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Correlation between fitness profile and situation efficiency in soccer

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Original scientific paper

Abstract
The main purpose of this study is to determine relation between Fitness profile and situation efficiency in soccer. For the purpose of this study 11 soccer players of Dinamo Zagreb, Soccer Club in the 2008/2009 season were tested. Firstly, the soccer's' basic morphological characteristics were measured: height (cm), weight (kg) and subcutaneous fat tissue (%). The VO2max test measured the following variables: average maximum oxygen intake (mL kg-1min-1), maximum heart rate frequency (b min-1) and maximum running speed (km h-1). Situational efficiency was determined by Prozone. Significant correlation was determine between overall number of passed balls and successfully passed balls (r=0,99), overall number of passed balls and unsuccessfully passed balls (r=0,79), unsuccessfully and successfully passed balls (r=0,71), average sprint length and maximum speed (r=0,83), number of sprint runs and unsuccessfully passed balls (r=0,63), total distance covered during the second half and number of sprint runs (r=0,62), total distance covered in sprint run and unsuccessfully passed balls (r=0,67), total distance covered in sprint run and number of sprint runs (r=0,91), height and weight (r=0,71), average maximum oxygen intake and total distance covered in sprint run (r=0,61), maximum running speed and number of sprint runs (r=0,76). These data only proves the complexity of success in soccer and the need for further research and improvement in the training processes, as well as the game of soccer. A greater variety of functional and motoric variables should be applied in future research and their correlation with various indicators of situational efficiency of soccer players should be analyzed as well.

Key words: **Soccer, fitness profile, situation efficiency**

Sažetak
Osnovni cilj ove studije je da utvrdi odnos između fitnes profila i stanja efikasnosti u nogometu. Za potrebe ovog istraživanja testirano je 11 nogometaša, Nogometnog kluba Dinamo Zagreb, u sezoni 2008/2009. Kao prvo, kod nogometaša su mjerene osnovne morfološke karakteristike: visina (cm), težina (mm) i potkožnog masnog tkiva (%). Testom VO2mak mijerene su slijedeće varijable: Prosječni maksimalni unos kiseonika (ml kg-1min-1), maksimalna frekvencija srca (B min-1) i maksimalna brzina trčanja (km h-1). Stanje efikasnosti je bilo određeno od Prozone. Značajna korelacija utvrđena je između ukupnog broja dodanih lopti i uspješno dodanih lopti (R = 0,99), ukupan broj dodanih lopti i neuspiješno dodanih lopti (R = 0,79), neuspiješno i uspiješno dodanih lopti (R = 0,71), prosiječna dužina sprinta i maksimalna brzina (R = 0,83), kao i broj šprintova kod bezuspiješno dodanih lopti (R = 0,63), ukupna pređena razdaljina u drugom poluvremenu i broj šprintova (R = 0,62), ukupna pređena razdaljina u šprintu i bezuspiješno dodanih lopti (R = 0,67), ukupna pređena razdaljina u šprintu i i ostvareni broj šprintova (R = 0,91), visina i težina (R = 0,71), prosiječan maksimalan unos kiseonika i ukupno pređena razdaljina u šprintu (R = 0,61), maksimalna brzina trčanja i broj šprintova (R = 0,76). Ovi podaci samo dokazuje složenost uspijeha u nogometu i potrebu za daljim istraživanjem kao i napredak u procesu obuke nogometne igre. Veću raznovrsnost funkcionalnih i motoričkih varijabli treba da se primijeni u budućim istraživanjima i njihova povezanost sa raznim pokazateljima stanja efikasnosti nogometaša i takva treba da budu analizirana, kao dobra.

Ključne riječi: **Nogomet, fitness profil, situaciona efikasnost**

Introduction

Soccer is one of the most widespread and most profitable sports today (Al-Hazzaa, Almuzaini, Al-Refeaee, et al., 2001; Ali A, Farrally, 1991; Aziz, Chia, The., 2000; Bangsbo, Nørregaard, Thørøe, 1991; Bunc, Psotta, 2001). One of the reasons why soccer is so popular is that a player must not have outstanding abilities in all areas (technical, tactical, biomechanical, physiological and mental), but must have a reasonable level in all areas. Throughout the history of soccer affects the lives of people of different social status around the world. Soccer belongs to a group of polystructural activities where the main objective to achieve more goals than the opponent. One of the most important researches are related to the effectiveness of situational parameters (Casajus, , 2001; Di Salvo, , Collins, Neill, and Cardinale, 2006; Franks, Goodman, and Miller, 1983; Helgerud, Engen, Wisløff, Hoff, 2001; Heller, Proch´azka, Bunc, et al., 1992; Hoff, Helgerud, 2004; Hoff, Wisloff, Engen, Kemi, Helgerud, 2002; Hughes and Franks, 1997; Kemi, Hoff, Engen et al., 2003). The majority of team sports face the problem of identifying and interpreting actions and events taking place in the soccer field. The notation analysis is an effective way of resolving this problem (Hughes and Franks, 1997). It primarily focuses on the movement analysis, technical and tactical estimation and statistical content. This is why the notation analysis is a technique of analysis of various performance aspects via the process of continuous event registration (Hughes and Frank, 1997). It has been proved that soccer coaches are less than 45% precise in their analyses of the events taking place within the 45-minute span of a soccer game (Franks, Goodman, and Miller, 1983). In order to obtain appropriate feedback, instruments of objective measurement are absolutely necessary. Such studies have become of importance in planning and programming of the training process because they provide the best feedback from the coaches so they can improve the quality of training and thus the quality of players will occur. Centre events of every soccer matches are eleven soccer players, specifically ten players and one goalkeeper. Each player works as an individual and as such has its own characteristics and abilities that in certain situations during the competitive activities come to play and this will result in unique technical - tactical actions of the individual. If we look soccer as activity there is a need for an answer to the question: what is the connection between the success of soccer players

during competitive activity with its functional and motor abilities? In order to try to answer this question we need to collect data through the diagnostic procedures and to determine the actual characteristics and abilities of players. Aerobic capacity significantly affects the technical performance and tactical decisions. Helgerud and colleagues (2001) showed that an increase in maximal oxygen (for 5 ml / kg / min) and running economy (7%), significantly affects players performance during the game. To be successful in soccer, endurance and strength are of great importance, but what a top player must own, with a good basic level of skills and sense of timing. Improvement of aerobic endurance in soccer for 30% has only meaning if the player is ability to manifest in accordance with situational requirements. During 90 min top players run 10-12 miles average intensity in the vicinity of lactate threshold, while goalkeeper run 4 kilometers. Danish study confirms previous observations, the players run 5-10% more in the first half than in the second, but aerobically prepared players can be spared this decline in their performance (Bangsbo, Nørregaard, Thørøe, 1991). However, no correlation was observed between individual VO_{2max} and lactate threshold and decrease in performance during the match performance. Also some studies show a significant correlation between VO_{2max} and the first and second halves of matches, and sprints performed by the players (Kemi Hoff, Engen, et al. 2003; Krustrup, Mohr, Bangsbo, 2005; Reilly, Bangsbo, and Franks, 2000; Rienzi, Drust, Reilly, Carter and Martin. 2000; Smaros, 1980). The results of previous investigations indicate the efficiency of developing various types of endurance and strength in soccer transformation the influence of different procedures. Interval training with 90-95% of maximum heart rate for 4 x 4 min may increase the admission of oxygen to 10-30%. Such a shift is possible if additional training is conducted for a period of 8-10 weeks (Helgerud et al. 2001; Helgrud and Hoff, 2004). There is evidence of differences in the physiological demands against the attacker, or central midfielders and defenders, based on the assumption that the central position demands the highest performance in soccer. Several studies have confirmed the assumptions that the central players have a higher VO_{2max} than the other players. So the main purpose of this study is to determine relation between Fitness profile and situation efficiency in soccer.

Methods

The test group consisted of 11 soccer players of Dinamo Zagreb Soccer Club in the 2008/2009 season of the Croatian First League. The data was gathered at two locations. The first set of data was gathered by the Sports Diagnostic Centre of the Faculty of Kinesiology, University of Zagreb, during the precontest period. Firstly, the soccer's' basic morphological characteristics were measured: height (cm), weight (kg) and subcutaneous fat tissue (%). Then they were subjected to a test with aim to assess their energy capacity on the treadmill. The test measured the following variables: average maximum oxygen intake (mL $kg^{-1}min^{-1}$), maximum heart rate frequency (b min^{-1}) and maximum running speed (km h^{-1}). One minute incremental maximal exercise tests on a motor-driven trademill (Run Race, Technogym, Italy) with 1.5% inclination. Portable breath-by-breath gas analysis system (Quark k4 b2, Cosmed, Italy) was used for respiratory gas exchange monitoring. Heart rate was monitored using a heart rate monitor (Polar Vantage NV, Polar, Finland). The maximal exercise test was interrupted when plateauing of oxygen consumption was noted or when subject perceived volitional fatigue. AT was assessed by a nonlinear increase in carbon dioxide to oxygen consumption ratio (V-slope method). For this purpose, four spiroergometric parameters were calculated and analyzed (VO_{2max}, HR_{max} – maximal heart rate, MRS_{AT} - maximal running speed, , HR_{AT} - heart rate at anaerobic threshold). Situational efficiency was determined by Prozone. Founded in 1998, ProZone are the leaders in providing match analysis products and services to sports organisations through delivering "best practice" performance insights. Our aim is to empower people involved in team-based sports through the provision of performance-affecting information. ProZone have several technologies and software that enable the capture of match information and the subsequent delivery of performance analysis. Data is captured from either standard video or via a set of cameras installed within a stadium, which offer a 'whole' vision of the field. The information captured supports analysis for individuals and teams from a single match or across multiple matches. Hence users are able to investigate trends and create benchmarks (objective accountability) for comparative performance analysis. ProZone core analysis systems (ProZone3 and MatchViewer) have been independently validated by numerous researchers and practitioners to ensure that the output data is both accurate and reliable (Di Salvo, Collins, Mc Neill and Cardinale, 2006). Since our inception, ProZone have worked alongside over 150 worldwide clubs, institutions, leagues, federations and governing bodies, and developed analysis systems that encompass all levels of the game; from grass roots to elite performance level. Moreover, the ProZone systems encompass all areas of the modern day coaching process, including real-time analysis post-match evaluation, scouting services and trend analysis. Importantly, all ProZone systems have been designed alongside some of the leading lights in the game meaning that the product range is 'coach-driven' and easy to use (Figure, 1, Figure, 2 and Figure, 3).

Figure 1. ProZone and the Coaching Process.

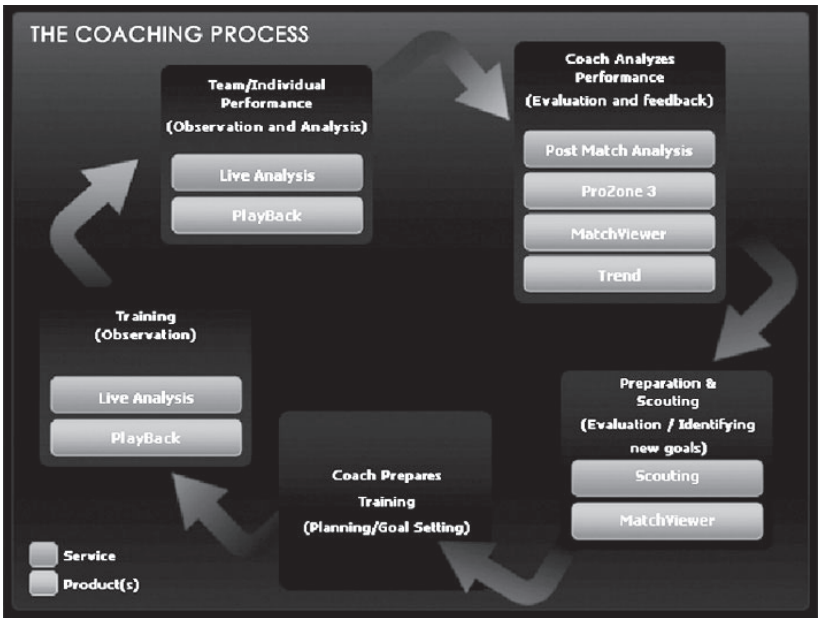
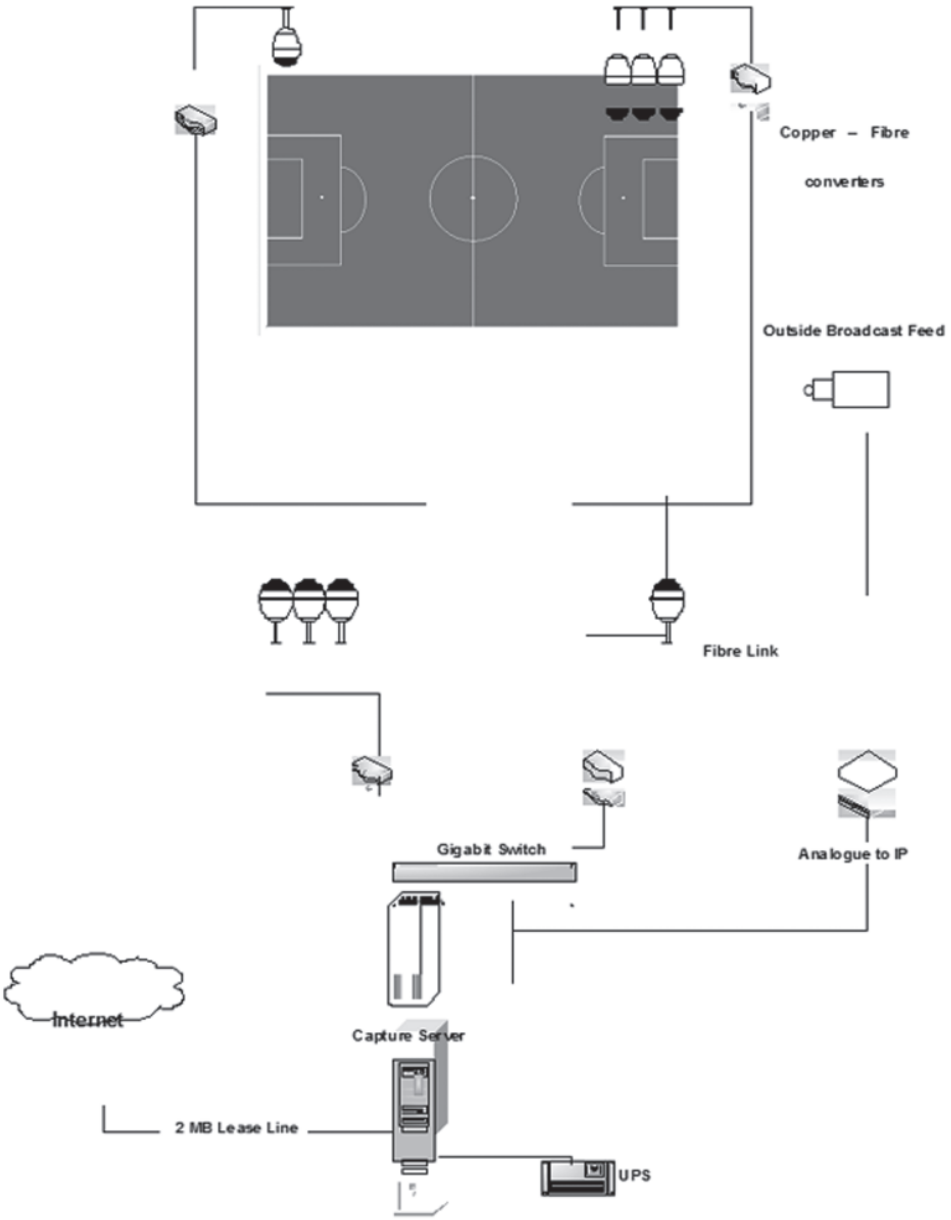


Figure 2. ProZone's Digital Capture System.



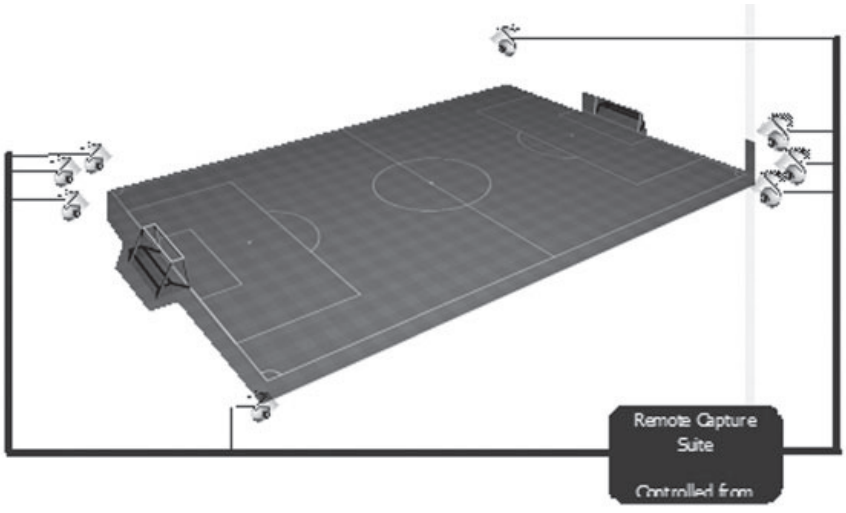


Figure 3. ProZone Camera Configuration with the Stadium.

It is ProZone's vision that analysis be used effectively within the feedback environment so we can help researchers and practitioners make better informed decisions. In addition to the provision of objective data, therefore, ProZone endeavour to deliver insights to those committed to enhancing performance. This could be in the form of simple benchmarking information (e.g. averages for comparative analysis), or more in depth trend analysis (e.g. identifying key performance indicators that lead to successful performance). For ProZone to accurately recreate the movements of football players during matches, an installation of specialised capture equipment must be undertaken at the stadium. The installation is normally permanent ('fixed'), although on occasions temporary installations have been performed. 8-12 camera sensors are located at all 4 corners of the stadium as depicted below. This unique camera configuration is vital for the following reasons;

1. **multiple angles;** for tracking players and also feedback sessions
2. **increases accuracy**; minimises distance between camera and players
3. **eliminates errors;** no blind spots when one camera's line of sight is blocked (e.g. by players crossing)
4. **resilience;** every area of pitch covered with minimum of two cameras, typically four

The digital stadium infrastructure means that ProZone are able to access the cameras remotely without the need for operation intervention during the game. The movements of every player are captured every 25th / second and a combination of automatic and manual tracking procedures are used to recreate these movements. The ProZone3 product is a complete reproduction of a 90 minute game. The data generated from this software provides an unrivalled range of physical and technical data, presented in a multiple formats including stats, maps multi-video, graphs and 2D game animation. When combined, this information provides the user with a comprehensive coaching tool that facilitates the analysis of every movement, action and interaction of each player for both teams. MatchInsight is a software licence that gives users the ability to self-code matches and produce MatchViewer analysis in the same format as if ProZone were providing a service to a customer.

Manager enables the user to insert the fixture details (match date, stadium, teams, players, officials, positions etc) and also house all the match information about all the games analysed, while Events is the actual programme that a user will use to code a match and produce the data that will automatically appear within the MatchViewer product upon completion.

The Events software guides the user through a sequential coding process, which involves inputting the Event (i.e. a shot, cross, header, pass etc), the Player(s) (maximum of 2 players per event) and Pitch Position (x/y coordinate). The data within MatchViewer is actually automatically calculated from the sequential coding process (i.e. the user cannot make subjective decisions on whether a pass was 'successful' or 'unsuccessful'; this is calculated mechanically by the nature of next event in sequence).

PlayBack is a software licence that provides real-time analysis of performance. Designed for 'live' use, PlayBack allows for half-time feedback (statistics and video) as well as in-game viewing and action replays (with slow motion, zoom and grab functionalities). With numerous drawing tools and presentational overlays, PlayBack can also be used as a coach-specific media player at any time during the week to facilitate post-match feedback or scouting analysis.

The statistical Package for Social Sciences SPSS (v13.0, SPSS Inc., Chicago, IL) was used for statistical analyses. Descriptive statistics (mean $\pm$ SD and range) were calculated for all experimental data. Kolmogorov-Smirnov test was used for testing normality of distribution. Statistical power, effect size and CV were calculated using the GPOWER software (Erdfelder, Faul and A. Buchner, 1996). Statistical analysis was performed using Person product-movement correlation coefficient. P values ≤ 0.05 were consider being statistically significant. The reliability of the test was determined using the reliability analysis (alpha) and by inter-class correlation coefficient (ICC).

Results

Table 1. Anthropometric and functional characteristics

	Age (years)	**Height** (cm)	**Weight** (kg)	**Subcutaneous fat tissue** (%)	**Average maximum oxygen intake** (mL kg^{-1}min^{-1})	**Maximum heart rate frequency** (b min^{-1})	**Maximum running speed** (km h^{-1})
J.T.	20,8	185,9	78,5	5,82	57,7	204	19
M.B.	19,3	184,6	76,5	4,99	64,7	189	19
M.Ma.	22,1	188,0	78,7	6,26	62,6	197	19,5
I.V.	24,7	187,5	82,7	5,1	62,6	202	20,5
B.B.	29,7	178,6	81,2	9,59	61,3	194	18,5
M.Mi.	28,4	174,6	67,8	5,17	68	204	20
I.B.	30,1	188,9	84,5	6,96	60,2	185	18
M.Ch.	25,3	181,6	78,6	6,71	54,1	181	18,5
C.Sa.	27,3	187,8	84,8	7,63	53,2	206	18,5
S.E.	27,3	176,4	77,8	7,19	55	193	17
A.T.	25,1	186,2	81	7,5	57,5	204	21

All the variables had normal distribution. Statistically significant correlations ($p<0.05$) have been established between the following variables: overall number of passed balls and successfully passed balls (r=0,99), overall number of passed balls and unsuccessfully passed balls (r=0,79), unsuccessfully and successfully passed balls (r=0,71), average sprint length and maximum speed (r=0,83), number of sprint runs and unsuccessfully passed balls (r=0,63), total distance covered during the second half and number of sprint runs (r=0,62), total distance covered in sprint run and unsuccessfully passed balls (r=0,67), total distance covered in sprint run and number of sprint runs (r=0,91), height and weight (r=0,71), average maximum oxygen intake and total distance covered in sprint run (r=0,61), maximum running speed and number of sprint runs (r=0,76). Analyzed tests had high values of reliability coefficients alpha, rage form 0,78 to 0,89. All analyzed test had high values of ICC rage from 0,89 to 0,97. Effect size for correlation coefficient was large ($r = 0.50$) as the values of statistical power (power = 0.95).

Table 2. Descriptive statistics of the indicators of situational efficiency and anthropometric and functional characteristics

	M ± SD	**Min**	**Max**	**Range**
Average sprint speed	2,07 ± 0,18	1,80	2,30	0,50
Average sprint length (m)	7,01 ± 1,87	5,10	11,90	6,80
Number of sprint runs	32,27 ± 11,14	11,00	51,50	40,50
Covered distance in the first half (m)	4774,45 ± 2406,77	0,00	6341,00	6341,00
Covered distance in the second half (m)	4571,1 ± 868,68	3223,33	5765,75	2542,42
Covered sprint distance (m)	244,87 ± 109,47	130,50	479,28	348,78

Discussion and conclusion

The values of morphological characteristics obtained in this study are in accordance with other studies in some European, while the average maximum oxygen intake slightly lower than in those investigations (Bunc and Pssota, 2001; Casajus, 2001; Ekblom, 1986; Heller et al., 1992).). All the variables of the situational efficiency have high reliability coefficients except for the variable of the maximum running speed which has a lower reliability coefficient (Cr $\alpha = 0,79$), but is still satisfactory. This means that all the mentioned variables represent accurate indicators of the situational efficiency of the soccer players. The coefficient of variation, as an indicator of the dispersion of results, is significantly low for the variable: average sprint speed (8,7%). This is due to the high quality of the selected test group. The other indicators point out greater dispersion, which is due to the players' various positions in the match, their technical-tactical tasks and their different levels of quality. The relative values of maximal oxygen from the players in the field are according to research of Stolen et al. (2005). Correlation indicates that players with better functional abilities are capable of doing more sprint runs. In other words, they can play in a soccer match with higher level of intensity and have a shorter period of recovery after such an activity, which only supports the recent research that indicates that the maximum oxygen intake (VO_{2max}) has a positive correlation with the covered distance in a soccer match (Bangsbo, 1991; Smaros, 1980). Since the correlation is statistically significant, we can conclude that the linear increase of oxygen consumption follows the linear increase in running speed. Percent body fat was correlated with age ($r = 0.58$) as expected, with aged we have increasing in the percentage of body fat. The correlation of the variable of the number of sprint runs and the variable of distance covered in the second half (r=0,62) and the variable of the covered distance in sprint run (r=0,94) is understandable because the players with more covered distance in general, especially with more covered distance in sprint run, do more sprint runs during a soccer match (O´Donoghue, 2001; Ohashi, Tagari, Isokawa, Suzuki, 1988; Reilly and Thomas, 1976; Tiryaki, Tuncel, Yamaner, et al. 1997; Wisloff, , Helgerud, and Hoff, 1998; Wislow, Helgerud, Hoff, 1998; Withers, Maricic, Waisilewski, Kelly, 1982). As a soccer player needs to cover a certain distance in order to reach high running speed, the correlation between the variables of average sprint run and maximum speed (r=0,83) is logical. The correlation of the variable of the number of sprint runs and the variable of maximum running speed (r=0,76) as well as the correlation of the variable of average maximum oxygen intake and covered distance in sprint run (r=0,61) indicate that players with better functional abilities are capable of doing more sprint runs. In other words, they can play in a soccer match with more intensity and have a shorter period of recovery after such an activity, which only supports the recent research that indicates that the maximum oxygen intake (VO_{2max}) has a positive correlation with the covered distance in a soccer match (Bangsbo, 1991; Smaros, 1980). A correlation between the sprint run number and maximum running speed was also established, as well as that between the covered distance in sprint run during a game and maximum oxygen intake. Thus, we can conclude that soccer players with better functional abilities cover a greater distance in sprint runs (Bangsbo, 1991; Smaros, 1980). It is obvious that the morphological characteristics and functional abilities are not the only key to the success of players. The success of players determines the number of other capabilities, technical characteristics and tactical knowledge. The high level of functional ability is a prerequisite for the success of players, but without optimal levels of other key components for success in soccer does not have the complete soccer player. These data only proves the complexity of success in soccer and the need for further research and improvement in the training processes, as well as the game of soccer. A greater variety of functional and motoric variables should be applied in future research and their correlation with various indicators of situational efficiency of soccer players should be analyzed as well. This is why it represents an excellent means of determining the concrete behavior in a game. It is also an excellent additional test of morphological, motoric and functional abilities of soccer players helping to identify the good and bad sides of soccer training and improvements of sports performance that have to be carried out in the training process.

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Submitted: October 27, 2010.
Accepted: November 13, 2010.

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