PHYSIOLOGICAL DIFERENCESS BETWEEN TOP ELITE AND ELITE WATERPOLO PLAYERS

Kemal Idrizović[1], Drago Milošević[1] and Ratko Pavlović[2]

[1] Faculty of sport and physical education, University of Montenegro
[2] Faculty physical culture and sport, University East Sarajevo

Original scientific paper

Abstract
The aims of this study were to establish the physiological attributes of top elite (the second position on the World Championship in Barcelona 2013) and elite (the fourth position in The Adriatic league in season 2012/13) male water polo players, and to determine whether these attributes discriminate top elite players from elite players. Measurements and tests of basic anthropometry (body hieght, body mass, BMI, arm span, leg length), and specific motor abilities, swimming speed, throwing velocity and maximal force capacity were conducted on two occasions, separated by one day. A total of 22 water polo players, 11 top elite and 11 elite (24.26±2.78 vs. 21.83±2.67 years of age) participated in this study. Of all applied tests and measures, they statistically significantly differed only in the results of two specific motoric tests: throwing velocity (78.81±3.84 vs. 71.27±4.29 km/h, $p<0.01$) and test of maximal force capacity (46.72±6.13 vs. 40.38±3.79 kg, $p<0.01$). This study revealed that the main differences between top elite and elite water polo players are in abilities of maximum shot velocity and the production of a maximum force. The results therefore identify important factors for elite players to improve in the transition phase from elite to top elite level.

Key words: *anthropometry, motor abilities, differences, water polo*

Introduction

The history of water polo lasts more than 150 years. During this period, this play has significantly changed and developed to the present level, which makes water polo one of the most interesting sport games. Since the number of countries where the top water polo is played is a relatively small (Hungary, Serbia, Italia, Montenegro and Spain), the popularity of this sport on the global level is a little weaker than other sport disciplines. This also can be a reason why in bases there is a smaller number of studies carried out on water polo compared to sport games such as football, basketball, handball or volleyball. Regardless of such facts, water polo develops as a game and the need for new researches is ever growing. For one and a half of century, the functional game demands of water polo players have incomparably grown so, as the time elapsed, physiological and playing profiles experienced big changes. So far, all this have made water polo one of most complex sport games nowadays. The game (water polo) has as its roots the aquatic festivals, called galas, which were held in the English resort towns in the mid-1800's. In order to attract more spectators the festivals included a rugby-style game which involved a submersible ball. The name is the only connection between water polo and the horse version, as polo was derived from the East Indies word "pulu" which means ball. The first "pulu" ball was made of Indian rubber (Smith, 1990). In the following period, such a figured out game will experience big number of changes and adaptations, during which it would be called with various names such as "water hand-ball", "aquatic football", "water rugby", and a dilemma about the name would be finished by the present name.

For all this time, the development of water polo as a sport game would flow and this lasts also in these days. Water polo is today a game that captures a number of different facets of some of the more popular sports in world culture. To visualize the sport, combine the dual skills of swimming and ball handling and, add to it the physicality and power play opportunities of hockey, the fast break opportunities and passing of basketball with the pivot (center) position, and the penetration and goalie play of soccer. Water polo players typically swim over 1.5 miles (2414 m) in a game (Snyder, 2008).

A panel of eight exercise physiologists ranked water polo highest in athleticism when comparing it to badminton, baseball, basketball, cross-country, football, golf, soccer, softball, swimming, tennis, track and field, volleyball, and wrestling. This ranking included measures for aerobic endurance, agility, anaerobic endurance, body composition, quickness, skill, speed and strength (Ludovise, 1991). Game like water polo is a vary stressful body-contact team sport that combines high-intensity short duration efforts such as swimming at maximum speed, elevation of the body from the water, and throwing, with rest or low-intensity actions (Tan et al., 2009). Water polo makes large demands on aerobic and anaerobic systems. The variety of work involved in the game for field players can be broken down as roughly 50-60% aerobic, 30-35% anaerobic, and 10-15%, immediate energy (ATP) system (Smith, 1998). Water polo players' heart rates have been measured in excess of 150 beats per minute for 91.8% of actual playing time (Pinnington et al., 1987).

On the other hand, water polo players blood lactate levels have been measured at a range of 7-9 mmol/l for elite male players. Each of individual activities, which a water polo player performs during the game, is itself a very demanding in a physiological sense. The entire system of all these activities makes water polo a sport game, which, because of this, has a very complex and difficult training processes of conditioning character. Exactly these trainings in concrete terms depend on an entire physiological burden which is placed by a water polo playing. Physiological measurements obtained during game play indicate a cumulative effect of the repeated sequences of activities and suggest there is a high metabolic demand on the athletes. The multiple individual skills and movements required for playing water polo also place considerable demands on the neuromuscular system. Observations of the frequency and duration of the different activities, and of the physiological responses to participating in a water polo match, are initial sources of information for designing training programmes specific to the game and to the different playing positions (Smith, 1998). Beside these information, those information defining the differences in profiles of top players in comparison to water polo players of lower level are designated as the very important. This is shown as a particularly important in case where it is necessary to differentiate top elite from elite level, namely which are characteristics determining the difference between the best world players and those who are positioned at a level beneath them. Are these differences, which undoubtedly exist, of functional-motoricity type or technically-tactical type? Can these differences be found within morphological characteristics, because some previous studies have discovered the existence of these differences between player's positions (Lozovina et al., 2009)? Can these differences be detected at all, or are they hidden in the specificities of each variable individually applied? On the basis of such a problem the main goal of this research is determined and it has an intention to determine differences between top elite and elite water polo players in their basic anthropometric and specific-fitness characteristics. As an additional goal of this study, a determining of profiles of top elite and elite water polo players, within the applied anthropometric indicators and sport-specific abilities is designated.

Methods

Subjects

The sample of examinees for this research consisted of 22 Montenegrin water polo players, 16.83 to 29.66 years old, with the playing experience for 6 to 16 years. They were divided into two groups with 11 examinees (field players only). The sample of 11 top elite water polo players was created of members of Montenegrin national team (24.26 ± 2.78 years), which, in last five years, have been the champions of Europe, once won the second position in Europe, then they were the winners of World league, two times the fourth at the Olympic Games, while the majority of members of Montenegrin national team were the members of teams which have been the winners of LEN Champions league in last ten years. The sample of 11 elite players was made of Water Polo Club Budva m-tel players (21.83 ± 2.67 years), which competes in Adriatic Water Polo League, which is probably most quality league in the world, for several years. The participants read and signed statements of informed consent before participants in the study.

Experimental Approach to the Problem

The study was performed in two phases during two last weeks of March of 2013. The first phase was performed during last two matches of Montenegrin national water polo team in the framework of qualifications for World league in water polo 2013 (where Montenegro, in the group with Croatia, Greece and Turkey, won the first position winning all six matches), and which also was a part of preparation for 15th FINA World Championship in Barcelona. During two days, firstly anthropometric and then, on the second day, functional motoric testing were carried out. The second part of testing, which was carried out in an identical way as the previous, was related to the testing of players of Water polo Club Budva, and it was carried out in approximately the same time interval, as the previous measurement, and during which the players would be in a standard competition training program in the framework of Adriatic Water Polo League matches.

Variables

Measuring of anthropometric characterstics was performed by trainied and experienced investigators according to the International Biological Program (Weiner and Lourie, 1969). The subjects were measured in the early morning during a single session. Unilateral measurements were taken on the right side of the body. The participants wore „light clothing" but no shoes.

Anthropometric characteristics were measured in the following order: body height, body mass, arm span and leg length. Anthropometric equipment used included anthropometer and weighting scale. The body height and body mass were assessed using a Seca stadiometer and weighting scales (Seca Instruments Ltd., Hamburg, Germany). In addition, body mass index was determined. Body mass index (BMI) or Quetelet index was calculated from dody height and body mass values using following formula: BMI = weight (kg) / height (m²). The water-polo-specific fitness was evaluated by: swimming sprint over a 20 metre distance, a water polo drive shoot test and dynamometric semi-tethered force test. The swimming sprint test over a 20 metre distance (20M) was commenced upon a sound signal, similar to sprinting for ball possession at the start of a game. The head was kept out of the water during the test (water polo front-crawl).

The subjects started in the water from either a front-on or side-on position. Their head remained behind the laser beam which marked the 0-metre starting point. When signalled, the subjects swam as fast as possible for 20 metres. A Longines swimming timing apparatus was used. Throwing velocity was measured by a drive-shoot test (SHOOT). Each subject was instructed to lift the ball from the water surface and throw it into a goal net as fast as possible. The examiner was positioned with a velocity-detecting radar (Speedster Radar Gun (Bushnell, Overland Park, Kansas, USA) behind the net. The semi-tethered dynamometric test (DYN) consisted of maximum intensity upright swimming using an eggbeater kick with a fast elastic line fixed to a special belt. An 'eggbeater kick' is a hands-free form of treading water that allows a swimmer to remain vertical and/or move in a vertical position. An athlete's legs mainly alternate between one-legged breaststroke kicks. This form provides continuous support because there are no breaks in the kick. The swimming force was recorded with the use of a tensiometric dynamometer coupled to a MAX-5 device (JBA Staniak, Poland) via a WTP 003 amplifier and Max 5.1 computer software. The subjects were instructed to perform the eggbeater kick as hard as possible and to achieve the maximal possible drag force. The maximal force achieved was recorded by the examinees and included in the data analysis.

Statistical Analyses

Descriptive statistics (minimum, maximum, mean, standard deviation) were calculated for all applied variables, by help of which a morphologic and specific motoric profile was determined. This study used a quasi-experimental, cross-sectional approach to examine the differences between anthropometric characteristics and specific fitness abilities top-elite and elite water polo players. Prior to the analysis data were tested for normality of distribution. Since it was not ascertained, a non-parametric test for two independent samples, Mann-Whitney U test of ranking sum, was applied. The $p \leq 0.05$ criterion was used for establishing statistical significance. All statistical analyses were conducted using version 21.0 of the Statistical Package for the Social Sciences (SPSS, 2012).

Results

However, in table 3, where the results of Mann-Whitney test are given, by application of which a statistical significance of differences in anthropometric characteristics and specific motoric tests of top elite and elite water polo players, it is possible to find only two statistical significant differences between these two levels of water polo players. Therefore, top elite and elite water polo players, in the space of five anthropometric indicators and three specific motoric tests, statistically significant differ in only two specific motoric tests, drive-shoot, performance and maximal dynamometric force achieved throughout eggbeater kick.

Discussion

Regardless of the fact that physical (strength, power throwing velocity) and anthropometric factors are very important for a final score in water polo (Alcaraz et al., 2012), namely that water polo demands a very high level of physical condition (McCluskey et al., 2010) and that an anthropometry is one of a key aspects in elite water polo (Norton and Olds., 2001), they are still not entirely defined an researched through the profiles of water polo players of different qualitative level, or their mutual differences. This statement particularly attains its significance when total changes in water polo game and its continual change in sense of movement speed, number of repetitions of some movements and strength manifestations are taken into account. According to our knowledge, this study is the first research where the basic anthropometric indicators and results on specific motoric tests among top elite and elite water polo players are compared. An additional significance to this study is given by the fact that top elite and elite water polo players were compared, beside the rest, in a throwing velocity which is one of most important aspects of total performances of water polo players (Smith, 1998, Van der Wende, 2005). An increased throwing velocity reduces the time in which the goalkeeper may detect the path of the ball and deflect (Bloomfield, 1990). This is undoubtedly a strong reason because of what the authors often dealt with this very important water polo playing quality (Davis and Blanksby, 1977; Elliott and Armour, 1988; Whiting et al., 1985; Feltner and Nelson, 1996; Ferragut et al., 2011; Alcazar et al., 2012). Beside a throwing velocity, exceptionally significant specific motoric abilities, such as swimming velocity (water polo front crawl) and maximal produced force in water, also were the topic of this research. We came to an importantly significant and interesting data, whose value will especially be shown in the support to future scientific works. First of all, regardless of visible differences in numerical values of measured anthropometric indicators of top elite and elite water polo players, given in tables 1 and 2, neither of these differences has not been shown as a statistically significant one (table 3). Such a result enables the statement that top elite and elite players between themselves have certain differences in basic morphologic indicators, but these differences are not on a significant level. In other words, of two water polo players of the same motoric qualities and tactically-technical knowledge, a higher probability to finds his position between top elite players will have the one whose values of anthropometric indicators applied in this work are on a higher level. Kondrič et al. (2012), in their recent study, comparing their results with the results by Ferragut et al (2011), which, among the rest, studied an anthropometric profile of Spanish elite water polo players, ascertained that Croatian elite junior with a bigger height and arm span are at positions wings, points and centers.

Table 1: Descriptive statistics of top elite water polo players

	Mean	Std. Dev.	Min	Max
Body height (cm)	189.22	5.62	180.00	199.00
Arm span (cm)	195.34	6.23	185.90	203.00
Leg length (cm)	103.04	4.35	97.00	110.70
Body mass (kg)	96.65	10.96	84.30	120.00
BMI (kg/m²)	26.97	2.49	24.60	33.20
20M (s)	10.89	.35	10.40	11.73
SHOOT (km/h)	78.81	3.94	71.00	82.00
DYN (kg)	46.72	6.13	40.00	58.00

BMI – body mass index; 20M – sprint swimming over 20 meters distance; SHOOT – drive shoot performance; DYN – maximal dynamometric force achieved throughout eggbeater kick

Table 2: Descriptive statistics of elite water polo players

	Mean	Std. Dev.	Min	Max
Body height (cm)	186.36	3.79	180.20	192.00
Arm span (cm)	191.99	4.18	183.40	198.10
Leg length (cm)	100.47	4.07	94.00	104.80
Body mass (kg)	89.42	7.17	79.20	100.80
BMI (kg/m²)	25.76	2.20	22.80	30.70
20M (s)	11.18	.49	10.48	12.05
SHOOT (km/h)	71.27	4.29	65.00	78.00
DYN (kg)	40.38	3.79	36.00	49.00

BMI – body mass index; 20M – sprint swimming over 20 meters distance; SHOOT – drive shoot performance; DYN – maximal dynamometric force achieved throughout eggbeater kick

Table 3: Differences between top elite and elite water polo players - (Mann-Whitney U-test)

	Sum of ranks TE	Sum of ranks E	Mann-Whitney U	Z	p-level
Body height (cm)	147.00	106.00	40.000	-1.346	.178
Arm span (cm)	148.00	105.00	39.000	-1.412	.158
Leg length (cm)	142.00	111.00	45.000	-1.018	.309
Body mass (kg)	150.50	102.50	36.500	-1.576	.115
BMI (kg/m²)	143.00	110.00	44.000	-1.085	.278
20M (s)	103.00	150.00	37.000	-1.544	.122
SHOOT (km/h)	175.00	78.00	12.000	-3.208	.001
DYN (kg)	171.00	82.00	16.000	-2.932	.003

BMI – body mass index; 20M – sprint swimming over 20 meters distance; SHOOT – drive shoot performance; DYN – maximal dynamometric force achieved throughout eggbeater kick

Table 1 gives the basic statistical parameters (arithmetic mean, standard deviation, minimal and maximal results) for anthropometric indicators and specific motoric tests which were applied in this study about top elite water polo players, namely of players Montenegrin national water polo team. Comparing these values with values from table 2, where the same data are summed up for players of Water polo Club Budva m-tel, it is possible to state that these values are bigger for all applied anthropometric indicators. Therefore, the water polo players of Montenegrin national team, top-elite water polo players, are higher, have bigger arm span and longer lower limbs, and they have bigger body masses in comparison to elite water polo players. On the other side, the results of specific motoric tests whose basic statistical parameters for top-elite water polo players are also given in table 1, and for elite water polo players in table 2, say that, during these tests, top elite players faster swum, accomplished a bigger maximal force and have a bigger shot velocity. On the other side, Kondrič et al. (2012) argue that the values of body mass and BMI are bigger in Spanish seniors compared to elite Croatian juniors, for which Kondrič et al. (2012) found a bigger level of a skin folds. Considering both mentioned studies from the standpoint of this research, it interesting to note that for water polo players of Montenegrin national team (top elite) the values higher than for water polo players of Spanish national team are ascertained in all estimated anthropometric indicators (Vila, et al., 2009; Ferragut et al., 2011). Also, members of Montenegrin national team have bigger values of all anthropometric indicators compared to members of Croation junior national team, while elite water polo players from this work, players of Water Polo club Budva, have approximately same applied anthropometric indicators as Croatian elite juniors. On the other side, in the research by Lozovina et al., (2009), water polo players of Croatian first league have bigger body heights (3.04 cm) and smaller body masses (3.03 kg) than their Montenegrin coleagues, while they are 5,86 cm higher and 4.2 kg heavier than the participants of Adriatic Water Polo League. Also, members of Montenegrin national team from this study have bigger body heights (4.72 cm) and body masses (5.95 kg) than their Greek peers

from the study by Tsekouras et al., (2005), while the elite water polo players from this work have bigger body masses (1.86 cm) and bit lesser body masses (1.28 kg) than members of Greek national team. Opposite to all mentioned data from this and previous studies, the findings by Canossa et al., (2011) significantly derogate and there the members of Portuguese national league have significantly smaller values of all mentioned parameters than the water polo players from other studies. Stated differences between water polo players from different contexts are evident and, as such, these are the results of works of water polo schools, namely their selection systems. A very close results of Montenegrin and Croatian water polo players can be explained by the fact that both national schools, and thence a way of selection of top water polo players, have roots in former, exceptionally successful, Yugoslavian school because both schools were parts of it. This statement is directly ascertained by the results of study by Dopsaj and Aleksandrovic (2009), where the members of Serbian national team, also a member of Yugoslavian school, accomplished very similar values. Differently it can be said that the morphological profiles of top elite water polo players in this and other studies are actually the result of selection as an important characteristic of all water polo school, and whose end result is actually the players of national teams of these countries. Generally analysed, the morphological indicators have significantly risen during last decades (Lozovina et al., 2012) and, as such, they undoubtedly can be considered as an important element of the profile of contemporary top elite water polo player. However, it should be noted that almost identical values of body height of top elite Montenegrin water polo players possessed by Hungarian and American water polo player, and their values were measured in works of Whithing et al. (1985) and Mészáros et al. (1988). In the space of specifical motoric tests (swimming velocity, shod velocity and maximal force), by help of which specific fitness qualities of top elite and elite water polo players are estimated, are detected in the part of a shot velocity and a maximal produced force, while at the test of a swimming velocity these differences were not observed. Such results have a very big weight and significance. Let us see, what is the matter with it. The water polo shot is a unique skill in which the player attempts to score a goal by throwing the ball as fast and accurately as possible at the goalie (Alexander et al., 2010). If we take into account that a throwing velocity is a movement activity of speed-strenght type and, as such, it first of all, depends on the level of the presence of fast muscle fibres, level of maximal strength, quality of inter and intramuscular coordination, coordination of the movement of various body parts (hands and shoulder belt, torso, lower limbs), and on the level of a specific technique, namely the ball catch and shot accuracy and, finally, the concentration and the ability of duly exploitation of speed-strength abilities and their direction to water polo ball, it can be concluded that the ascertained differences in shot velocity are not only in this potential but in all those functional-motoric qualities that synergetic act during the same activity as the water polo shot is. The speed of a fast shot in water polo for highly skilled players can reach up to 22 m/s, which is close to 80 km/h or 50 mph (Ball, 2005, according Alexander et al., 2010), that are almost identical values with those for top elite Montenegrin water polo players. One of the basic mechanic factors influencing the shot velocity is a path length during which the ball is under an action and exposed to a constant acceleration. The bigger an absolute strength of a water polo player the bigger an acceleration and one of positive factors of absolute strength is also player's body mass. These argument can be taken into account for the explanation of bigger shot velocity of members of Montenegrin national team compared to those of Spanish national team (Vila et al., 2009; Ferragut et al ., 2011), which had this anthropometric indicator on the smaller level. Abraldes et al., (2012) analysed a shot velocity during water polo matches at European championship in Malaga, Spain, discovered maximal values that are smaller than the values of listed for top elite water polo players in this study, and it is very interesting that just on that championship Montenegrin water polo players won the gold medal. As the same players are in a question, it can indirectly be drawn a conclusion that water polo players during matches do not attain its top shot velocities. Thence, in a study by Arables et al (2012) the biggest average shot speed was recorded, a which is 4.44 km/h smaller than a the velocity measured in this research. The greater speed reached was in the shot without goalkeeper, when a tactical situation is included, the speeds have been smaller (Van der Wende, 2005). The smaller average values of a peak shot velocity were also recorded by the members of American national team in the study by Whiting et al. (1985). The second detected difference in this research is related to the first level of the production of a maximal force of top elite and elite water polo players. If the basic factors of the production of maximal force in a specific water polo test are determined, it can be seen than, except a maximal force, the technique of movement of water polo player (eggbeater kick) in water during such a test is also exceptionally important, and, therefore, an ability of full use muscle system. More precisely, for the accomplishment of a good result at this test, not only is it necessary to possess a high level of maximal strength, but also compulsory specific movement knowledge which will enable the exploitation of this ability. In this study, Sanders (1999) says that in water polo, duel play is the player's basic position in both the offense and the defense. The position essentially enables players to block the opponent by holding their arms so as to perform the TE-TA elements, using the eggbeater kick technique simultaneously Essentially, the eggbeater kick is also used to raise the upper body for the purpose of receiving a pass, passing, shooting for goal, or blocking the

opponent's shooting, passing or receiving actions. The eggbeater kick is a cyclic action of the lower limbs with the actions of the right and left sides being similar but opposite in phase, meant to sustain the body in the elevated position or to push the opponent's body strongly. Regardless of the importance of such a movement, Dopsaj (2010) argues that so far no research has published studies of the pulling force characteristics realized in water and by eggbeater kick techniques within the effort system which is dominant in competitions. Better results that top elite water polo players accomplished in relation to elite ones, indicate, as in case of shot velocity, to the much more complex differences between these two levels of water polo players than it is shown only by results on these two tests. This additionally explains, although small at a first look, but actually a very complex difference between elite and top elite water polo players, which was ascertained in this research. In other words, it can be said that a shot velocity and the production of maximal force are only final manifestation of much more complex differences in physiological processes, that are in the base of such movements.

Conclusion

Beside morphologic characteristics, most representative indicators of characteristics or water polo players are the results on specific motoric tests. These depict the potentials representing a final physiologic reach in the adaptation (of each water polo player individually) onto characteristics of a sport discipline as water polo is. The main goal of this research was to detect the possible differences exactly in the basic morphological characteristics and specific motoric abilities of top elite and elite water polo players. Since these are very close qualitative levels of water polo game, it is obvious that found differences have a very big importance for all future research of such, or similar topic. Also, in the process of selection of younger promising water polo players, the results of this research will be of a great help when it is necessary on the basis of safe criteria, chose a young water polo player among other players having approximately the same characteristics and qualities like him. This study ascertained that top elite and elite water polo players do not differ statistically important in the space of the applied anthropometric indicators (body mass, body height, arm span and body mass index). The abilities of shot velocity and the production of maximal force determined the same, but very important differences of these two groups of water polo players. It is important that stated statistically significant differences in the test of swimming velocity are not found, what is, although it is standard activity in water polo, in relation to two other specific motoric tests less specific. In that way, one can make a conclusion that, on a top level, are "nuances" making a difference between top elite and elite water polo players, namely in a very complex structure of specific functional motoric abilities, that water polo as a sport demands. The differences between top elite and elite water polo players, identified by this study, certainly are not the only ones and these probably also exist in the space of tactical-technical skills, however, since it was not the topic of this study, there remains a possibility that in the next researches these option will be researched.

References

Alcaraz, P.E., Abraldes, J.A., Ferragut, C., Vila, H., Rodríguez, N., & Argudo F.M. (2012). Relationship Between Characteristics of Water Polo Players and Efficacy Indices. *Journal of Strength and Conditioning Research, 26*(7), 1852-1857.

Alexander, M., Hayward, J., & Honish, A. (2010). *Water Polo: A Biomechanical Analysis of the Shot.* Sport Biomechanics lab, The University of Manitoba.

Bloomfield, J., Blanksby, B.A., Ackland, T.R., & Allison G.T. (1990). The influence of strength training on overhead throwing velocity of elite water polo players. *Australian Journal of Science and Medicine in Sport, 22*(3), 63-67.

Canossa, S., Martin J.F., Figueiredo, P., Fernandes R.J., Argudo, F.M., & Garganta J.M. (2011). Kinanthropometric Profile of Portuguese Water Polo Players. *Portuguese Journal of Sport Science, 11*(Suppl. 2), 49-52.

Davis, T., & Blanksby B.A. (1977). A cinematographic analysis of the overhand water polo throw. *Journal of Sports Medicine and Physical Fitness, 17*(1), 5-16.

Dopsaj, M., & Aleksandrović, M. (2009). Basic anthropomorphological characteristic of elite senior Serbian water polo players according to field position. *International Journal of Fitness, 5*(2), 47-57.

Dopsaj, M. (2010). Pulling Force Characteristics of 10 s Maximal Tethered Eggbeater Kick in Elite Water Polo Players: A Pilot Study. In P.L. Kjendlie, R.K. Stalman, & J. Cabri (Eds), *The XIth International Symposium for Biomechanics and Medicine in Swimming* (pp. 69-71). Oslo: Norwegian School of Sport Science.

Elliott, B.C., & Armour, J. (1988). The penalty throw in water polo: a cinematographic analysis. *Journal of Sports Sciences, 6*(2), 103-114.

Feltner, M.E., & Nelson, S.T. (1996). Three-dimensional kinematics of the throwing arm during the penalty throw in water polo. *Journal of Applied Biomechanics, 12*(3), 359-382.

Ferragut, C., Abraldes, J.A., Vila, H., Rodríguez, N., Argudo F.M., & Fernandes, R.J. (2011). Anthropometry and Throwing Velocity in Elite Water Polo by Specific Playing Position. *Journal of Human Kinetics*, 27(1), 31-44.

Lozovina, M., Đurović, N., & Katić, R. (2009). Position specific morphological characteristics of elite water polo players. *Collegium Antropologicum, 33*(3):781-789.

Lozovina, M., Lozovina, V., & Pavičić, L. (2012). Morphological changes in elite male water polo players: Survey in 1980 and 2008. *Acta Kinesiologica, 6*(2), 85-90.

Ludovise, B. (1991). *In Demand, This Sport is Top*. LA: Los Angeles Times, 16 January.

Mészáros, J., Soliman, Y., Othman, M., & Mohácsi, J. (1998). Body composition and peak aerobic power in international level Hungarian athletes. *Facta Universitatis Series Physical Education, 1*(5), 21-27.

Pinnington, H., Dawson, B., & Blanksby, B. (1987). *Training for Water Polo*. Department of Human Movement and Recreation Studies, University of Western Australia.

Sanders, R.H. (1999). Analysis of the 'eggbeater kick' used to maintain height in waterpolo. *Journal of Applied Biomechanics*, *15*(3), 284-291.

Sanders, R.H. (1999). A model of kinematic variables determining height achieved in water polo boosts. *Journal of Applied Biomechanics, 15*(3), 270-283.

Smith, H.K. (1998). Applied Physiology of Water Polo. *Sports Medicine, 26*(5), 317-334.

Smith, J.R. (1990). *The World Encyclopedia of Water Polo*. Los Olivos, Ca: Olive Press.

Snyder, P. (2008). *Water polo for Players & Techers of Aquatics*. LA: Los Angeles Olympic Foundation.

Tan, F.H., Polglaze, T., & Dawson, B. (2009). Activity profiles and physical demands of elite women's water polo match play. *Journal of Sports Science 27*, 1095-1104.

Tsekouras Y. E., Kavouras S. A., Campagna A., Kotsis, Y. P., Syntosi S. S., Papazoglou, K., & Sidossis, L.S. (2005). The anthropometrical and physiological characteristics of elite water polo players. *European Journal of Applied Physiology, 95*(1), 35-41.

Van der Wende, K. (2005). *The Effects of Game-Specific Task Constraints on the Outcome of the Water Polo Shot*. Auckland, New Zealand: Auckland University of Technology.

Vila, H., Ferragut, C., Argudo, F.M., Abraldes, J.A., Rodrígues, M., & Alacid, F. (2009). Relationship between anthropometric parameters and throwing velocity in water polo players. *Journal of Human Sport and Exercise, 4*(1), 57-68.

Whiting, W.C., Puffer, J.C., Finerman, G.A., Gregor, R.J., & Maletis G.B. (1985). Three-dimensional cinematographic analysis of water polo throwing in elite performers. *The American Journal of Sports Medicine, 13*(2), 95-98.

FIZIOLOŠKE RAZLIKE IZMEĐU TOP ELITNIH I ELITNIH VATERPOLISTA

Sažetak

Cilj ovog istraživanja je bio utvrđivanje fizioloških atributa top elitnih (drugo mjesto na Svjetskom prvenstvu u Barceloni 2013. godine) i elitnih (četvrta pozicija u Jadranskoj ligi u sezoni 2012/13) vaterpolista, i da se utvrdi razlikuju li se ti atributi međusobno između ove dvije razine vaterpolista. Procjena temeljnih antropometrijskih pokazatelja (tjelesna visina, tjelesna masa, BMI, raspon ruku, dužina noge), i testovi specifičnih motoričkih sposobnosti, brzine plivanje, brzine šuta i produkcije maksimalne sile, su provedeni u dva navrata, odvojeni jednim danom. U studiji je sudjelovalo 11 top elitnih i 11 elitnih vaterpolista (24.26±2.78 vs. 21.83±2.67 godina), koji su se od svih primijenjenih testova i mjera statistički značajno razlikovali samo u rezultatima dva specifično-motorička testa: brzine šuta (78.81±3.84 vs. 71.27±4.29 km/h, p<0.01) i testu za procjenu maksimalne sile (46.72±6.13 vs. 40.38±3.79 kg, p<0.01). Ova studija je pokazala da su glavne razlike između top elitnih i elitnih vaterpolo igrača u sposobnostima maksimalne brzine šuta i produkciji maksimalne sile. Rezultati ovog istraživanja su identificiralii jako bitan faktor za elitne vaterpoliste, odnosno u čemu moraju napredovati tijekom tranzicije od elitnoj prema top elitnoj razini.

Ključne riječi: *antropometrija, motoričke sposobnosti, razlike, vaterpolo*

Received: July 24, 2013
Accepted: December 10, 2013
Correspondence to:
Assoc.Prof.Kemal Idrizović, PhD
Faculty of sport and physical education
University of Montenegro
Podgorica, Montenegro
Tel: +382 67 541 617
E-mail: kemo@t-com.me