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Original research article

THE EFFECT OF VARIOUS LEG KICK TECHNIQUES ON THE VERTICAL JUMP AMONG WATER POLO PLAYERS

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Zoran Bratuša, Milivoj Dopsaj

University of Belgrade, Faculty of Sport and Physical Education, Belgrade, Serbia

Abstract. *A vertical in-water jump is a very important element of the game. Efficient leg kicks in the water should be a basis for the regular and efficient performance of the vertical jump technique. The main aim of this paper was to define the relations between various tests in which the characteristics of the techniques of the breaststroke leg kick and eggbeater leg kick were measured in water and the maximal height of the vertical in-water jump. The sample included 29 junior water polo players of an average age of 15.8 years. The results were analyzed using descriptive statistics and a correlation analysis. The maximum height of each vertical jump was recorded using a video recording device. The characteristics of drag force were defined with three separate variables for the breaststroke leg kick and eggbeater leg kick: the average peak of the maximum drag, the average impulse of drag force and the average peak of explosive drag force. The average maximal height of the vertical jump was 148.21±5.99 cm. The results have shown that the greatest statistically significant correlation was with the characteristics of the drag force of breaststroke leg kicks at the level of almost 99%. The characteristics of the drag force of the eggbeater leg kick did not show a statistically significant correlation, only the velocity of the eggbeater leg kick and the endurance in a vertical position for 5s and for 15s statistically significantly correlated in the performance of the vertical in-water jump technique among young junior water polo players.*

Key words: *breaststroke leg kick, eggbeater leg kick, leg kicks, vertical in-water jump*

INTRODUCTION

The specificity of water polo is reflected, primarily, in the environment where it is played. Therefore, the technical and tactical as well as motor requirements of this game are the results of the environment where the game takes place. Water, as a medium in

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Corresponding author Zoran Bratuša
Faculty of Sport and Physical Education, University of Belgrade, St. Blagoja Parovića 156, 11000 Belgrade, Serbia Phone: +381 11 3531000 • E-mail: zbratusa@gmail.com

which the competition takes place, is a limiting factor that has a major impact on the motor, tactical and technical area. In the tactical and technical area, the elements of specific movements and the skills of techniques and tactics are realized. In the motor area, other swimming movements in the game are realized. Unlike sports games that take place on land, and are characterized by the vertical position of the players only, in the game of water polo a player, in addition to a vertical position, assumes a horizontal one as well. The percentage of representation of horizontal and vertical positions during the game is the main indicator of diversity of the outplay in the water, whereas the position of the body determines the character of the load and is, therefore, an important factor of structuring the load of the training process (Petric, 1991; Dopsaj & Matkovic, 1998; Platanou, 2004; Takagi, Nishigima, Enomoto, & Stewart, 2005).

As a game, water polo is classified into the group of sports in which non-stereotyped movements and the situations characterized by complex movements and the expression of all men's physical features prevail (Dopsaj, 1993). During a match, a player performs a great number of movements in water in both the horizontal and vertical position, with or without a ball, with or without interaction with an opponent (Dopsaj et al., 1998).

The modern concept of the training process involves the application of methods and techniques of knowledge which monitor and evaluate the effect of the applied training and competitive activities on the direction and intensity of the training adaptation (Bratusa, Matkovic, & Dopsaj, 2003; Dopsaj & Bratuša, 2003). Since the main goal of any process of sports training is the development of an individual so that he could achieve top results, the process itself develops as a multi-year plan during which those skills, abilities and knowledge prevailing in a specific sport are developed and increased as much as possible.

A vertical in-water jump is a very important element in the game, especially among the elements of covering the defense area and resolving attack situations with high shots resulting in an almost certain goal. The ability of players to perform a good vertical in-water jump is a characteristic that represents a basic skill and technical benefit which provides an advantage in the game and, at the same time, indicates the ability of a player to provide adequate support in the water from which he would perform a vertical jump or any other technique for which a vertical explosive initial movement is required (Gatta, 1992). For a player to perform the vertical in-water jump technique it is necessary that the techniques of the breaststroke leg kick and eggbeater leg kick first create a precondition for the vertical jump and to enable a player's stable position in the water (Sanders, 1999; Dopsaj & Thanopoulos, 2006[b]). The quality vertical in-water jump is a result of creating an area of support (Gatta, 1992), i.e. grasping a great volume of water between a player’s legs and at the same time applying as much force as possible in the shortest possible period of time enables a vertical in-water jump. Since the measuring of the vertical in-water jump requires the provision of special technical measuring conditions as well as special measuring devices, all of which make up the conditions for training control which is difficult for the coaches, from the given aspect (Platanou, 2005). There are no studies which examine the quantitative relations between different motor abilities among water polo players, so there was a practical as well as a scientific need for such a study.

Therefore, the main aim of this paper was to define the relation between various tests in which the characteristics of the techniques of the breaststroke leg kick and the eggbeater leg kick in water were measured, along with the maximal height of the vertical in-water jump.

METHODS

The survey was conducted by applying a transverse non-experimental method. As to the cognition methods, deduction with logical analysis, as well as an analytical and synthetic method of inference were used (Ristanovic & Dacic, 1999; Hemlin, 2001). For data collection, a field test method was applied. To measure the characteristics of the force and drag power of the techniques of the egg beater leg kick and breaststroke leg kick, the dynamometric method was used by means of a tensiometric probe, in accordance with the procedure previously described (Barbosa, Dopsaj, Okicic, & Andries Júnior, 2010; Dopsaj, 2010[a]).

The sample of participants

The sample of participants comprised 29 junior water polo players aged 15.83 ± 0.83 years, of a mean height of 185.15 ± 5.25 cm, weight 81.71 ± 7.67 kg, who were involved in the systematic and regular training process for an average of 7:38 ± 1:47 years. The players were the members of the national team in their age group (12 players) and the key players in their clubs competing in national championships.

The testing methods

The testing required appropriate work organization. Due to the complexity of the measurement technology in water, and the great number of measured variables, the measurement was carried out in several phases, following a particular protocol. Before the testing, all of the athletes were informed about the aim and significance of the testing, as well as the tests they were about to take. There were 6 tests carried out in horizontal swimming, and in the vertical position, in freestyle swimming in motion, swimming in place with a resistance band, endurance in a vertical position with different loads (4 different weights), and the vertical in-water jump.

- Test 1 and 2: Swimming the breaststroke leg kick and eggbeater leg kick for 25m – The testing was carried out in a large 50 m, Olympic-size pool. A player, at the sign of the timekeeper, starts by pushing off from the edge of the pool and swims at maximum speed the breaststroke leg kick only, and then after an adequate break of at least 3 minutes, the eggbeater leg kick. During the given testing, the players' position was such that their arms were stretched in front of their heads in the extension of the body axis and with their hands resting on a ball. When a player cuts an imagined line with his head at the 25th meter, the timekeeper turns off the stopwatch. The times achieved were recorded in a form especially designed for that purpose (Dopsaj et al, 2003).
- Test 3: Maintaining a vertical position with an additional load with the eggbeater leg kick and arms outwards (Fig. 1). The participant maintains a vertical position with his arms stretched outwards, doing alternating egg beater leg kicks and wearing a belt with weights attached to it around his waist at the same time. The water polo player maintains a vertical position until collapse, with his elbows and the tip of his chin above the surface of the water. Each player was tested for four different weights. The time was measured in a referent position with a predetermined weight added, and in accordance with the procedure previously

described (Dopsaj & Thanopoulos, 2006[a]). The measurement was completed when the participant withdraws, i.e. when his chin or his elbows submerge in the water. The values of the load weight that can be endured by a participant in that position for a certain period of time were calculated by the method of mathematical modelling (Dopsaj & Thanopoulos, 2006[b]).

Fig. 1 Endurance in a vertical position

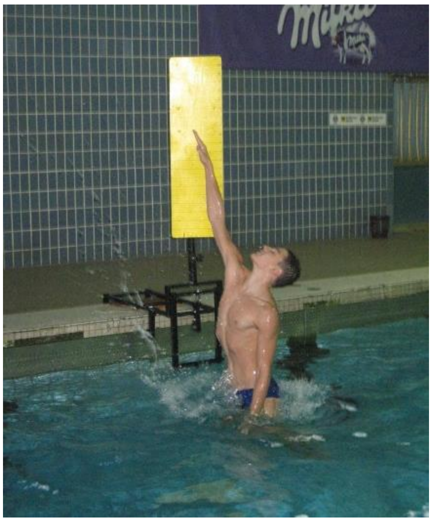

Fig. 2 In-water jump

- Test 4 and 5: Swimming the breaststroke leg kick and eggbeater leg kick for 30 seconds in place with a resistance band – a participant is in the horizontal position with a belt with shoulder pads to which one end of a rope is attached, while the second end of the rope is attached to the probe attached to the pool wall. The participant performs breaststroke leg kicks and egg beater leg kicks in water with maximum force (with an adequate break between two drags) while his hands rest on the ball. The force with which the participant stretches the rope is being transferred to the probe that sends a signal to a computer and the programme automatically records all the changes, second by second for the total predetermined time of the measurement of 30s. After an adequate break of at least 3 minutes, the measurement is repeated (Dopsaj, 2010[a]).
- Test 6: A vertical in-water jump with one arm stretched upwards (picture 2) – The maximal height is measured by each player performing three vertical in-water jumps so that his hand reaches the measuring panel set up on a console above the water, on which a measuring scale is marked for each centimeter. There is a visible numerical mark at every 5 cm. Each attempt is recorded by a camera and the participant's name and number of attempts are clearly noted, all of which is recorded by the camera. After the analysis of the video material, the height of the best attempt is entered into a particular form (Bratusa & Dopsaj, 2012[b]; Platanou, 2005). The result is obtained by adding the measured height of the lower edge of the panel in relation to the water surface which is constant (measured before the test) and the value displayed on the panel. The obtained result is the absolute maximum value of the vertical in-water jump.

Variables

In this research, the variables used covered the morphological area as well as the area of motor characteristics of the leg extensors in water by applying the technique of the breaststroke leg kick and the technique of the eggbeater leg kick.

- Anthropometric variables
  - Body height (BH), expressed in cm,
  - Body weight (BW), expressed in kg,
  - Body Mass Index (BMI), expressed in kg/m^2,
  - Percentage of fat (fat), expressed in %,
- Absolute values of motor variables describing the breaststroke leg kick and egg beater leg kick in both the horizontal and vertical position:
  - Average maximum velocity of swimming only eggbeater leg kicks (V_$L_{EGGKICK}$), expressed in meters per second (m/s)
  - Average maximum velocity of swimming only breaststroke leg kicks (V_L_{BKICK}), expressed in meters per second (m/s)
  - Average value of the additional load in endurance in the vertical position with eggbeater leg kicks in the first second (V_VRTkg_1s), expressed in kilograms (kg)
  - Average value of the additional load in endurance in the vertical position with eggbeater leg kicks in the fifth second (V_VRTkg_5s), expressed in kilograms (kg)
  - Average value of the additional load in endurance in the vertical position with eggbeater leg kicks in the fifteenth second (V_VRTkg_15s), expressed in kilograms (kg)
  - Average value of the additional load in endurance in the vertical position with eggbeater leg kicks in the thirtieth second (V_VRTkg_30s), expressed in kilograms (kg)
  - Average value of the maximum drag force generated by eggbeater leg kicks in place (V_$L_{EGGKICK}$Fmax _30s), expressed in Newtons (N),
  - Average impulse of drag force generated by eggbeater leg kicks in place (V_ $L_{EGGKICK}$ ImpF_30s), expressed in Newton seconds (Ns),
  - Average value of explosive drag force generated by eggbeater leg kicks in place (V_$L_{EGGKICK}$RFD_30s), expressed in Newtons per second (N/s),
  - Average value of the maximum drag force generated by breaststroke leg kicks in place (V_L_{BKICK}Fmax_30s), expressed in Newtons (N),
  - Average value of the impulse of drag force generated by breaststroke leg kicks in place (V_L_{BKICK}ImpF_30s), expressed in Newton seconds (Ns),
  - Average value of explosive drag force generated by breaststroke leg kicks in place (V_L_{BKICK}RFD_30s), expressed in Newtons per second (N/s),
  - Average value of the maximum vertical in-water jump (V_maxiskok) expressed in centimeters (cm).

All the obtained results were analyzed using basic descriptive statistical analysis where the following parameters were calculated: MEAN, SD, CV%, MIN and MAX. The Pearson correlation was applied to determine the similarities and the level of dependence between the studied variables. The level of statistical significance was defined at 95% of the probability criterion, i.e., at the level of $p < 0.05$ (Hair, Anderson, Tatham, Black, 1998) All of the data were processed using Microsoft ® Office Excel 2010 (Copyright ©

2010 Microsoft Corporation) and IBM SPSS 19 for Windows (IBM Company SPSS Inc. Copyright ©, 1989-2010).

RESULTS

The basic descriptive indicators of the morphological characteristics of the sample and the motor characteristics of the leg extensors are given in the Table 1. The statistical analysis indicates that the morphological sample belonged to a homogenous group where the coefficient of variation (cV%) of the individual variables does not exceed 30% (Hair et al., 1998), except for the anthropometric variable of the percentage of fat, where the value of cV% was at the level of 42.73%. As to the motor sample it may be said that it also belonged to a homogenous group where the coefficient of variation (cV%) of the individual variables does not exceed 30%, except for the variables: endurance in a vertical position for 1 second – V_VRTkg_1s, where the value of cV% was at the level of 54.68%, and endurance in a vertical position for 5 seconds – V_VRTkg_5s, where the value of cV% was at the level of 40.68%, whereas the variables of endurance in a vertical position for 15 seconds – V_VRTkg_15s, and endurance in a vertical position for 30 seconds– V_VRTkg_30s had limit values (34.38% and 32.22% respectively). The results of the coefficients of variation of the motor characteristics of the leg extensors with different techniques (the breaststroke leg kick and eggbeater leg kick) have shown that the studied sample was mainly homogenous in the range of values of the coefficients of variation cV% at the level of 4.04% for the variable V_maxiskok, and up to 29.18% for the variable V_ L_{BKICK}RFD_30s, which proves that the group of examined water polo players was homogenous in relation to the physical characteristics measured. Generally, it could be stated that the studied sample was homogenous regarding morphological and motor characteristics. Thus, it could be claimed that the sample was reliable for drawing conclusion and representative in relation to the population of junior water polo players.

Table 1 The basic descriptive data of the sample

	N	Mean	SD	cV%	Min.	Max.
A_BH (cm)	29	185.15	.25	2.83	175.90	196.50
A_BW (kg)	29	81.71	7.67	9.38	70.40	93.90
A_BMI (kg•m^{-2})	29	23.69	2.14	9.03	19.40	28.70
A_Fat (%)	29	9.05	3.87	42.73	2.30	18.20
V_$L_{EGGKICK}$ (m/s)	29	0.95	0.06	6.26	0.85	1.07
V_L_{BKICK} (m/s)	29	1.05	0.07	6.68	0.88	1.19
V_VRTkg_1s(kg)	29	42.55	23.27	54.68	20.92	103.81
V_VRTkg_5s(kg)	29	15.56	6.33	40.71	8.03	37.51
V_VRTkg_15s(kg)	29	7.97	2.74	34.38	4.17	18.72
V_VRTkg_30s(kg)	29	5.26	1.69	32.22	2.76	12.08
V_$L_{EGGKICK}$Fmax_30s (N)	29	157.46	19.93	12.66	117.96	200.23
V_$L_{EGGKICK}$ ImpF_30s (Ns)	29	45.43	10.64	23.41	20.33	63.46
V_$L_{EGGKICK}$ RFD_30s (N/s)	29	337.85	80.73	23.89	201.56	498.89
V_L_{BKICK}Fmax_30s (N)	29	227.18	49.17	21.65	145.99	350.24
V_L_{BKICK}ImpF_30s (Ns)	29	55.99	14.59	26.06	20.33	94.72
V_L_{BKICK}RFD_30s (N/s)	29	545.47	159.15	29.18	292.69	926.47
V_maxiskok(cm)	29	148.21	5.99	4.04	137.00	160.00

The results of the correlation analysis are presented in Table 2. The average maximum height of the vertical in-water jump was 148.21±5.99 cm with a range of 137.00 cm, as a minimum value of the maximal height, and up to 160.00 cm, as the maximum value. The analysis of the results has shown that the height of a jump, i.e the reach height, is statistically significantly correlated with: swimming velocity V_$L_{EGGKICK}$ (r=0.396, p=0.033), V_L_{BKICK} (r=0.535, p=0,003), endurance in the vertical position V_VRTkg_5s (r=0.379, p=0.043) and V_VRTkg_15s (r=0.374, p=0,046) and the characteristics of the drag force of the breaststroke leg kick only V_L_{BKICK}Fmax_30s (r=0.632, p=0.000), V_L_{BKICK}ImpF_30s (r=0.547, p=0.002) and V_L_{BKICK}RFD_30s (r=0.470, p=0.010).

Table 2 The correlation of the studied variables in water

	V_max iskok	V_NB	V_NP	V_VRT kg_1s	V_VRT kg_5s	V_VRT kg_15s	V_VRT kg_30s	V_NB Fmax	V_NB ImpF	V_NB RFD	V_NP Fmax	V_NP ImpF	V_NP RFD
V_maxiskok	**1**												
V_$L_{EGGKICK}$	**.396 .033**	1											
V_L_{BKICK}	**.535 .003**	**.871 .000**	1										
V_VRTkg_1s	.357 .057	**.563 .001**	**.628 .000**	1									
V_VRTkg_5s	**.379 .043**	**.575 .001**	**.620 .000**	**.955 .000**	1								
V_VRTkg_15s	**.374 .046**	**.544 .002**	**.567 .001**	**.830 .000**	**.957 .000**	1							
V_VRTkg_30s	.352 .061	**.494 .006**	**.501 .006**	**.691 .000**	**.872 .000**	**.976 .000**	1						
V_$L_{EGGKICK}$Fmax_30s	.351 .062	.136 .481	.073 .705	.112 .563	.134 .488	.144 .455	.144 .455	1					
V_$L_{EGGKICK}$ImpF_30s	.189 .325	.052 .790	-.074 .704	-.069 .722	-.097 .617	-.117 .546	-.125 .517	**.648 .000**	1				
V_$L_{EGGKICK}$RFD_30s	.088 .650	-.032 .870	.074 .705	.223 .245	.232 .225	.229 .232	.218 .257	.244 .202	**-.452 .014**	1			
V_L_{BKICK}Fmax_30s	**.632 .000**	**.471 .010**	**.544 .002**	**.378 .043**	**.441 .017**	**.473 .010**	**.473 .010**	**.544 .002**	**.372 .047**	-.058 .766	1		
V_L_{BKICK}ImpF_30s	**.547 .002**	.361 .054	**.449 .014**	.149 .440	.150 .437	.144 .456	.134 .489	**.394 .034**	**.441 .017**	-.266 .163	**.831 .000**	1	
V_L_{BKICK}RFD_30s	**.470 .010**	**.541 .002**	**.544 .002**	**.381 .042**	**.465 .011**	**.502 .006**	**.498 .006**	**.558 .002**	.286 .132	-.028 .887	**.834 .000**	**.560 .002**	1

DISCUSSION

Based on the descriptive indicators of the anthropometric variables included in this study (Table 1), we may conclude that the sample of participants was extremely homogenous, which has been proved in a comparison with the results of studies published by other authors (Stirn, Strmecki, & Srojnik, 2014; Kondric, Uljevi, Gabrilo, Kontić, & Sekulić, 2012). A trend of the physical development of the participants, their anthropometric characteristics (body height and body weight), the analysis of their body status followed the structure in comparison with the results obtained by other authors (Lozovina & Pavičić, 2004; Aleksandrovic, Radovanovic, Okicic, & Madic, 2005) the motor characteristics of leg kicks in water also confirmed that the sample was homogenous. The level of velocity characteristics, kinetic characteristics, the results of maximum endurance in the vertical position and the height of the maximum vertical jump also followed the trend of the development expressed by the results in relation to age, which also corresponds to the results of other authors (Dopsaj et al, 2003; Dopsaj, Matkovic, Thanopoulos, & Okicic, 2003; Platanou, 2006; Dopsaj, 2010[b]; Kondric et al, 2012; Stirn et al., 2014).

In relation to the parameters of maximum endurance in the vertical position, the results of the previously published studies have shown that among elite water polo players aged 19.3±2.6 years, BH=1.914±0.048 m and BM=88.2±7.5 kg, the level of preparation was 36.43±12.17 kg for the time interval of 30 s (Dopsaj et al., 2006[b]). The same study has determined that the correlation coefficients were the highest exactly in the intervals up to 10 s, where they exceeded the value of 30%. This only proves the fact that the variability of physical ability, i.e. the preparedness of water polo players is the greatest in relation to the anaerobic and alactate zone of strain, so that a high coefficient of variation may be accepted as a methodological characteristic, and not as the inhomogeneity of the sample. In addition, it must be emphasized that the results of the loads for keeping afloat on the water surface in the vertical position during intervals of 5, 15 and 30 seconds, were 2.34, 3.52 and 4.55 times greater than those of the participants examined in this study (15.56 vs 36.43, 7.97 vs 28.08 and 5.26 vs 23.95 kg, for 5, 15 and 30 seconds). The given difference is the result of different measuring methods, where in this study the players maintained a vertical position by using their legs, since their arms were outstretched, whereas in the study of (Dopsaj et al., 2006[b]), the players maintained the same position with both their arms and legs. The difference is obviously the result of a much more efficient technique, in terms of achieving higher scores as a result of the greater thrust for keeping a float on the water surface during the movements of both the arms and legs, than only those of the legs.

In relation to the parameters of the vertical jump, the results of the previously published studies have shown that elite water polo players of an average age of 22.9±2.1 years, on the test of the vertical in-water jump (Platanou, 2006) achieved the absolute maximum average height of 148±6.8 cm, with a range of 133 of the minimum height, up to 161.5 cm of the maximum height. By comparing the results of these two studies, it may be concluded that the results achieved by the young water polo players were almost identical to the results of the previous study, which indicates the exceptionality of the studied sample.

The leg kicks measured in various positions were cyclic (the breaststroke technique), and alternating (“eggbeater leg kick” technique). In measuring the vertical jump, the combination of alternating and simultaneous leg kicks at the time of the push off was applied. If we are to describe precisely the vertical in-water jump, it should be pointed out that it is a short-term maximum movement performed by water polo players in the water. The mechanism allowing a jump is certainly a strong breaststroke leg kick in water, which should enable the performance of the technique. When performing the technique of the vertical in-water jump, a water polo player does not have a firm support for take-off, which means that the player has to “create a point of support” (Gatta, 1992). In order to perform a quality vertical jump, it is necessary to, after the alternating movements of the legs, the eggbeater leg kicks in a short moment of time, kick simultaneously with both legs in order to generate the force which will enable the vertical jump. Such a leg kick in the water is not often regular, and we cannot call it a breaststroke leg kick to the full extent. However, it is, still, closest to this technique from the biomechanical point of view. Although the leg kick enabling a vertical in-water jump is not regular, the results have shown that the variable of the average maximum vertical in-water jump V_maxiskok is statistically significantly correlated with almost all the variables at a level higher than $p \leq 0.05$, and with the variable of the average maximum force (F) of the breaststroke leg kick $V\_L_{BKICK}Fmax\_30s$, which is statistically significantly correlated at the level higher than $p \leq 0.01$ (Table 2, r=0.632, p=0.000). However, with the variables describing the maximum kinetic characteristics of the alternating leg kick in the water eggbeater leg kick ($V\_L_{EGGKICK}Fmax\_30s$; $V\_L_{EGGKICK}ImpF\_30s$; $V\_L_{EGGKICK}RFD\_30s$) there was no statistically significant correlation. (Bratusa & Dopsaj, 2012[a]), in their pilot study, at the initial level, defined the relation between the kinetic characteristics of the drag force of the breaststroke leg kick technique in the water in place (30 seconds) and the maximum height of the vertical in-water jump. The results of that study have shown that the maximum height realized during a vertical in-water jump among elite junior water polo players statistically significantly depended only on the absolute values of the characteristics of drag force (30 s) at the level of 34.48% of the explained variance. The unexplained variance of 65.52% most likely depends on the technique of the vertical jump and other morphological and functional characteristics of a player.

The skill of maintaining a vertical position represents the ability to generate buoyancy force, that is, during the preparatory phase of the vertical jump with the movement of both the arms and legs, and during the final phase of the jump with the leg kicks. When the technique of the vertical jump only is studied, i.e. the efficacy of a simultaneous leg kick, it should be pointed out that it depends on the volume of the fluid grasped, which represents a mass of the support against the water, and which is determined as a relative amount dependent on dynamic and kinematic parameters (the trajectory - the route of movement) of the foot-lower leg-thigh system. If, in performing the technique, a great force is applied in a short period of time, and a large amount of water is buoyant at the same time, the technique will be more effective (Sanders, 1999). In order for a player to thrust a great amount of water with his legs and generate extra drag force which is, during the upward movement, transformed in reactive force and lift force, the assumption is that in addition to the optimum force affecting the water mass, the player must have optimum movements of the working segments, i.e. he must have well-developed elasticity of the hip joint, knee joint and ankle joint (Maglischo, 1993). Accordingly, in order to perform the technique of the maximum vertical in-water jump efficiently, in addition to the ability of the leg agonist muscles to develop a greater level of muscular force, an adequate technical performance is also required.

In addition to the kinematic features of the legs, above all, the maximum average force Fmax, as it has already been emphasized, the velocity of stretching the legs, the variable of the maximum velocity of swimming only the breaststroke leg kicks V_L_{BKICK} plays an important role in the performance of the technique which is, again, a dominant result of the kinematic characteristics (Fmax, ImpF and RFD).

Although the variable of the maximum vertical in-water jump V_maxiskok does not correlate statistically significantly with either the kinetic variable of the alternating leg kick – eggbeater leg kick, the alternating leg kick is one of the basic techniques in the sport of water polo (Stirn et al., 2014; Bratusa, 2015). As such, the alternating leg kick does not have a direct effect on performing the vertical jump, but the technique of the alternating leg kick is a basic technique of the preparation of the position for the jump, the stabilizer of the body, and it provides the necessary optimum support against the mass of water before and after the jump technique itself. It directly enables positioning of the gravity of the body in an optimum position and on the level for quality technique performance. After the jump, it maintains the body – the center of gravity of the body - at the level necessary for the quality continuation of the vertical movement, i.e. the action of the jump and maximum vertical reach. The correlations between the vertical jump V_maxiskok and endurance with a load of 5 and 15 seconds– V_VRTkg_5s and V_VRTkg_15s, and the limit values of endurance in the vertical position with a load of 1 and 30 seconds (V_VRTkg_1s where r=0.375 p=0.057 and V_VRTkg_30s where r=0.352 p=0.061) exactly proves that the alternating movements of legs in the water – the eggbeater leg kick, is one of the basic techniques in water polo necessary for performing any other related leg kick technique, regardless of whether they are directly or indirectly linked technically and in a combination of movements or not.

5. Conclusion

The results of this study have shown that the explosive characteristics of the breaststroke leg kick (Fmax, ImpF and RFD) when swimming in place, the maximum velocity of swimming the breaststroke leg kick and eggbeater leg kick, as well as the endurance with the maximum load in a vertical position of 5 and 15 seconds of the eggbeater leg kick statistically significantly correlate, i.e. they have a positive impact on the performance of the vertical in-water jump. It may be concluded that a quality vertical jump requires an explosive breaststroke leg kick in order to achieve a quality and efficient realization of the technique. However, it being just a part of the factors affecting the vertical jump, it is necessary that the junior players, in addition to an adequate preparation of the breaststroke leg kick – as a form of symmetrical and simultaneous movement of leg stretching, are adequately technically trained in relation to the technique of the eggbeater leg kick, but also have adequately developed elasticity of their legs, i.e. their elasticity should provide the maximum efficacy of the performance of the vertical jump technique .

The practical significance of this research exactly stems from the awareness that in addition to physical preparedness, the development of the contractive ability of the leg extensors - explosivity, at the same time, they should work on the development of elasticity, which should enable quality training of the dominant techniques important for efficient specific movement in water polo.

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UTICAJ RAZLIČITIH TEHNIKA UDARCA NOGAMA NA VERTIKALNI ISKOK VATERPOLISTA

*Vertikalni iskok iz vode je veoma važan element u igri. Efikasan istovremeni udarac nogama u vodi trebalo bi da predstavlja osnovu za kvalitetno izvođenje tehnike vertikalnog iskoka. Osnovni cilj ovog rada je definisanje relacije između karakteristika sile vuče nogama tehnikom prsno i tehnikom bicikl u vodi i dohvatne visine vertikalnog iskoka iz vode. Uzorak ispitanika je sastavljen od 29 vaterpolista juniora prosečne starosti 15.8 godina. Rezultati su podvrgnuti deskriptivnoj statistici i korelacionoj analizi. Maksimalna visina vertikalnog iskoka snimana je video kamerom. Karakteristike sile definisana je sa tri varijable posebno za udarac nogama prsno i posebno za udarac nogama bicikl: prosečna maksimalna vrednost sile, prosečni maksimalni impuls sile vuče i maksimalna eksplozivna sile vuče. Prosečna dohvatna visina iskoka je bila 148.21±5.99 cm. Rezultati su pokazali da najveću statistički zn*č*ajnu korelaciju ima sila vuče udarca nogama prsno u vodi, skoro 99,0%.Karakteristike sile udarca nogama bicikl u vodi nisu pokazale statistički značajnu korelaciju sa tehnikom vertikalnog iskoka, ali brzina udarca nogama bicikl u vodi statistički značajno korelira sa izdržajem u vertikali od 5 sekundi i od 15 sekundi sa opterečenjem, kao priprema za izvođenje vertikalnog iskoka iz vode vaterpolista juniora.*

Ključne reči: *noge prsno, noge „bicikl“, udarci nogama, vertikalni iskok*