Vinko Lozovina[*]
Leo Pavičić[**]
Mislav Lozovina[***]

ISSN 0469-6255
(135-141)

ANALYSIS OF INDICATORS OF LOAD DURING THE GAME IN THE ACTIVITY OF THE CENTER IN WATERPOLO

Analiza nekih pokazatelja opterećenja u igri sidruna tijekom utakmice u vaterpolu

UDK 797.253.012
Izvorni znanstveni članak
Original scientific paper

Abstract

Water polo, as an activity, belongs to the category of polystructural complex move sports. The activities of a central player were sampled during competitive games of the First National League. The study is aimed to define a set of new measurement variables for the objective recording of the amount, intensity and duration of player's activities, and its evaluation by means of factor validity criteria. On the sample of 91 entities, 29 variables were applied. Measurements were made by competent, trained officials. Basic statistics of all measured variables is presented as referral values of various player activities. In the factor analysis, three factors are found to be significant explaining 84.6% of source variability, which is a subset of multivariate normally distributed variables. Factors are interpreted as: Quantity of actions, Intensity of activity in the horizontal body posture, and the time spent in a game. Of the first two, body posture is found to be specific in water polo, due to specifics of the game played in water. It is concluded that the proposed variables and measurement procedures are very well suited and objectively instrumented, for the purpose of measurement of the energetic aspect of kinesiological activity analysis.

Key words: water polo, kinesiology, center, factor analysis, indicators of load

Sažetak

Vaterpolo kao sportska aktivnost pripada kategoriji polistrukturalnih kompleksnih gibanja. Aktivnost sidraša (centra) praćena je na reprezentativnom uzorku na službenim utakmicama odigranima u okviru Prve nacionalne lige. Cilj ovom istraživanju bio je definirati nove mjerne varijable za objektivno bilježenje količine, intenziteta i trajanja aktivnosti centra tijekom utakmice, te odrediti njihovu evaluaciju na osnovi faktorskog kriterija. Na uzorku od 91 entiteta mjereno je 29 varijabla. Mjerenja su izvršili kompetentni, kvalificirani istrenirani mjeritelji. Bazična statistika svih mjerenih varijabla prezentirana je kroz referalne vrijednosti svih sidraševih aktivnosti. Rezultati faktorske analize pokazuju da tri dobivena faktora signifikantno objašnjavaju 84,6% izvornog varijabiliteta, u subsetu multivarijantno normalno distribuiranih varijabla, zadržanih u konačnoj analizi. Dobiveni faktori interpretirani su kao: "Količina akcija, Intenzitet aktivnosti u horizontalnoj poziciji, i Vrijeme provedeno u igri." Utvrđeno je da postoje izvori varijabiliteta koji su povezani s intenzitetom igre na poziciji centra. U intenzitetu je uočeno da postoje dva aspekta. Jedan izražen kroz broj, tj. količinu akcija, kojega definira prvi faktor dobiven u ovom istraživanju, i drugi izražen kao razina angažmana, definiran drugim faktorom dobivenim u ovom radu. Kao treća latentna struktura pojavljuje se vrijeme provedeno u igri. Mjerni instrument konstruiran kao baterija testova prema dobivenim rezultatima može se preporučiti za korištenje i mjerenje različitih aspekata opterećenja centra u vaterpolu tijekom igre. Značenje ovog rada ogleda se u mogućoj primjeni rezultata u planiranju i programiranju treninga, selekciji, usmjeravanju i usavršavanju za "radno mjesto" centra u vaterpolu.

*** Vinko Lozovina, Split College of Maritime Studies, 21000 Split**
**** Leo Pavičić, Faculty of Kinesiology, University of Zagreb, 10000 Zagreb**
***** Mislav Lozovina, Faculty of Kinesiology, University of Zagreb, 10000 Zagreb**

Ključne riječi: vaterpolo, kineziologija, sidrun, faktorska analiza, indikatori opterećenja

Introduction
Uvod

Sports activities and the water polo team game likewise can be analyzed in respect of two basic kinesiological perspectives: the first is energetic, dealing with amount, intensity and duration of motor actions; the second is dealing with information flow where technique, tactical, and strategic aspects are treated. It is obvious that, tactically assumed, energetic abilities are of utmost importance for the players in order to be capable to fulfill their roles and duties in team tactics.

Characteristic course of the water polo game, the positioned attack is organized of player's actions, defined by their roles, to enable the team to attempt to score. The positioned attack phase in water polo is a situation when one player positions himself at about two meters in front of the goal (center role), two players are positioned on the sides (wing role), and remaining players are in second line attackers role[1-6]. In the defense game phase, players are covering opposing team players according to their attack roles. The centers role is dominated by a large amount of a duel situations in vertical posture, and even so with critical loads in the horizontal posture[5-6].

In this experimental study, we are dealing with amount and variety of energetic loads of the player in role of center in water polo. In order to accomplish this aim, it was necessary to define a new sample of variables for the objective measurement of all centers' activities during a competition game. It is expected that from a wider selection of variables, it would be possible to find such subset of variables, satisfying conditions for multivariate statistical analysis, to establish a latent source of variability of center actions. Studies oriented to the observation of players loads during competition in team games and analysis in respect to amounts, types and intensities of players' actions in game are not very common. Studies of team game analysis in regard to the players or team efficiency in competition games, or aimed for analysis of game structure, are more present, and besides water polo[3,4,6,13,14,15], also cover other team games as soccer[6,7], basketball[9-11], or volleyball[12].

The ‘‘center’’ role
Uloga sidruna

From the moment the center sits at the two meters, on his back he is continually covered by an opponent defender (vertical body posture). Conditions and difficult balance in the water are more complicated and special training is truly needed for this effort to be endured. This is the reason that the best prepared center spends somewhat more that two quarters constantly playing at an unusual high level of effort. They are very effective in those minutes of the game. The centers who by chance must endure more minutes (constrain play) play less effectively and concisely, but those who by chance must play the entire game are principally inaccurate, which is logical. They even cannot be prepared for such high intensity for the duration of the play. Playing the game spontaneously at a lower level significantly drops their effectiveness. A special part of the game of the center is played with players more or less, which is trained as maximal type of effort in the vertical position. Considering on today’s excellent preparedness, premier league teams, and the center is the center point of attention. In the horizontal body posture (swimming in water polo) the center mainly swims short distances (20 to 25 m) but at high speed and intensity. For this part of the game (from the offense phase to the defense and reverse) the center must be specially and in a specific way prepared.

Our hypothesis was that it will be possible objectively to describe the activity (role) of the center in the game by the real and precise registrated : different types, quantity of movements in different intensities, duration and frequencies in vertical and horizontal posture. We expect more latent structures (more then one factor) for the same role – center in water polo.

Materials and Methods
Experiment description
Materijali i metode
Opis pokusa

Activity of a center during a game was monitored and recorded during official competition games of the First national water polo league. The officials were positioned high where they had optimal view of the playing field and of the official time clock which showed the official clean game time and time clocks that showed attack time. Standard water polo playing field markers (2 and 4 meter signs, etc.) are used as very good reference for estimation of swimming distances. All games selected for the experiment were played in the same swimming pool. Each of six officials consecutively recorded every action taken by his designated player. In order to qualify, each official had to undergo special training and pass the appropriate test of consistency in measuring.

Sample
Primjer

Entities, or basic information source, in this analysis, are quarters of the water polo game. According to the rules, water polo is played in quarters of 9 minutes of duration in clean game time (about 20 minutes of real time). Between the quarters are pauses (2-4 min). Measured samples used in this analysis consist of 87 quarters of the officially played competition games.

Variables

Varijable

Actions of players in water polo, as set of game elements are recorded[4]. Variables were defined to measure: frequencies of actions, the distances passed on the playing field recorded in meters, and, estimate of intensity of appropriate action in modalities of: low, sub maximal and maximal. The number and duration of duels are measured in seconds whom a player spends in the game with uneven number of players (a player plus or a player minus).

As a whole, a sample of 21 variables is used for recording of player activity in the game (Table 1). Beside those, another eight variables were calculated as unpondered linear sum as it is shown in the formulae in Table 1. Those variables are: FMXSMX as a measure of total frequency in crawl and backstroke swimming with maximal and sub-maximal intensity, MMXSMX as a measure of total distance in meters in crawl and backstroke swimming with maximal and sub-maximal intensity, FLAGAN as a measure of total frequency in crawl and backstroke swimming with low intensity, MLAGAN as a measure of total distance in crawl and backstroke swimming with low intensity, FIGVM, SIGVM are respectively frequency and time duration in totals of play with uneven number of players for teams due to exclusions by game referee, FAKCIJA as total frequencies of actions, and METARA as total distances passed by player in meters.

Table 1. Variables and descriptions

Tablica 1. Varijable i opisi

No.	Variable' names	Description
1.	FKRMAX	Frequency of swimming style crawl, intensity - maximal
2.	FLEDMAX	Frequency of swimming style backstroke, intensity - maximal
3.	FKRSMX	Frequency of swimming style crawl, intensity sub - maximal
4.	FLEDSMX	Frequency of swimming style backstroke, intensity sub - maximal
5.	FKRLAG	Frequency of swimming style crawl, intensity - low
6.	FLELAG	Frequency of swimming style backstroke, intensity - low
7.	FPRLAG	Frequency of swimming style breaststroke, intensity - low
8.	FDUEL	Frequency of duels
9.	FIGVIS	Frequency of actions with player more
10.	FIGMAN	Frequency of actions with player less
11.	MKRMX	Distance in crawl in maximal speed in meters
12.	MLEDMX	Distance in backstroke in maximal speed in meters
13.	MKRSMX	Distance in crawl in sub maximal speed in meters
14.	MLEDSMX	Distance in backstroke in sub maximal speed in meters
15.	MKRLAG	Distance in crawl at low speed in meters
16.	MLEDLAG	Distance in backstroke at low speed in meters
17.	MPRLAG	Distance in breaststroke at low speed in meters
18.	SDUEL	Time duration of duels in seconds
19.	SIGVIS	Time duration with players more in seconds
20.	SIGMAN	Time duration with players less in seconds
21.	SUKUPNO	Total time spent in play in seconds
22.	FMXSMX	= FKRMX + FLEDMX + FKRSMX + FLEDSMX
23.	MMXSMX	= MKRMX + MLEDMX + MKRSMX + MLEDSMX
24.	FLAGAN	= FKRLAG + FLEDLAG + FPRLAG
25.	MLAGAN	= MKRLAG + MLEDLAG + MPRLAG
26.	FIGVM	= FIGVIS + FIGMAN
27.	SIGVM	= SIGVIS + SIGMAN
28.	FAKCIJA	= FMXSMX + FLAGAN + FIGVM
29.	METARA	= MMXSMX + MLAGAN

Data analysis

Analiza podataka

The basic statistics have been calculated, moments of distributions, i.e., arithmetic mean, standard deviation, kurtosis and skew ness of distributions, and minimal and maximal result, for each analyzed variable.

The matrix of Pearson correlation coefficients between variables is calculated and factor analysis, under component model, was performed. The final factor solution was defined according to OBLIMIN oblique factor rotation criterion. The analysis was performed using standard SPSS package for Windows (ver. 10.0).

Table 2. Basic statistics
Finding (mean ±standard deviation, kurtosis, skewness, minimal and maximal values and valid N)

Tablica 2. Osnovna statistika
Dobiveni podaci (aritmetička sredina ± standardna derivacija, izbočenost, nagnutost krivulje, minimalne i maksimalne vrijednosti i broj validnih slučajeva

Varijable	X.	S.D.	K	S	Min.	Max.	N
FKRMX	,45	,78	3,26	1,90	0	3	91
FLEDMX	,03	,18	26,89	5,32	0	1	91
FKRSMX	4,42	2,93	2,46	1,30	0	16	91
FLEDSMX	,20	1,09	75,40	8,39	0	10	91
FKRLAG	9,09	5,20	2,20	1,32	1	29	91
FLELAG	,74	1,09	1,20	1,43	0	4	91
FPRLAG	1,07	1,52	3,45	1,79	0	7	91
FDUEL	5,57	2,96	-,46	,34	0	12	91
FIGVIS	1,19	1,16	1,32	1,10	0	5	91
FIGMAN	,98	1,06	,82	1,06	0	4	91
MKRMX	4,89	9,44	10,71	2,78	0	58	91
MLEDMAX	,25	1,53	45,87	6,65	0	12	91
MKRSMX	67,52	52,88	4,18	1,68	0	302	90
MLEDSMX	,32	1,23	13,16	3,78	0	6	91
MKRLAG	115,44	73,30	1,38	1,23	7	372	91
MLEDLAG	4,85	7,85	3,24	1,84	0	37	91
MPRLAG	7,05	11,15	7,23	2,36	0	62	91
SDUEL	43,33	31,08	2,81	1,41	0	168	91
SIGVIS	14,04	14,28	-,46	,73	0	52	91
SIGMAN	12,76	14,68	1,34	1,16	0	66	91
SUKUPNO	339,01	119,6	-,73	,26	90	540	91
FMXSMX	5,10	3,32	2,01	1,27	0	16	91
MMXSMX	72,87	54,58	3,35	1,55	0	302	90
FLAGAN	10,89	6,25	1,85	1,35	2	32	91
MLAGAN	127,34	78,36	1,28	1,24	21	389	91
FIGVM	6,76	3,06	-,62	,02	0	13	91
SIGVM	26,80	22,43	,61	,77	0	106	91
FAKCIJA	22,75	8,42	,55	,71	7	48	91
METARA	200,04	79,63	-,05	,67	60	417	90

Table 3. Correlation matrix of variables used in the final analysis

Tablica 3. Međusobni odnos osnova varijabli rabljenih u konačnoj analizi

	FDUEL	SDUEL	SUKUPNO	FMXSMX	MMXSMX	FLAGAN	MLAGAN	FIGVM	SIGVM	FAKCIJA	METARA
FDUEL	1,00										
SDUEL	0,79	1,00									
SUKUPNO	0,50	0,54	1,00								
FMXSMX	0,04	-0,00	0,19	1,00							
MMXSMX	0,48	-0,03	0,22	0,90	1,00						
FLAGAN	0,46	0,53	0,60	- 0,22	-0,30	1,00					
MLAGAN	0,55	0.61	0,67	- 0,29	-0,33	0,94	1,00				
FIGVM	0,93	0,76	0,56	0,09	0,13	0,49	0,57	1,00			
SIGVM	0,13	0,14	0,35	0,06	0,15	0,17	0,20	0,38	1,00		
FAKCIJA	0,70	0,66	0,72	0,26	0,17	0,83	0,79	0,76	0,29	1,00	
METARA	0,60	0,60	0,82	0,32	0,36	0,72	0,76	0,67	0,30	0,90	1,00

Table 4. Factor structure, eigenvalues and percent of explained variance

Tablica 4. Struktura čimbenika, vrijednosti i postotak objašnjene promjene

Variable	Factor 1	Factor 2	Factor 3
FDUEL	0,92	-0,00	0,12
SDUEL	0,88	-0,10	0,18
SUKUPNO	0,71	0,09	0,71
FMXSMX	0,10	0,94	0,14
MMXSMX	0,06	0,95	0,17
FLAGAN	0,72	-0,46	0,62
MLAGAN	0,78	-0,48	0,61
FIGVM	0,90	0,07	0,34
SIGVM	0,14	0,12	0,73
FAKCIJA	0,89	0,05	0,64
METARA	0,81	0,18	0,72
Eigenvalues	5,94	2,32	1,04
Explained variance	54%	21,1%	9,5%

Table 5. Factors correlation matrix

Tablica 5. Čimbenici međusobnog odnosa

	Factor 1	**Factor 2**	**Factor 3**
Factor 1	*1,00*		
Factor 2	*-0,04391*	*1,00*	
Factor 3	*-0,36403*	*0,03953*	*1,00*

Results and discussion

Rezultati i rasprava

As shown in Table 2, the numbers of variables, because of their scattered occurrences during the game, do not have normal distribution. Most significant departs from normal distribution are observed in variables: FKRSMX, MLEDMAX, MLEDSMX, MPRLAG, SIGMAN, FIGMAN and FLEDSMX. Statistics of derived variables shows that all those variables have approximately normal distribution. Due to such notable depart from normal distribution some directly measured variables are excluded in further multivariate statistical analysis. However, for the purpose of reference, values of statistics of all measured variables are presented.

This analysis shows (Table 2.) that during a game, a center spends on average 444.13 seconds per quarter or 1356 seconds in game (clean time). He swims 200.41 meters per quarter or 801 meter in the game, of which 72.87 meters per quarter in sub maximal and maximal intensities (MMXSMX), or 291.5 meter in the game. At low intensity, center swims on average 127.34 meters per quarter or 509 meters in the game (MLAGAN). With a player plus or a player minus, he spends on average 26,80 seconds per quarter or 107 seconds in the game (SIGVM). In the duel, he spends 43.33 seconds per quarter or 173 seconds in the game (SDUEL). In the vertical posture and at maximal load, a center spends in total 280 seconds (SDUEL+SIGVM), which is about 21% of his playing time[13-14].

From the correlation matrix of variables (Table 3.), a wide range of values is noted, from zero correlation variable SDUEL with FMXSMX, to high correlation of this variable with variables FIGVM, FAKCIJA, MLAGAN, and METARA. Variable FIGVM is highly correlated with variables FDUEL (0.93) SDUEL (0.76), MLAGAN (0.57) and SUKUPNO (0.56). A high positive correlations variable FIGVM with variables FDUEL (0.93), SDUEL (0.76), FAKCIJA (0.76) and METARA (0,67) are noted. Group of variables SDUEL, FDUEL, FAKCIJA and METARA are mutually high correlated, expressed in coefficients from 0.60 to 0.90. It is noticed that variable SUKUPNO with mainly all variables have correlation over (0.50).

Three factors retained in analysis as most important, according to Gutman-Kaiser criterion, explain 84,6% variance of the total system variance.

The first factor is defined by variables with high positive projections of variables: FDUEL, SDUEL, FIGVM, FAKCIJA and METARA (0.92, 0.88, 0.90, 0.89 and 0.81), and with somewhat lower but significant coefficients of variables FLAGAN, MLAGAN and SUKUPNO (0.72, 0. 78 AND 0.71). Low coefficients on this factor have variables FMXSMX, MMXSMX and SIGVM. This factor is predominantly defined by variables which measured intensity of game from frequency, respectively number for actions. Thus, this factor is called Quantity of Actions. On this factor, we can recognize a typical center which is prevailing defined by duels.

The second factor is dominantly defined by high projections of variables FMXSMX and MMXSMX. (0.94 and 0.95). With somewhat lower, negative, but significant projection this factor also defines variables FLAGAN and MLAGAN (-0.46 AND –0.48). This factor can be interpreted as Intensity of activity in horizontal body posture, here expressed trough modality on sub maximal and maximal level. In this constellation we can recognize movable center, with a low number of duels. This type of center on the two meters performs a task to keep a ball till a break and attack to play in cooperation with other attacker from the team.

The third factor is defined by high positive values in variables SIGVM, METARA and SUKUPNO (0.73, 0.72 and 0.71) and with something low, but significant values, by variables FAKCIJA, FLAGAN and MLAGAN (0.64, 0.62, 0.61). The dominant characteristic of this factor is The time spent in a game. From the constellation of this factor the center is possible to describe as a non-typical center, without duels. During the game, in attack phase, he takes a place on two meters but his team plays with second line attackers. He plays formal center role during attack. It is evident that there is a source of variability related with intensity of activity of the center during the game. In the intensity, two aspects are noted. The first aspect is demonstrated by a number or quantity of actions in the vertical posture, defined by the first factor, and the second aspect is the level and type of activity in horizontal posture defined by the second factor. As a third latent structure appears the time spent in a game. It is interesting to note that the level of load (intensity) is not so much related to time spent in the game, as it is related to the vertical and horizontal body posture loads, in respect to water surface, during the game.

Structures of the third factor are associated with second factor structure and have a zero correlation with first factor. The first relation can be peculiar artifact, because greater number of actions needs from a player more time spent in the game. On the other side the level of load is not related to time spent in the game. Variables FLAGAN and MLAGAN (frequency and meters) have the equal projections on any of three factors, with the objection that the third factor is negative. It is possible that the third factor is formed as a consequence of the fact in consideration of an account of position which center plays in the team, he is the least of all driving out player. Therefore his presence in the parts of the game with unequal number of players (a player plus or a player minus) is characteristically high and on this factor except variable SIGVM which dominantly define this type of center presence are variables SUKUPNO, METARA and AKCIJA which finally talk about the time.

Conclusion

Zaključak

From a wide selection of variables measuring the total activity of a center in water polo game, it is possible to define a subgroup with satisfactory factor validity. This set of variables describes all important activity aspects and loads of a center position or role in game. The experiment is carried out in a controlled setting provided by standardized conditions with regard to the entities observation (competition games of First national league), and competent trained officials made observations. A set of new 29 variables are used for measurements of amount, intensity and duration of activities of center role during a game quarter. For variables basic statistics, mean, standard deviation, kurtosis and skew ness are calculated and presented as referral values. Subset of variables with approximately normal distribution was analyzed for the purpose of finding latent structure and in order to evaluate new set of variables by means of its factor validity. Three factors are found to be significant according to GK criterion and explaining 84.6% of source variance. Interpretation of factors as quantity of actions (1.), intensity of activity in the horizontal body posture (2.), and the time spent in a game (3.) indicates specificity of water polo game. These specifications are important to body postures due to the water environment in which this game is played. Similar findings are present in experimental study of other player roles in water polo[12,13,14,15]. Such experimental findings, as type of kinesiological activity analysis, should be of referral usefulness for other studies, and can be used for planning and programming training procedures in water polo sport.

References

Literatura

[1] M. MIHOVILOVIĆ, *Osnovi vaterpola* (In Croat) (Sportska stručna biblioteka, Zagreb, 1952)

[2] V. LOZOVINA, *Vaterpolo* (In Croat) (1995)

[3] L. PAVICIC, *Some Possibilities for Formal Definition Of Waterpolo Game*. In (Perl, J. (Ed.) Sport und informatik II, Bundesinstitut fur Sportwissenshaft GmbH, Köln 1991).

[4] L. PAVIČIĆ, V. LOZOVINA, Z. ŠIMENC, *Analiza repertoara elemenata vaterpolo tehnike*. (In Croat) (Vaterpolo savez Hrvatske, Biblioteka-Stručni prilozi br. 8, Zagreb1988).

[5] V. LOZOVINA, *Sport. Praks.*, 3. (In Croat) (1984) 14.

[6] M. DOPSAJ, I. MATKOVIĆ, *The structure of technical and tactical activities of water polo players the first Yugoslav league during the game* . In Biomechanics and Medicine in Swimming VIII, edited by Keskinen, K., Komi, P. Holander, A., Department of Biology of Physical Activity, Finland: University of Jyvaskula, Jyvaskula, P. 435. (1999).

[7] W. DUFOUR, *Computer-assisted Scouting in Soccer.* In: T.Reilly, J.Clarys and A.Stibbe (Eds.): World Congress od Science and Football (E.&F. Spon, London. 1993).

[8] G. GERISH, AND M. REICHELT, Computer and Video-aided analysis of football games. in T.Reilly, J.Clarys and A.Stibbe (E.&F. Spon, London. 1993).

[9] K. L. WALGIN, The Basketball Evaluation System: a Scientific Approach to Player Evaluation. In (J. Krausse, ed.: Coaching Basketball, Indianapolis: Master Press 1994).

[10] S. TRNINIĆ, *Analiza i učenje košarkaške igre*. (In Croat) (Pula: VIKTA, d.o.o. 1996).

[11] S. TRNINIĆ, A. PERICA, L. PAVIČIĆ, *Kineziologija*, 26 (1-2) (1994) 27.

[12] V. JANKOVIĆ, N. MARELIĆ, D. MILANOVIĆ, *Kineziologija*, (In Croat) 23 (1-2) (1991)

[13] V. LOZOVINA, L. PAVIČIĆ, The influence of morphological measurements on the tactic choice in water polo. In Proceedings. ("Kinesiology for 21. Century – Dubrovnik, 1999).

[14] V. LOZOVINA, L. PAVIČIĆ, Analysis of Indicators of Load During the Game in Activity of the Heavy Defender in Water Polo. In Proceedings. ("Kinesiology new perspectives – Opatija, 2002)

[15] V. LOZOVINA, L. PAVIČIĆ, Analysis of Indicators of Load During the Game in Activity of the Second Line Attacker in Water Polo, Collegium Antropologicum, vol 27, 1/2003, pg. 343 – 351. , Zagreb

Rukopis primljen: 20.2.2004.