest 30 m sprint time ($r= -.581$; $p < 0.01$) (Table 3) indicates that the similar time (4 to 5s) and loading intensity (maximum) are brought about with the same type energy transfer system (ATP-PCr) (Wilmore & Costill 2005; Guyton, 2011). But Meckel et al., (2009) found no any relation between the fastest sprints at 40m and 20m and WAnT peak power and they have asserted that the reason of that result is in wingate test only leg and in sprint test only big muscle groups are included to the activity.

In soccer match analyses the quick recovery abilities of elite soccer players at high intensity exercise periods are prioritized. For this reason, the ability of soccer players requires consecutive high intensity sprint actions with or without ball (Mohr, 2003). The strong relation between repeated sprint test fatigue percentage as an indicator of maintaining sprint quality and maximal oxygen consumption has been proved by the MP value as an indicator of wingate test lactate part ($r = -.802$; $P<0.01$) (Table 3;). The similar results by means of time and power at these performance tests, despite one of the tests was performed on fixed cycle can be taken as the reflection of using both energy sources (ATP-PCr and glycolytic systems) (Wilmore & Costill 2005; Guyton 2011).

In a study carried out with 33 elite soccer players of 16-18 age interval in the middle of the season the correlation in a level of $P<0.05$ between VO_2max and 12 x 20m repeated sprint test (RST) performance decrement (PD) was determined but it was reported that there was no relation between 6 x 40m RST performed with intervals of 30 seconds and PD (Meckel et al., 2009). There has been a moderate relation between 8 x 40m RST with a resting intervals of 30 seconds and VO_2max (Aziz et al., 2000), no relation was reported 6 x 20m RST with a resting intervals of 20 seconds and VO_2max (Aziz et al., 2007). It has been stated that high intensity activity level of premiere league soccer players in league matches meaningfully affects the success rating of their teams Di Salvo et al., (2009). The ability of repeated sprint has been affected by recovery time between sprints (Bogdanis et al., (1996). Although it has been said that in soccer performance distance covered with high power is more important than the total distance covered and there is a relation between distance covered with high power and VO_2max (Bangsbo & Lindguist, 1992) there are various studies in which the positive relation between the distance covered in soccer matches and VO_2max has been stressed (Hoff 2005; Krustrup, 2003; Drust, 1998; Reilly, 2003; Franco, 2005). The efficiency aspect of aerobic energy system has been the dominant view in determining the recovery rate after intense activities (Krustrup et al., 2003; Spencer, 2005; Glaister, 2005; Meckel et al., 2009). It has been stated that the exercises with aerobic characteristics has a positive and meaningful change in all of the soccer game components such as sprint number, interception abilities, completed or uncompleted passes, distance covered and VO_2max values (Helgerud et al., 2001). This proves that VO_2max has an effect on energy transfer metabolism takes part during the performance of activities with different power values. No relation has been detected between hematological values of soccer players and performance values shown through aerobic and anaerobic mechanisms (Table 3; $p>0.05$). An assessment of situation (the level at that moment) about hematological index of soccer players was (Cazzola, 2000; Schumacher et al., 2002; Nikolaidis et al., 2003; Fallon, 2004; Sergej, 2004) performed, in some studies it was reported that these values occurred during measurements performed all throughout the season with certain intervals are not consistent but eventually there is no meaningful change (Silva et al., 2008, Filaire et al., 2003). At the study in which the physical and physiological characteristics of elite and non-elite Serbian soccer players, it has been observed that there is no hemoglobin value difference despite there is a meaningful age and VO_2max differences between groups (Sergej, 2004). At the measurements performed at the beginning, middle and end of the 12 week process with the participation of 12 professional soccer players who are member of same team at national level no correlation has been detected between anaerobic threshold and hematological parameters (Silva et al., 2008). In some studies the relation between VO_2max and hemoglobin (Kanstrup & Ekblom, 1984; Gore et al., 1997) was mainly attributed to muscle adaptations at anaerobic threshold (Billat et al., 2003). Because there has been no increase at the erythrocyte amount in acute exercises, expecting an increase at the hemoglobin amount was not seen meaningful. It was stated that red cell (erythrocyte) and hemoglobin levels was increased as a result of hemoconcentration just after the ultra marathon races of 56 and 160 kms and highest hemodillution at the recovery period after the 160 km race was 48 hours after the race (Viru & Viru, 2001). When this study and the previous ones has been taken into consideration no integrity was seen at the relation especially between erythrocyte and hemoglobin values of sportsmen and the performance levels whether in cross-sectional or longitudinal studies. This situation makes out the effect of oxygen transportation, oxygen uptake rate, oxygen debt, mitochondrial intensity, oxidative mechanisms, certain exercise conditions and types along with central component (Cardiac Output) which is one of the limiting factors that regulates the existing oxygen uptake (Linstedt, 2001; Joyner, 2008).

It is apparent that different energy transfer processes that meet the energy need at the physical activities and changes based on time and intensity affect each other. Developing the aerobic and anaerobic components in concordance with suitable exercise loading will be a possible result for development of the recovery ability. This change will especially help to maintain high intensity efforts and increase the number of activities in high intensity with short term. This compatible feature that affects individual and team performances will take an important role at the success. The ability to continue high intensity activities during the match will also positively affect biomechanics and aesthetics of the performance of target play with or without the ball. The players' being away from the area where the ball is played will possibly decrease the activity intensity during that period. Making the recovery period more efficient will make it possible to make the player who would take a role at the continually changing form and tempo of the game especially physiologically ready before trying a high power activity. Without ignoring the individual abilities, the person who plans the exercises should employ a loading program that has content enables the players to use the time intervals during the match most effectively.

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