INTERNAL AND EXTERNAL VALIDITY OF THE MOVEMENT RANGE MEASUREMENT OF TOP SOCCER PLAYERS DURING THE MATCH MEASURED USING THE SOFTWARE SYSTEM TRACKING MOTION BIOIRC

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Abstract: The aim of this study is to determine the internal and external validity of measuring the range of motion of top players during a match measured using Software System Tracking Motion BIOIRC. The research was conducted on a sample of 63 players, who were recorded during 11 official matches from the following clubs or national teams: Red Star F.C. Belgrade; Radnicki 1923 F. C. Kragujevac; Partizan F. C. Belgrade; Bordoaux F. C. Bordoaux; senior national teams of Serbia and the National Team of Belgium. The variables provide estimates of the variability of the movement of top players during the game, followed by the software system Tracking motion (BioIRC, Kragujevac, Serbia). The parameters of the movement structure were analyzed by a descriptive statistical method, and the reliability of the monitored variables was examined using linear regression analysis. Based on the obtained results of player movement during the analyzed matches, it can be concluded that the internal and external validity of the range of player movement during the first and second half of the match is very high, both at the level of the whole team and the team lines.

Keywords: validity, measurement, movement range, game, top soccer players

1. Introduction

In modern, top football, tracking motion and analysis of player movement data during a match have become an important diagnostic-analytical tool for analyzing and understanding the functionality and situational efficiency of players. The information they provide us is extremely popular and applicable, both in diagnostics and analysis, as an indispensable segment of sports science, and in the implementation of the daily training process and competition of athletes.

The importance of the application of this research in training and analytical practice draws special attention, so the series of scientific and research procedures were carried out in order to initiate a new direction of influence, aiming at the

improvement of the effectiveness and exactness of training tools and methods (postulates).

Software tracking and movement analysis are a very important tool for determining the metabolic profiles of training stimuli in the micro and macro periodization of the training process. For that purpose, special software was created for tracking and analyzing movements.

The wide range of information obtained by using such analytical systems indicates the quality and quantity of competition, processing the structure of individual matches in an exact way.

According to the results of previous research conducted in this area, the top football players cover from 11.1 to 13.5 kilometers on average during the game, depending on the position in the team. The structure of the movement is classified according to intensities into movement with low intensity, moderate intensity, high-intensity running and submaximal and maximum running (sprint). (Railly 2000; Bangsbo 2003)

Motion tracking by the software system BIOIRC gave results that were to a large extent in line with the results of tracking the movements of players from the best European leagues and the Champions League.

Table 1. Display of average values of player motion during the match at different levels of competition based on research by different authors
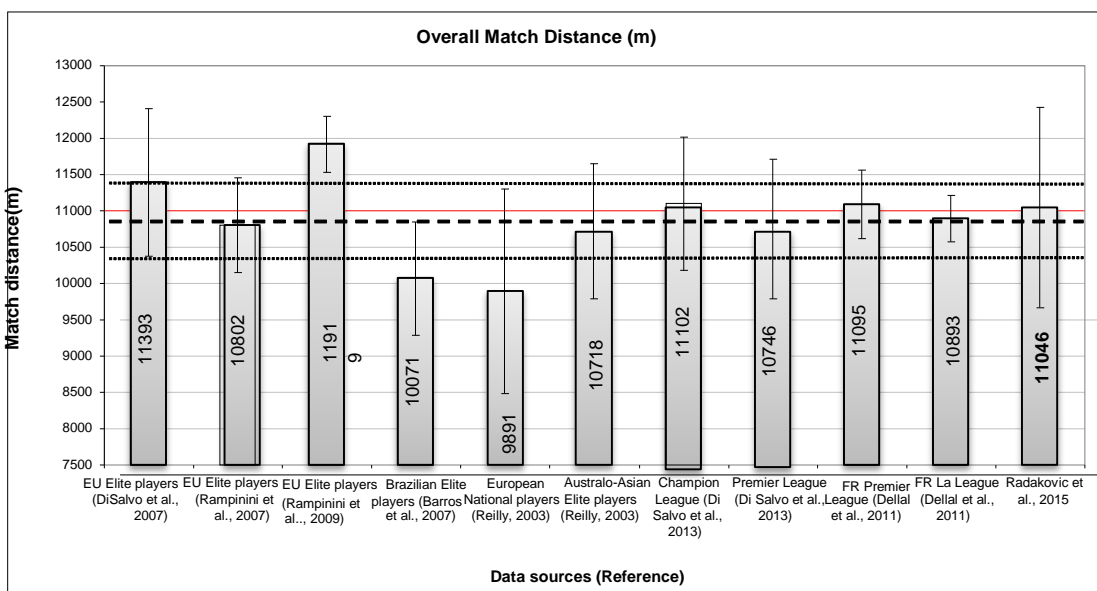
The aim of this study is to determine the internal and external validity of the movement range measuring of top players during a match measured using the Software System Tracking Motion BIOIRC.

The obtained data indicate a methodological approach in measuring the structure of the movement of top players using the software method of tracking motion.

2. Methods

Respondents

The research was conducted on a sample of 63 players, who were recorded during 11 official matches from the following clubs or national teams: Red Star F. C. Belgrade; Radnicki 1923 F. C. Kragujevac; Partizan F. C. Belgrade; Bordoaux F. C. Bordoaux; senior national teams of Serbia and the National Team of Belgium.

The observed matches were UEFA League qualifications: Red Star - Omonia and Red Star - Bordeaux in the 2012/13 season; semifinal matches of the Serbian Cup in the 2011/12 season; Red Star-Partizan and Partizan-Red Star; World Cup Brazil 2014 qualification match: Serbia-Belgium; and matches of the Serbian Premier League in the 2014/15 season. The structure of players was: 19 players from the defensive line, 23 players from the midfield line and 21 players from the attack line. The players were selected randomly for analysis, provided that they were playing all 90+ minutes of the match.

Variables

The variables provide estimates of the variability of the motion of top players during the game, followed by the software system Tracking motion (BioIRC, Kragujevac, Serbia).

Variables analyzed in the first half of the match:
-Team 1st half, movement of all team players during the first half
-Defense 1st half, movement of defense players during the first half
-Middle 1st half, movement of midfielders during the first half
-Attack 1st half, movement of attacker players during the first half

Variables analyzed in the second half of the match:
-Team 2nd half, movement of all team players during the second half
-Defense 2nd half, movement of defense players during the second half
-Middle 2nd half, movement of midfielders during the second half
-Attack 2nd half, movement of the attacker during the second half

Software system for motion analysis performance

Recording of matches using Tracking Motion system BIOIRC was performed with two identical Sony NEX-VG10 video cameras, in full-HD resolution, and one control camera with high-speed performance. The algorithmic part of video processing software, i. e. the part for tracking player movements, was based on determining a measure of the similarity of the statistical color distribution of objects. Videos of the match were processed in several phases.

For the purpose of analysis of video files, the videos were compressed with the XVID codec in MOV format, with a refresh rate of 30 frames per second. The algorithmic part of the software for monitoring the movement of players, i. e. for processing videos, is based on determining the measure of similarity of the statistical color distribution of objects.

The essence is that the analysis software monitors the motion of the players on the entire field, analyzing the recordings of both halves of the field alternately, depending on the current activity of the players. The analysis speed on the Intel (R) Core2Duo E6750@2.66GHz computer, 2GB RAM, Win7 32bit, is ~ 4 frames per second.

Motion tracking analysis involves different types of measurements, not just the description or highlighting of specific procedures that must be undertaken to achieve the given goal. The methods used in this research can be roughly classified as high technologies based on a hardware system and based on an algorithm. They represent a very useful tool in sports analytics and diagnostics, as well as planning, training programming and selection and creation of new training methods in professional and top sports.
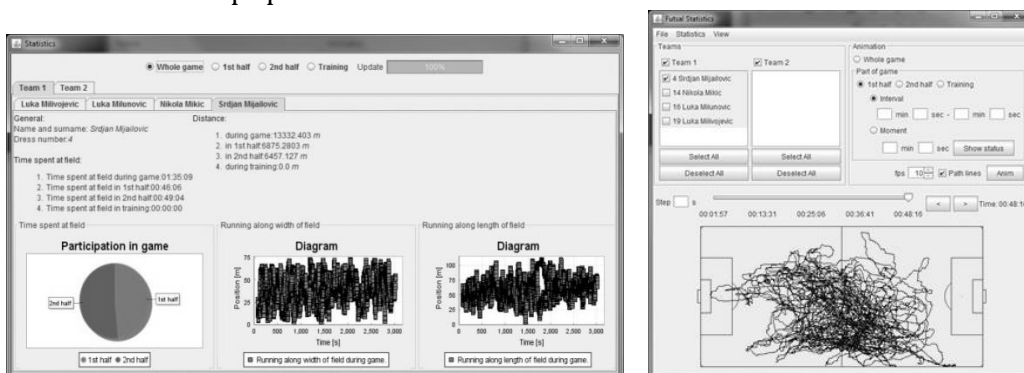
Figure 1. Application for display and statistical analysis of player movement: a) participation in the total movement during the match and numerical display b) visualization of player movement and software capabilities.

Software performance and capabilities include individual, line, or team tracking of players at any time during the match, which allows coaches to have real-time

information on the position and manner of movement of their own or opposing players at any time during the match.

This way of analysis enables the perception of positive and negative responses to the requirements of the game, tactical ideas, or individual actions of players on the field, which was previously impossible. Also, the visual effects are very significant in the depictions to the actors themselves in the field, in terms of analysis and correction of specific details related to certain movements.

Software and hardware progression allows the use of real-time video recording, transformation, as well as filtering software that simultaneously displays the footage and 2D views and match analysis schemes. All results are dynamically synchronized in real-time, so the researcher, coach and athlete can use them efficiently, as a base for evaluation of the motor and functional performance of their players and their reflection on efficiency in situational conditions.

The method of software monitoring of player movements during a football match provides the possibility of an exact insight into the structure of player movements, and perception of situations on the field, offering sports experts and coaches great opportunities for corrections and analysis.

At the same time, numerous observations, perspectives and predictions can be made under different situational conditions, and then the necessary adjustments of training stimuli can be made for the development of given abilities according to metabolic movement profiles.

Measurement results are given for general parameters, after obtaining experimental results, using image processing and video software for analysis and preparation of numerical calculations, which is only part of the software's capabilities.

The main goal of this study was to create an absolute insight into the structure, scope and intensity of player motion on an individual and integral level.

The software can display data in the form of graphs and numerical representations expressed in meters, or percentages of total movement as a function of time (Figure 1). It is also set to perform a 2D display of movements at any time during the match, in parallel with the tracking of the match, and most importantly the program allows countless operations and analyzes in any time interval, on an individual, group, or integral level, for one, or both teams simultaneously.

From the above, it follows that coaches and sports experts can use this software to monitor the movements of their own or opposing players at any time and in any part of the field.

This level of sophistication of the tracking motion software BIOIRC offers great opportunities in terms of analysis and demonstration of movement, the position of the player at a given time, and as such can be a means of tactical, not just analysis of functional effectiveness of players during the game.

Methods of statistical data processing

The parameters of the movement structure were analyzed by a descriptive statistical method, where the following were calculated: average values (Mean), standard deviation (SD), coefficient of variation (cV%), standard measurement error expressed in absolute (Std. Error. Aps.) and relative (Std. .Error. Rel.) values, minimum (Min) and maximum (Max) value of measured variables.

The reliability of the monitored variables was examined using linear regression analysis, using the method for defining interclass correlation data (ICC and Cronbach's Alpha), while the difference between pairs of variables was determined using univariate analysis of variance (ANOVA). All analyzes were performed using the software package SPPSS 19.0, and the criterion for the probability of differences or correlations was at the level of $p = 0.05$.

3. Results and Discussion

The basic descriptive indicators of the variables of player movement in the first and second half at the level of the whole team are shown in Table 1.

It can be claimed that all measured variables, in relation to the results of the entire sample of players, are very reliable because the coefficient of variation does not exceed 15.81% (Table 1, Defense II half) up to only 2.33% variation (Attackers II half). In relation to the relative value of the standard measurement error, as a method of measurement error, it can be claimed that it ranges from 0.94% for the Forwards in the second half to 5.00% for the Defensive Players in the second half. In other words, in relation to the average of all measurement errors of the monitored variables by positions, it is at the level of 2.24% (Table 1).

Table 1. Basic descriptive statistics of measured variables

	Mean (m)	SD (m)	cV%	Std. Error. Aps. (m)	Std. Error. Rel. (%)	Min (m)	Max (m)
Overall sample of players (N = 51)							
I half	5507.77	704.52		98.65		3548.57	6875.28
II half	5538.5	718.20		100.57		3762.32	6808.21
Whole game	11046.27	1422.72		199.22		7310.89	13683.49
Defence (N = 18)							
I half	5095.04	683.76				4041.5	6049.23
II half	5309.75	812.57				3938.6	6612.7
Whole game	10404.79	1496.33				8038.0	12242.0
Midfielders (N = 17)							
I half	5993.55	605.09				6145.8	6875.3
II half	5902.65	589.15				6096.8	6808.2
Whole game	11896.2	1194.24				12242.6	13549.5

Attackers/Strikers (N = 16)					
I half	5455.97	509.27		5586.0	6017.5
II half	5408.94	608.17		5596.5	6009.7
Whole game	10864.91	1117.44		11182.6	11930.9

Table 2 shows the results of the calculated reliability coefficients for the examined variables. Based on the obtained results, it can be claimed that the level of general validity, i. e. validity for the entire sample of players is at the level of 0.944 (Table 2, Cronbach's Alpha) and is statistically highly significant (p = 0.000). Very high coefficients of validity were also determined for players by positions, as follows: for Defensive - 0.952, p = 0.000; for Midfielders - 0.937, p = 0.000; and for Attackers - 0.925, p = 0.000 (Table 2).

Table 2. Reliability results

	Cronbach's Alpha	ANOVA F relation	P value	Intraclass Correlation Coefficient				
				Single Measures	Average Measures	95% Confidence Interval		P value
						Lower Bound	Upper Bound	
Overall sample of players								
I vs II half	0.944	0.449	0.506	0.894	0.944	0.821	0.938	0.000
Defenders								
I vs II half	0.952	8.089	0.011	0.909	0.952	0.774	0.965	0.000
Midfielders								
I vs II half	0.937	1.670	0.215	0.882	0.937	0.705	0.956	0.000
Attackers/Strikers								
I vs II half	0.925	0.403	0.535	0.860	0.925	0.646	0.949	0.000

The results of linear regression analysis are shown in graphs 1 to 4, in order to define the linear degree of agreement of the results of the distance in the first and second half as a measure of the similarity of the examined variables using the Tracking Motion software system.

Graph 1 shows the distribution parameters of the dependence of the players' movement in the whole team during the first and second half based on linear regression. At the general level (Chart 1) it can be claimed that the degree of agreement of the results of the first and second half in relation to the achieved distances during the game is at the level of the determination coefficient of $R^2 = 0.8$, or at 80% of the explained variability.

Graph 1 .: Linear regression of distance dependence during the first and second halves for all team players
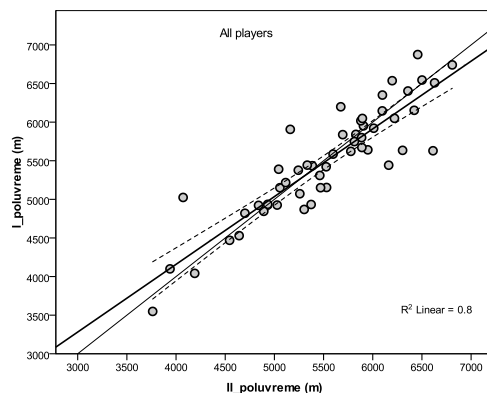

The distribution parameters of the dependence of the movement of the defensive line, middle line and attacking players during the first and second halves are shown in Graphs 2, 3 and 4. The obtained results (Graph 2, 3 and 4) confirm that the degree of agreement of the first and second half-time results in relation to the realized distances during the game for the defensive line is at the level of the determination coefficient of $R^2 = 0.851$, i.e. at the level of 85.1% of the explained variability, for the middle line at the level of the determination coefficient of $R^2 = 0.779$, i.e. at the level of 77.9% of the explained variability and for the line of attack at the level of the determination coefficient of $R^2 = 0.764$, i.e. at the level of 76.4% of the explained variability of movement.

Graph 2. Linear regression of the dependence of the distance of movement during the first and second half for the players of the defensive line of the team
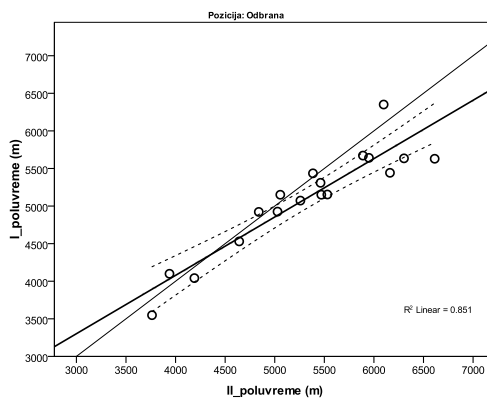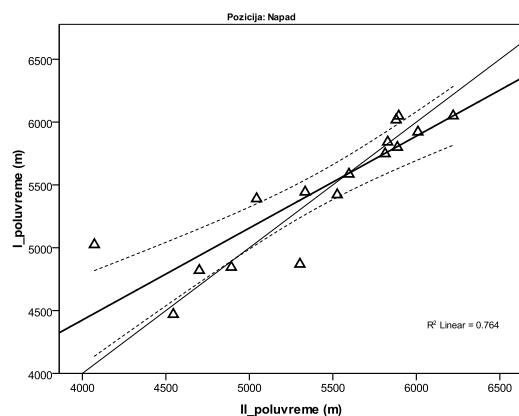
Graph 3. Linear regression of distance dependence during the first and second halves for team midfield players
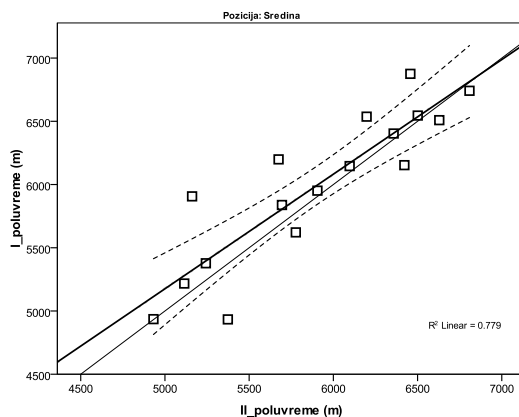
Graph 4. Linear regression of the dependence of the distance of movement during the first and second half for the players of the attacking line of the team

4. Conclusion

Based on the obtained results of player movement during the analyzed matches, it can be concluded that there is a high level of measured motion results as a measure of similarity of examined variables using Tracking Motion software system, i. e. that the internal and external validity of player movement during the first and second half, both at the level of the whole team and along the lines of the team, is very high - the degree of validity is in the domain of very high value, for players of the whole team (Cronbach α = 0.944), defensive (Cronbach α = 0.952) and attacking lines of the team (Cronbach α = 0.937), and for team midfielders (Cronbach α = 0.925).

Based on previous research, the average value of the volume of movement of top football players from various European league competitions during the game, as a

global standard, is 10880 ± 561 m (reliability interval Mean ± 1SD is 10319 to 11441 m). Based on the fact that the value of the total average distance of football players measured using Tracking Motion software BIOIRC is within the average ± 1 standard deviation of the value of a given variable measured by researchers in previously published reference research, it can be claimed that the external validity of the system used is scientifically acceptable.

This confirms that software analysis is characterized by a high degree of sensitivity and satisfactory coefficients of internal and external validity. The software analysis system is a very precise analytical instrument, with exact parameters that are very useful for explanation and use in the work methodology of coaches and sports experts, and as such is recommended in analytical-diagnostic practice in football.

The needs for exactness and validity of future studies on similar topics impose the necessity of a larger number of analyzed matches (respondents), different technical-tactical requirements and qualitative levels of competition, in order to confirm correlations and interdependencies of given parameters on a large sample and impose them as a standardized analytical-diagnostic tool in the methodology of working in football.

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