STRONG RELATIONOSHIP BETWEEN AEROBIC FITNESS AND TOTAL DISTANCE COVERED IN JUNIOR SOCCER PLAYERS

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Abstract
Field and laboratory based physiological testing has become common among competitive field soccer players. However, how performance in such tests relates to performance during game play remains undetermined. Therefore, the purpose of this cross-sectional study was to examine the relationship between aerobic fitness and match performances among junior soccer players. Thirty seven junior soccer players were randomly selected using as stratification criteria age and playing role. Aerobic fitness was measured by laboratory and field tests. In addition, total distance covered during the match was determined. The total distance covered was associated with all variables of aerobic fitness. In addition, regression analysis showed that all tests for assessing aerobic fitness had significant impact on that criterion variable Total distance. Results showed that soccer players must have well physiological profile which allows them to achieve great sport results on important competitions.

Key words*: football, fitness, relation, match activity*

Introduction

In order to compete at an elite level, soccer players are expected to possess morphological and physiological characteristics that are important for both, the sport of soccer as well as to their playing position (Hazir, 2010). Game of soccer consists of sprints, as well as speed and directions changes as a key features in this type of sports (Sheppard & Young, 2006). Recent time– motion analysis has been conducted during competitive match play (Dellal et al, 2010a). Previous studies showed that players cover between 10,496 to 11,779 m per official game and that 9.2% of the activities were considered high intensity (Dellal et al, 2010a; Dellal et al, 2010c; Di Salvo et al, 2009). In addition, there is a decrease in the high-intensity activity and the total sprint distance covered as matches progressed (Di Salvo et al, 2009). Aerobic fitness is consider to be a relevant component of the physiological make-up of elite young soccer player (Reilly, Bangsbo, & Franks, 2000; Reilly, Williams, Nevill, & Franks, 2000; Reilly, 2005). A great number of fitness tests have been used to determine the players' fitness levels, to prepare the necessary short- and long-term training programmes, and to provide motivation and feedback to the players (Ingebrigtsen et al, 2014).Laboratory tests are considered to possess better validity, but recently more soccer-specific field performance tests have been designed due to better simulation of soccer match play. Research in soccer players concerning association of match activity and field and laboratory tests have provided mixed results. The VO2max of elite female players was found to correlate with the amount of high intensity running (r=0.81, *P*<0.05, Krustrup*et al*., 2005) whilst VO2max was not correlated with high intensity activity in elite male players (r=0.38, *P*>0.05, Krustrup*et al*.,2003).Male soccer players show strong relationship between VO2max and the total distance covered in a match (r=0.52, P<0.05) and between Yo-Yo Intermittent Recovery Test performance and the amount of high intensity running (>15 km.h-1) completed during a game (r=0.71, P<0.05) (Krustrup et al., 2003). However, there is no relationship between VO2max and the total distance covered in a match in elite female players (r=0.20, *P*>0.05, Krustrup*et al*., 2005). It has been reported that soccer coaches select young players based on their anthropometry characteristics rather than their physical performance or skills (Helsen, Starkes, &VanWinckel, 1998). The majority of studies have focused largely on players 11–16 years of age – an age interval when individual differences in growth and biological maturation are perhaps at their greatest (le Gall et al, 2010). In contrast, there is little data for older or late adolescent players aged 17–20 years, which is the last competitive age group before players face challenges associated with the highest competitive levels in the sport. Most of professional soccer players started their careers at this level between 17 and 20 years of age. Moreover, it is generally expected that youth players at this age and stage of development are ready to compete at the highest levels. Therefore, other than just anthropometry advantage, should be also considered in the selection of young soccer players for developing future high-class players. In order to identify factors that may be relevant in the selection process it is of great importance to investigate the relationship of match activity with other players' characteristics. Therefore, the purpose of this cross-sectional study was to examine the relationship between aerobic fitness and total distance covered among junior soccer players.

Methods

Subjects
Thirty seven soccer players (age 18.4±0.1 years, height 1.67±4.8 cm, body mass 53.6±1.8 kg), all members of six junior National Soccer teams in Croatia (N=50) were randomly selected using as

stratification criteria age and playing role. The players were informed about the experimental procedures and possible discomforts associated with the study. Written informed consent was received from all players and parents after verbal and written explanation of the experimental design and potential risks of the study. Informed consent was obtained from each of the participants and their parents or legal guardians only after familiarization with the procedures used in this study. In order to improve internal validity players were blinded about the work hypothesis informing the aims of this observational study. All players agreed to provide their maximum will effort in order to perform at their best during all the field tests and competitions considered in this study. The study was approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb according to Helsinki Decleration. The participants were aware that they could withdraw from the study at any time. Selection criteria included: (1) participation at professional (top three division leagues) level of football competition for at least 5 years, (2) all players participated in at least 75% training sessions per week and played at least 16 matches during season, (3) no consumption of exogenous anabolic-androgenic steroids or other drugs that might have affected their physical performance or hormonal balance during the study (for at least 6 months (4) no recent history of febrile illness, muscle lesions, lower limb trauma, and metabolic diseases. Soccer players were instructed not to change their normal eating habits during the entire period of data collection. Nutritional supplements were not included in their diets. In addition, players were instructed to refrain from drinking beverages containing caffeine or alcohol and from consuming food during the 3 h before testing.

Procedures

Testing procedures were performed during the last stage of the competitive season (April- May 2014). Height and body weight were measured before breakfast and all other measurements were taken at the same time of day (between 8:00AM and 10:30AM), within the last two weeks of the competitive season period. Height was measured to the nearest 0.1 cm using a portable stadiometer (Holtain Ltd, Crymych, U.K.), and body weight to the nearest 0.1 kg using an electronic balance scale (Tanita TBF 401A, Japan), with the players wearing no shoes and only light clothing. Match activities were determined according to Castagna, D'Ottavio, &Abt, (2003) as follows:

1. Walking (0.4 to 3.0 km•h-1); 2. Jogging (3.0 to 8.0 km•h-1)); 3. Medium Intensity Running (MIR; 8.0 to 13.0 km•h-1); 4. High-intensity Running (HIR; 13.0 to 18.0 km•h-1); 5. Sprinting (>18.0 km•h-1). Data was collected with System 3D tille sport analyzer that measures distance traveled in different intensities running. In this way, it was determined the total distance covered during the match, as well as the distance traveled by walking, jogging, running and sprinting.

Table 1. Match analysis data (n=37)

Match activity	mean±SD	min	max
Walking (0.4-3.0 km/h) (m)	5535.41±225.78	5120.00	5850.00
Jogging (3.0-8.0 km/h) (m)	1602.70±328.34	1100.00	2200.00
MIR (8.0-13.0 km/h) (m)	1726.43±333.85	1200.00	2300.00
HIR (13.0-18.0 km/h) (m)	683.51±134.52	500.00	890.00
Sprinting (>18.0 km/h) (m)	402.97±170.85	200.00	700.00
Total distance (m)	9951.03±1132.63	8360.00	11710.00

HIR= High Intensity Running; MIR= Medium Intensity Running.

Competitive matches (11 vs. 11, n=3) were played at the same time of the day (15.30 pm) on a regular sized synthetic-grass soccer pitch over two halves each lasting 45 min. Match air temperature and relative humidity were 22.8±1.8 C° and 40±9.8% respectively. In order to avoid dehydration, drinking was allowed to players. A minimum of 6 and a maximum of 9 players were observed during the same competitive match. Each player was observed for a minimum of two and a maximum of three competitive matches (within 10 days) and physical match performance categories were reported as mean of the observed games.

Aerobic fitness was measured with field and laboratory tests. The Beep test and 12 minute running test were performed according to the procedures suggested by Davis et al., (1992) and Castagna, Abt, &D'Ottavio, (2002). All test were performed in a random order and on separate occasions (i.e. at least 72 apart) within 10-15 days before or after the competitive matches on a grass football pitch.

Beep test

The beep test was conducted as previously described (Davis et al., 1992). Briefly, players ran back and forth between two lines, spaced 20-m apart, in time with the "beep "sounds from a compact disc (20-m Shuttle Run test CD, Australian Sports Commission). Each successful run of the 20-m distance was a completion of a shuttle. The "beep "sounded at a progressively increasing pace with every minute of the test and correspondingly the player must increase his running speed accordingly. The player was warned if he did not reach the end line in time once. The test was terminated when he i) could not follow the set pace of the "beeps "for two successive shuttles, and/or ii) stopped voluntarily. Typically the scores in the beep test are expressed as levels and shuttles, but these values are discontinuous and cannot be used in statistical analysis. The total distance covered (i.e. 20 m x number of completed shuttles) was therefore reported as the player's performance measure in the MST and used in the statistical analysis.

12 minute running test (12MRT)

The 12MRT times were clocked with an electronic stopwatch (Casio HS 30 W, Tokyo, Japan). The 12 MRT consisted in covering as much as distance as possible running for 12 min on a tartan athletic-track. Only 10 players at a time were tested and time passage feedback was provided to players throughout the test at regular intervals (i.e., every

2 min). Distance covered was assessed making subjects remain on the athletic-track spot reached at end of the 12 min run and counting laps performed. Experienced and qualified fitness trainers implemented all tests.

VO2max test
Maximal Aerobic Uptake (VO2max) was determined following an incremental treadmill run to fatigue (Woodway Ergo ELG 55 treadmill; Woodway GmbH, Weil am Rhein, Germany) with gas exchange and ventilatory variables being analysed breath-by-breath using a calibrated computer-based exercise system (Jaeger Oxycon Pro online gas analyser; Erich Jaeger GmbH, Hoechberg, Germany). Heart rate (HR) was continuously recorded (Polar®; Lake Success, NY, U.S.A.). Each subject performed an incremental exercise test to exhaustion on a motorised treadmill (Jaeger Laufergotest, Germany) for determination of maximal oxygen uptake (VO2max).Following a 5 min warm-up, the incremental treadmill protocol commenced at a workload of 8 km h−1 and a 1.5% grade. The treadmill speed Fitness performance in soccer players was increased by 0.5 km h−1 every 30 sec until volitional exhaustion. Gas exchange measurements were made breath-by-breath during the test and for 3 min during the recovery (Medical GraphicsCardiopulmonary Exercise System CPX, USA).

Astrand test
To estimate players' aerobic capacity, we used the Astrand test. All players completed the Astrand test (Åstrand&Ryhming, 1954) on a cycloergometer (Monark 834, Sweden). Heart rate was measured by a pulsometer (Advantage NV; Polar, Kempele, Finland) and used to estimate absolute (L·min1) nd relative (ml·kg1·min1) maximal oxygen uptake (VO2max) by Astrandnomogram.

Statistical analyses
The data obtained in the research was processed using the application statistics program SPSS 20.0, adjusted for use on personal computers. The descriptive statistics were expressed as a mean (SD) for each variable. Data sets were checked for normality using the Kolmogorov–Smirnov test of the normality of distribution. Relationships between variables were assessed using Pearson's product moment correlation. In determining the global relation between aerobic fitness and total distance covered the regression analysis was used. Significance was set at 0.05.

Results

During the match players covered 9951,03 ±1132,63m (8360,00-11710,00m) of which 683,51 ±134,52m, (500,00-890,00m) were performed at HIR. Details of match activities are presented in table 1. Association between aerobic fitness and total distance covered is reported in table 2. The total distance covered was significantly associated with Beep and Astrand test (0.85 and 0.82) respectably.

In addition, Cooper test was significantly related to total distance covered (0.76). There is also small, but significant ($p<0.05$) correlation between VO2max and total distance covered(Table 2).

Table 2. Association between aerobic fitness and total distance covered

	Variables	Total distance
Aerobic fitnesstests	**Beep test**	0.85*
	Astrand test	0.82*
	VO_{2max} test	0.36*
	12MRT	0.76*

Regression analysis (Table 3) revealed significant associations between aerobic fitness and total distance covered. Results of laboratory and field tests showed that aerobic fitness has strong impact on criterion variable. Concerning the field tests, the biggest impact on criterion was found in Beep test ($\beta = 0,44$; $p< 0,01$). Among laboratory tests, Astrand test showed great impact on criterion($\beta = 0,33$; $p<0,05$), while VO2max test showed negative impact, but with statistical significance ($\beta = -0,20$; $p< 0,05$).

Table 3. Influence of predictor variables on criterion variable Total distance covered

	Varijable	β	Standard error β	b	Standard error b	t	p
Aerobic fitness tests	**Astrand**	0.33	0.15	181.94	81.65	2.23	0.03*
	VO_{2max} test	-0.20	0.09	-92.83	44.65	-2.08	0.05*
	Beep test	0.44	0.15	439.55	150.15	2.93	0.01*
	12MRT	0.31	0.12	1.41	0.56	2.52	0.02*

$R=0.90$, $R^2=0,81$, Criterion variable: Total distance; $p<0.05$

Discussion and conclusion

This study aimed to investigate the relationship between aerobic fitness and total distance covered in elite junior soccer players. The results of this study demonstrate a significant relationship between aerobic fitness and the total distance covered in elite junior soccer players.
Tests for aerobic fitness has positive and significant correlation with total distance covered (0.36-0.85, $p<0.05$). Castagna&D'Ottavio (2001) showed that VO_{2max}has negative impact on walking forward ($r= -0.71$; $p<0.05$), but positive influence on Jogging ($r= 0.89$; $p<0.05$) and total distance covered. Strong relationship was found between High intensity activity and Yo-Yo IR1 performance (Castagna, Impellizzeri, Cecchini, Rampinini, & Alvarez, 2009) for male young soccer players ($r=0.77$, $p<0.001$) and by Krustrup et al, (2003), and Krustrup , Mohr, Ellingsgaard and Bangsbo (2005) for adult male ($r=0.71$, $p<0.05$) and female ($r=0.76$, $p<0.05$) soccer players. However, in contrast to previous studies no significant relationship was observed between Total distance and Yo-Yo IR1 ($r=0.42$, $p=0.14$ CI95% 0.31-0.53) (Castagna, Impellizzeri, Cecchini, Rampinini, & Alvarez, 2009; Krustrup et al, 2003; and Krustrup , Mohr, Ellingsgaard and Bangsbo, 2005). In contrast to the Yo-Yo IR1, Castagna et al, (2010) found that the Multistage Fitness Test performance was largely related to total distance ($r=0.62$, $p=0.02$).

In this study laboratory and field tests showed large to very-large association (see Table 2) with total distance covered, that have been demonstrated to be soccer-specific dependent variable (Iaia, Rampinini, & Bangsbo, 2009).This study findings clearly demonstrate that aerobic fitness, as determined by commonly used field and laboratory tests is related to physical match performance in young male soccer players.

Soccer coaches usually select young players based on their anthropometry characteristics rather than their performances. Therefore, scientific rationale must be provided in the long-term process of player development. Our study supports the conclusions that beside the anthropometry advantage, psychological and soccer-specific skills should be also considered in the selection of soccer players. The present study showed no significant relationships between morphological and match performances among junior soccer players. However, these results should be of interest to soccer coaches because they may help, directly or indirectly, to improve athletes' performance. Since the measurements were conducted in the end of the season, this study is limited by the fact that changes in body composition may occur from the start to the end of an athlete's training and competitive season. Accordingly, further studies should be very careful in determining the right timelines for measuring anthropometric characteristics and body composition. In summary, soccer players change their morphological content during the conditioning period and during the competitive season. Therefore, periodic measurement should be conducted in order to design the training protocols in right order.

The main finding of the present study is that the match performance characteristics of junior soccer players are related to the aerobic fitness of players. Players' performance in both laboratory and field-based physiological assessments were associated with performance during match play. The degree of association with total distance covered was not different for laboratory and field measures.

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SNAŽNE RELACIJE IZMEĐU AEROBNOG FITNESSA I UKUPNO PRIJEĐENE UDALJENOSTI KOD NOGOMETAŠA JUNIORA

Sažetak
Terenski i laboratorijski temeljena fiziološka ispitivanja postala su uobičajena među natjecateljskim nogometašima. Međutim, kako se nastup u tim testovima odnosi na izvedbu tijekom igre ostaju neodređeni. Stoga je cilj ovog istraživanja bio ispitati odnos između aerobnog fitnessa i nastupa među mladim nogometašima. Trideset i sedam nogometaša je slučajno odabrano, uz korištenje stratifikacije uzrasta i uloge u igri kao kriterija. Aerobna sposobnost mjerena je laboratorijskim i terenskim testovima. Osim toga je određena ukupna udaljenost pokrivena tijekom utakmice. Udaljenost je povezana sa svim varijablama aerobne kondicije. Osim toga, regresijska analiza pokazala je da svi testovi za procjenu aerobne sposobnosti imaju značajan utjecaj na kriterijske varijable. Rezultati su pokazali da nogometaši moraju imati dobar fiziološki profil koji im omogućava velike sportske rezultate na velikim natjecanjima

Ključne riječi: *nogomet, fitness, relacije, aktivnost na utakmici*

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