CORRELATION BETWEEN THE INDICATORS OF SITUATIONAL EFFICIENCY, MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES OF FOOTBALL PLAYERS

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Original scientific paper

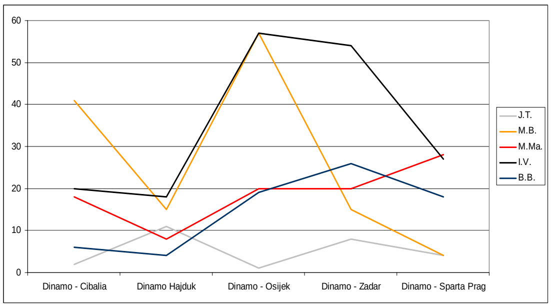
Abstract

In the 2008/2009 season eleven top football players of Dinamo Zagreb Football Club were assigned to the test group subjected to the system of three morphological measurements, three variables for the estimation of functional abilities on the treadmill and ten indicators of the situational efficiency of football players obtained by the Prozone3 system. The correlation between the variables applied in this research was determined by a correlation analysis; on the other hand, a series of regression analyses determined the correlation between the set of anthropometric indicators and functional abilities as a system of predictor variables in relation to every indicator of the situational efficiency as a criterion variable. The correlation analysis showed a statistically significant correlation between some variables (p<0,05). However, the series of regression analyses indicated a lack of statistically significant correlation between the system of predictor variables consisting of anthropometric characteristics and functional abilities and the measured indicators of situational efficiency (p>0,05) except for the variable of unsuccessfully passed balls. The conclusion was that the morphological characteristics and functional abilities do not possess any predictive value on the indicators of situational efficiency of the tested group of top football players.

Key Words: *Football, notation analysis, efficiency, indicators, morphological and functional dimenions*

Introduction

Football belongs to the group of complex polistructural kinesiological activities whose main aim is to score more goals than the opposite team, or allow fewer scores by the opposite team. Each of the 11 subjects chosen for the test group possesses unique characteristics and abilities that manifested themselves during the competing activity, and resulted in their unique technical-tactical activities. The perception of football as a kinesiological activity raises a question: How is the success of an individual football player during a competing activity linked with his characteristics and abilities? In order to answer this question, it is first necessary to apply diagnostic procedures and establish the football players' real characteristics and abilities. Then instruments for objective measurement should be applied with the aim of gathering as much relevant information as possible on the actual players' performance during the competing activity. The process of gathering information on a competing activity is called a notation analysis. The data thus obtained are called the indicators of situational efficiency. The majority of team sports face the problem of identifying and intepreting actions and events taking place in the football field. The notation analysis is an effective way of resolving this problem (Hughes and Franks, 2004). 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, 2004). Football coaches are able to monitor only the parts of the football field where the core of the game (a ball game) takes place while the information on the game and movements in the other parts of the football field is not known. Every coach's aim is to improve a player or a team by giving them feedback on their performance. Scientific research has proved that human observation and memory are not sufficiently reliable and cannot serve as accurate and objective indicators of an athlete's performance, especially not in a complex sport such as football. It has also been proved that football coaches are less than 45% precise in their analyses of the events taking place within the 45-minute span of a football game (Franks and Miller, 1986). In order to obtain appropriate feedback, instruments of objective measurement are absolutely necessary. They may comprehend various forms of video analyses that rely on data processing during a football game or afterwards, and on biomechanical or computerised notation system. Video recording ensures the most realistic and understandable form of feedback information. In combination with quantitative feedback information it can probably guarantee the best understanding of the information and its use in the modification of later performances (Hughes and Frank, 1997). Hand and computerised notation systems facilitate the collection of information with the aim of analysing the players' movements, assessing the tactical and technical efficiency and providing statistical compilation. The development of computer and video technology has led to certain changes in the performance analysis and in the use of this analysis in the process of training improvement. The main methods of rendering the mentioned data more objective include the use of video/notation analyses (Hughes and Frank, 1997). Team sports can achieve significant success by using computerised notation analysis, and thus obtained information can be used for instant feedback, database development, identification of positions in the game that need to be improved, assessment and also as a mechanism of selective search via game recording (Franks et al., 1983). So far there has been a number of scientific studies in the field of football where the authors engaged in the analysis of characteristics and abilities of football players (Wisloff et al., 1998; Rienzi et al., 2000; Reilly et al., 2000; Casajus, 2001). There have also been studies where the authors focused on the analysis of situational efficiency of football players (Luhtanen, 1993; Tiryaki et al., 1997; Pearce and Hughs, 2001; Luhtanen et al., 2002). However, having studied the available literature, we have not been able to idenfity a single study of the correlation between, on the one hand, the indicators of situational efficiency measured by a computerised notation system and, on the other, morphological characteristics and functional abilities of players.



Graph 1. Overall number of passed balls in five games

Problem and Aim

This study tried to resolve the problem of correlation between, on the one hand, the indicators of situational efficiency and on the other, the morphological characteristics and functional abilities of the top football players. Thus, the aim of the study was to establish the correlation between all the measured variables and to establish the correlation between, on the one hand, the morphological characteristics and functional abilities as a set of predictive variables and, on the other, every variable of the situational efficiency of football players.

Methods

The test group consisted of 11 football players of Dinamo Zagreb Football Club playing in five football matches 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 pre-contest period. Firstly, the footballers' basic morphological characteristics were measured: height (cm), weight (kg) and subcutaneous fat tissue (%). Then they were subjected to a test with the 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}). The second part of the data collection refers to the collection of the indicators of situational efficiency, which was carried out by means of Prozone3, an up-to-date and most objective instrument of measurement of this kind. Prozone3 is an interactive analysis system developed in accordance with the demands of top football coaches. The precondition for its use is the installment of at least 8 video cameras inside the football stadium, and in this research 9 video cameras were used. The video recording is then analysed by means of Prozone3 software, most frequently following a football match.

In general, Prozone3 provides a rerun of the whole 90-minute match. The data stored in this software analyse the movements, actions and interactions of every player in both teams. Numerous studies have proved independently the efficiency of this system in providing accurate and reliable information (Di Salvo et al., 2006). Ten indicators of situational efficiency were used in this research (Table 3). The gathered data were processed by SPSS v13.0, a statistical software product for data management and analysis. The reliability of the indicators of situational efficiency were determined with Cronbach's α coefficient and interclass correlation coefficient. Then descriptive parameters and correlation coefficients were calculated, which was followed by the use of regression analyses with the aim of determining the correlation between, on the one hand, anthropometric and functional characteristics and, on the other, the indicators of situational efficiency. Every variable of these indicators was set as a criterion variable while the variables of anthropometric and functional characteristics represented a set of predictive variables.

Results

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 maxium oxygen intake and total distance covered in sprint run ($r=0,61$), maximum running speed and number of sprint runs ($r=0,76$).

Table 1. Anthropometric and functional characteristics

	Age (years)	Height (cm)	Weight (kg)	Sub-cutaneous 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

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

	M ± SD	Standard Error AS	Min	Max	Range	Coefficient of variation	Cronbach's α	Interclass Correlation coefficient
Maximum running time (km h^{-1})	9,11 ± 0,18	0,06	8,80	9,40	0,60	1,97%	0,71	0,71
Passed balls	26,17 ± 15,74	4,74	5,20	55,00	49,80	60,14%	0,91	0,91
Successfully passed balls	22,21 ± 14,07	4,24	3,60	47,67	44,07	63,35%	0,92	0,92
Unsuccessfully passed balls	3,78 ± 2,37	0,71	1,00	8,50	7,50	62,70%	0,87	0,87
Average sprint speed	2,07 ± 0,18	0,05	1,80	2,30	0,50	8,70%	0,95	0,95
Average sprint length (m)	7,01 ± 1,87	0,56	5,10	11,90	6,80	26,68%	0,98	0,98
Number of sprint runs	32,27 ± 11,14	3,36	11,00	51,50	40,50	34,52%	0,81	0,81
Covered distance in the first half (m)	4774,45 ± 2406,77	725,67	0,00	6341,00	6341,00	50,40%	1,00	1,00
Covered distance in the second half (m)	4571,1 ± 868,68	261,92	3223,33	5765,75	2542,42	19,00%	0,79	0,79
Covered sprint distance (m)	244,87 ± 109,47	33,01	130,50	479,28	348,78	44,70%	0,90	0,90
Age (god.)	25,46 ± 3,56	1,07	19,30	30,10	10,80			
Height (cm)	183,64 ± 5,05	1,52	174,60	188,90	14,30			
Weight (kg)	79,28 ± 4,68	1,41	67,80	84,80	17,00			
Subcutaneous fat tissue (%)	6,63 ± 1,37	0,41	4,99	9,59	4,60			
Average maximum oxygen intake (mL $kg^{-1}min^{-1}$)	59,72 ± 4,67	1,41	53,20	68,00	14,80			
Maximum heart rate frequency (b min^{-1})	196,27 ± 8,58	2,59	181,00	206,00	25,00			
Maximum running speed (km h^{-1})	19,05 ± 1,15	0,35	17,00	21,00	4,00			

Table 3. Indicators of situational efficiency

	Maximum	**Overall**	**Successfully**	**Unsuccessfully**	**Average**	**Average**	**Number of**	**Covered**	**Covered**	**Covered**
J.T.	9,1	5,2	3,6	1,6	2,16	6,84	29,8	6310	4103,5	232,2
M.B.	9	26,4	23	3,4	2,2	6,06	23,4	6214,33	3958,25	140,08
M.Ma.	9,18	18,8	12,6	4,2	1,8	7,8	44,8	5002,2	4056,6	396,12
I.V.	9,16	35,2	31,6	3,6	2,04	7,04	39,2	5845	5346,8	302,8
B.B.	9	11,75	10,5	1,25	2,025	6,1	24,25	6178,5	5217	157,02
M.Mi.	9,4	42,5	34	8,5	2,1	8,275	51,5	6032,5	5765,75	479,27
I.B.	8,97	55	47,67	7,33	1,8	6,13	30,33	5024	5092,33	242,37
M.Ch.	8,8	27	22,33	4,67	2,27	5,1	27,67	6341	3223,33	177,67
C.Sa.	9	41	38	3	1,85	5,55	35	5571,5	5013,5	198,7
S.E.	9,4	13	12	1	2,2	11,9	11	0	3316	130,5
A.T.	9,2	12	9	3	2,3	6,2	38	0	5189	236,8

Table 4. Results of regression analyses

Criterion variable	ρ^2	$F_{(7,3)}$	P
Maximum running speed (km h^{-1})	0,63	0,73	0,67
Overal number of passed balls	0,84	2,24	0,27
Successfully passed balls	0,81	1,80	0,34
Unsuccessfully passed balls	0,98	24,95	0,01
Average sprint speed	0,83	2,07	0,30
Average sprint length (m)	0,51	0,45	0,83
Number of sprint runs	0,90	3,78	0,15
Covered distance in the first half (m)	0,23	0,13	0,99
Covered distance in the second half (m)	0,94	6,38	0,08
Covered sprint distance (m)	0,84	2,20	0,28

Discussion and Conclusion

The obtained values of the morphological characteristics are in accordance with the research carried out on top football players in some European leagues (Czech, Slovakian, Spanish and Swedish), as well as the average maximum oxygen intake that is insignificantly lower than in the mentioned research (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 α = 0,71), but is still satisfactory. This means that all the mentioned variables represent accurate indicators of the situational efficiency of the football players. The coefficient of variation, as an indicator of the dispersion of results, is significantly low for the variables of the maximum running speed (1,97%) and 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 high correlation between the variable of the overal number of passed balls and the variable of successfully passed balls (r=0,99) on the one hand, and the variable of unsuccessfully passed balls on the other (r=0,79) results from presenting the data in absolute values. It is logical to assume that, on average, players with more passed balls also have more successfully and unsuccessfully passed balls. Trainers would especially profit if the future results for successfully and unsuccessfully passed balls per player were expressed in percentage and in relation to the total number of passed balls per game. It is interesting to notice that there is a statistically significant correlation between the variables of unsuccessfully passed balls and number of sprint runs (r=0,63) and the variable of covered distance in sprint run (r=0,67). Certain studies (Rampinini et al., 2008; Rampinini et al., 2009) have proved that this is caused by the influence of tiredness on technical performance and accuracy in ball passing during a football match. 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 football match. As a football 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 football 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 (VO2max) has a positive correlation with the covered distance in a football match (Bangsbo, 1994; Smaros, 1980). A series of regression analyses provided interesting results and showed that with such top football players the set of predictive variables consisting of several morphological characteristics and three variables estimating functional abilities (average maximum oxygen intake, maximum heart rate frequency, maximum running speed on the treadmill) are not a statistically significant predictive factor for the variable of the football players' situational efficiency measured by Prozone3 system.

The variable of unsuccessfully passed balls is an exception, which further proves the fact that the set of morphological characteristics and the measurement of functional abilities do not serve as indicators or predictors of high efficiency of top football players during a football match. A correlation between the sprint run number and maximum running speed was also established, as well as that betweeen the covered distance in sprint run during a game and maximum oxygen intake. Thus, we can conclude that football players with better functional abilities cover a greater distance in sprint runs (Bangsbo, 1994; Smaros, 1980). It is obvious that the mentioned set of morphological characteristics and functional abilities does not represent a predictor of real situational efficiency of top football players. The real situational efficiency is determined by a number of other abilities, characteristics and technical-tactical knowhow.

Of course, a high level of functional abilities is essential for success in a football match, but many other characteristics also define the situational efficiency of top football players in modern football. This proves the complexity of success in football and the necessity of use of such notation analyses in the measurement of real and concrete indicators of situational efficiency in football players. A greater variety of functional and motoric variables should be applied in future research and their correlation with various indicators of situational efficiency of football players should be analysed as well.

Prozone is primarily a tool that provides the detection of the real situational efficiency of an invidual player and the team in concrete situations. This is why it represents an excellent means of determining the concrete behaviour in a game. It is also an excellent additional test of morphological, motoric and functional abilities of football players helping to identify the good and bad sides of football training and improvements of sports performance that have to be carried out via the training process.

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POVEZANOST PARAMETARA SITUACIJSKE EFIKASNOSTI S MORFOLOŠKIM KARAKTERISTIKAMA I FUNKCIONALNIM SPOSOBNOSTIMA NOGOMETAŠA

Sažetak

Na uzorku od jedanaest vrhunskih nogometaša Nogometnog kluba Dinamo u sezoni 2008/2009. primijenjen je sustav od tri morfološke mjere, tri varijable za procjenu funkcionalnih sposobnosti mjerenih na pokretnoj traci i deset pokazatelja situacijske efikasnosti nogometaša dobivenih sustavom Prozone3. Relacije između pojedinih varijabli primijenjenih u ovom istraživanju utvrđene su korelacijskom analizom, dok je povezanost skupa antropometrijskih pokazatelja i funkcionalnih sposobnosti kao sustava prediktorskih varijabli u odnosu na svaki parametar situacijske efikasnosti kao kriterijske varijable utvrđena serijom regresijskih analiza. Rezultati korelacijske analize su kod nekih varijabli pokazali međusobnu statistički značajnu povezanost (p<0,05). Serija regresijskih analiza je pokazala kako sustav prediktorskih varijabli koji se sastojao od antropometrijskih karakteristika i funkcionalnih sposobnosti nema statistički značajnu povezanost (p>0,05) s mjerenim pokazateljima situacijske efikasnosti, osim s varijablom neuspješna dodavanja. Zaključeno je da skup morfoloških karakteristika i funkcionalnih sposobnosti nema prediktivnu vrijednost na pokazatelje situacijske efikasnosti mjerenog uzorka vrhunskih nogometaša.

Ključne riječi: *nogomet, notacijska analiza, efikasnost, morfološke i funkcionalne dimenzije*

Received: October 15, 2010.
Accepted: December 20, 2010.
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