Original Article

Anthropometric characteristics of top water polo players in relation to playing position in the game

ELVIRA NIKŠIĆ[1], EDIN BEGANOVIĆ[2], EDIN MIRVIĆ[3]
[1]Faculty of Educational Sciences, University of Sarajevo, BOSNIA AND HERZEGOVINA
[2,3]Faculty of Sport and Physical Education, University of Sarajevo, BOSNIA AND HERZEGOVINA

Abstract
Modern water polo is characterized by fast and attractive play as well as mutual contacts of players, which requires specific anthropometric characteristics from water polo players. Morphology is important in every sport, which is why top water polo players are selected and shaped based on the requirements of the water polo game. The anthropometric characteristics that characterize today's top water polo players include a higher height and longer limbs with a narrower waist and wider shoulders. Body weight has increased. The level of muscle mass increases in relation to adipose tissue. In any sport, success is determined by analysis of various interrelated anthropological dimensions. The aim of this study was to determine differences in the anthropometric characteristics of top water polo players in relation to their playing positions. The study was conducted on a sample of 208 water polo players, who were participants of the 34th LEN European Water Polo Championships. Statistically significant differences in body height were recorded between the positions of wing and center back, center forward, and goal keeper (p <0.05). Differences in body weight were recorded between the positions of wing and center back, center forward (p <0.05), center forward and center back, and goal keeper (p <0.05), and differences in BMI were recorded between the positions of center back and wing, center forward, and goal keeper (p <0.05). Morphological characteristics play a vital role in determining the success of athletes as confirmed by the results of our study in which there were statistically significant differences in the morphological characteristics. The highest body height and BMI were recorded in central defenders, while attackers had the highest body weight.
Key words: Body mass index, body height, body weight, top sport, water polo, water polo positions

Introduction

Water polo is a team game with a ball in the water, and it is dominated by complex movements. Modern water polo is characterized by fast actions with pronounced attacks of numbers, strong and precise shooting on goal, and solid game in contact, which requires psychomotority of players at a high level. From complex actions, the water polo player must apply all positions on and in the water, and thus, a large lung capacity is required to withstand this swimming rhythm (Lupo, Capranica, Cugliari, Gomez & Tessitore, 2015). In terms of energy, it falls into the category of mixed anaerobic–aerobic sports (50–50%), and the game is played by six players and a goal keeper on the other side. During the game, six players perform various tasks of both offensive and defensive types. Regarding the movement structure of water polo players during the game, 35% of the total player time is in the quasi-horizontal phase (everyone swims at all levels of intensity during the game), while the remaining 65% of the time is in the quasi-vertical version of the phase (vertical positions achieved by the backstroke, which is also known as water polo cycling). Kondić and Šajber (2016) aimed to determine the differences in swimming abilities between groups of water polo players according to the four primary positions in the game (center, wing, left or right outer, and middle outer). Swimming abilities were found to be differentially related to positions in the game. While the wings are excellent at sprinting, midfielders dominate in terms of short-distance swimming. There are no significant differences in anaerobic or aerobic swimming abilities.

The playing time of water polo players by position in competition is so diverse that it is very important to make a good training and recovery strategy for each player and adjust it individually to each water polo player (Melchiorri et al., 2020). Aleksandrović et al. (2015) pointed out the significant influence of anthropological dimensions on the specific motor abilities of selected young water polo players. This enables the proper selection process of young water polo players.

Each player predominantly takes on a role intended primarily for him; however, during the game, he may find himself in positions in which he can take on other roles as well. The five playing roles in water polo are defined as center, wing (left and right), back, outside forward (left and right), and goal keeper. Taking into account movements and efficient performance, each of these roles requires different and special morphological and motor characteristics. Players who can perform the best specific roles due to such a structure are assigned

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Corresponding Author: ELVIRA NIKŠIĆ, E-mail: elvira.beganovic1982@gmail.com

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dominant roles by their coaches of 1–10, i.e., players are assigned to specific positions according to their physical structure. In any sports discipline, success is determined by analysis of various interrelated anthropological dimensions, i.e., motor, functional, morphological, cognitive, and conative. Many of these factors intertwine into a single structure that is responsible for performing tasks in water polo and forming an anthropological structure that is suitable for water polo players. Water polo trainings also lead to adjustments of the morphological subsegment of the anthropological structure, optimizing the morphological structure in accordance with the specific requirements of the sports discipline (Lozovina, Đurović, Katić, 2009). Janjić, Gardašević, and Trivun (2018) found that the greatest influence on situational performance in young water polo players in terms of morphological characteristics include the variables of chest circumference, body height, and hand and foot width with positive effects, whereas body weight and subcutaneous adipose tissue are aggravating factors for performing situational motor tasks in 12-year-old water polo players.

Modern water polo is characterized by fast and attractive play as well as frequent mutual contacts of players, which requires specific morphological characteristics from water polo players (Lupo, Tessitore, Minganti and Capranica, 2010). The morphology of the athlete, i.e., his anthropometric characteristics, is an extremely important factor in every sports discipline, including in water polo. Therefore, for continuity from generation to generation, top water polo players are selected and shaped based on the current requirements of the water polo game and the individual profile characteristics of each player. Among other things, these are the main factors for the conclusion that the anthropometric characteristics of elite water polo players have changed over the last (analyzed) 28 years. The shape of the body has changed in terms of greater height and longer limbs with a narrower waist and wider shoulders. Body weight has increased. The level of muscle mass has increased in relation to adipose tissue. The observed changes are a consequence of the trend of acceleration and sports morphological adaptation (optimization) (Lozovina, Lozovina and Pavičić, 2012).

Data has shown that the top elite water polo players have the same anthropometric characteristics as elite ones; they achieve the same maximum swimming speed, but they have a statistically significantly higher level of shot speed and manifestations of maximum force. Precisely, all the aforementioned characteristics of the water polo game and their changes over time lead to the need for permanent verification of the connections within and between the morphological and motor profile of a modern top water polo player. Such research leads to information, which may indicate changes in the specificity of the interrelationship of anthropometric indicators and the physical performance of elite water polo players; however, there are no scientific studies on this (Idrizović et al., 2014). Water polo is characterized by a very dynamic and extremely fast team game and thus, it is a polystructural sports game.

The characteristic of high pace of outplaying in water polo is based on the exceptional technical and tactical mastery of the elements of the water polo game, which are based on certain morphological, motor, psycho-social, and other characteristics. Knowing the clear hierarchical structure of all these factors on which the result in modern water polo will depend is the most important condition for the selection of talent in water polo and more rational planning and programming of training. To create the preconditions for quality planning and programming of the training process, it is necessary to determine all these factors that lead to success in modern water polo through planned training. According to previous research, success factors in the water polo game can be classified into three groups: 1) the first group consists of morphological characteristics, motor abilities, functional abilities, cognitive and conative factors, and sociological characteristics; 2) the second group of factors consists of theoretical knowledge, technical–tactical abilities, specific motor skills, etc.; 3) and the third group of factors consists of situational efficiency and results achieved in competition (Popo et al., 2018).

The intensity decreases as the end of the match approaches, which makes it difficult to implement tactics planned for the match (Botonis et al., 2016a, 2016b; Melchiorri et al., 2010; Platanou and Geladas, 2006) and the same is manifested in other team sports (Michalsik et al., 2015; Povoas et al., 2014; Montgomery et al., 2008) The duration of the match is a factor that influences development and fatigue, which impairs the water polo performance of players (Botonis et al., 2018). Water polo is a water sport that is played with a ball for men and women, and which today enjoys great popularity in the world and is the oldest team discipline of the Olympic Games as well as football. Water polo is a team sport that is in the group of polystructural complex kinesiological activities and differs from other team sports because it is played in a completely different and specific environment - water (Mirvić & Nurković, 2018).

Material and methods

Participants This study included a sample of 208 water polo players, who were representatives of national teams in Croatia, Spain, France, Georgia, Germany, Greece, Hungary, Italy, Malta, Montenegro, the Netherlands, Romania, Russia, Serbia, Slovakia and Turkey and who were divided into four subsamples, namely wing: 51, center back: 70, center forward: 55, goal keeper: 32; they were participants of the 34th LEN European Water Polo Championships.

Research Design The results for the purposes of this study were collected from the official website of the European Water Sports Association LEN (https://wp2020budapest.com/). BMI was calculated by dividing body mass with the square height of the body in meters (Kubayi, et al., 2017). To accurately obtain the results,

two authors of this paper independently downloaded the results and statistically processed them. Based on the final processing of the results, it was determined that the results of both authors matched.

Statistical Analysis All data collected by the research were processed using descriptive and comparative statistics. From the space of descriptive statistics, for each variable, the measures of central tendency and measures of dispersion were calculated: arithmetic mean (mean), variation width (range), and standard deviation (std. dev.). From the space of comparative statistics, a discriminant parametric procedure was used, analysis of variance with one factor (ANOVA) and Post Hoc, which determined the differences in relation to the playing position. The statistical program for personal computers of SPSS for Windows version 20.0 was used for data processing.

Results

Table 1 shows the numerical quantitative indicators of the water status of the water polo players. The highest average height and BMI were recorded at the center back position, followed by the center forward and goal keeper positions, while the lowest height and BMI were recorded for the wing position. The highest body weight values were recorded in the center forward, center back, and goal keeper positions, while the lowest weight was recorded for the wing players.

Table 1. Descriptive statistics in relation to the player's position

| Position	Variables	N	Mean	Std. Dev.	Range
Wing	Body Height	51	188	.064	1.77-2.04
	Body Weight		89.92	7.72	72-106
	BMI		25.19	1.93	19.5-30.3
Center back	Body Height	70	193	.055	1.82-2.05
	Body Weight		96.36	9.19	72-115
	BMI		29.27	1.71	21.0-29.0
Center forward	Body Height	55	192	.061	1.78-2-07
	Body Weight		100.04	11.16	75-130
	BMI		26.90	2.40	21.9-34.6
Goal keeper	Body Height	32	192	.059	1.75-203
	Body Weight		92.97	7.41	82-110
	BMI		25.06	2.07	21.4-28.8

To determine the statistically significant differences between playing positions, depending on the numerical parameters for assessment of physical status, the analysis of variance with one factor (ANOVA) was applied (Table 2). Table 2 shows that statistically significant differences were present for anthropometric characteristics of body height ($p < 0.05$), body weight ($p < 0.05$), and BMI ($p < 0.05$).

Table 2. Differences in anthropometric characteristics of water polo players – ANOVA and Post Hoc

Anthropometry	Position				ANOVA	
	WG	**CB**	**CF**	**GK**	**F**	**p**
Body Height	188±.064†	193±.055	192±.061	192±.059	6.493	.000
Body Weight	89.92±7.72‡	96.36±9.19	100.04±11.16◊	92.97±7.41	11.606	.000
BMI	25.19±1.93	29.27±1.71ᵛ	26.90±2.40	25.06±2.07	8.603	.000

Note: WG-wing; CB-center back; CF-center forward; GK-goal keeper; WGvsCB, CF, GK p<0.05†; WGvsCB, CF p <0.05‡; CFvsCB, GK p <0.05◊; CBvsWG, CF, GK p <0.05ᵛ

The results of Post Hoc Table 2 shows the differences in anthropometric characteristics in relation to the playing position. Statistically significant differences in body height were recorded between the positions of wing and center back, center forward, and goal keeper ($p < 0.05$). Differences in body weight were recorded between positions of wing and center back, center forward ($p < 0.05$), center forward and center back, and goal keeper ($p < 0.05$), while differences in BMI were recorded between positions of center back and wing, center forward, and goal keeper ($p < 0.05$). Figure 1 shows the average anthropometric characteristic values of water polo players.

Figure 1. Antropometric characteristics of the water polo players

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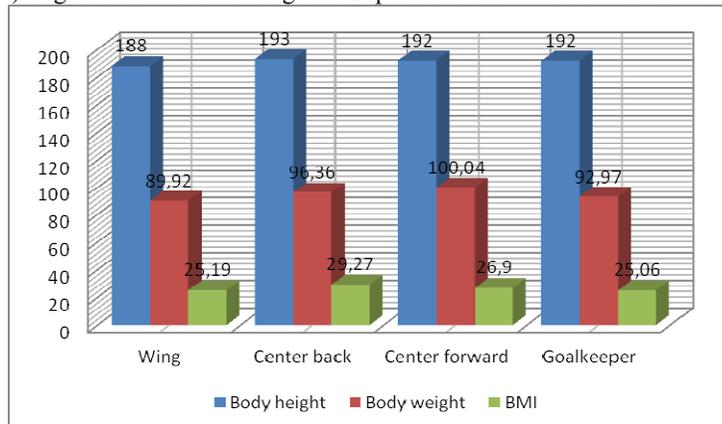
Discussion

This study, which aimed to determine the morphological characteristics of top water polo players, was conducted on a sample of 121 water polo players. The structure of a set of 23 morphological variables was determined by applying factor analysis, and then, the differences between all pairs of positions (role in the game) were determined by applying Post hoc analysis. The factor structure showed that four basic superior latent dimensions are responsible for direct measurable manifestations of the morphological parameters. The first latent dimension relates to the mechanism of growth and development; the second is determined almost exclusively by adipose tissue and skeletal growth in length; the third latent dimension differentiates skeletal growth in length, which accompanies subcutaneous adipose tissue, from muscle mass development and skeletal growth in width, while the fourth latent dimension mainly differentiates skeletal growth in width versus skeletal growth in length. Oblimin transformation of the main components is defined by the circular dimensionality factor, subcutaneous adipose tissue factor, longitudinal skeletal dimension factor, and transverse skeletal dimension factor. The results of analysis of variance (ANOVA) and homogenization of positions in the game of water polo for each individual variable after Post hoc analysis showed that there were significant differences within groups as well as between groups for all anthropometric variables except in the skin fold of the upper arm. Statistically, two groups of roles in the game differed significantly: 1) centers and defenders and 2) goal keepers, wings, and outside players. Significant differences were found between water polo players who play in the center position and fullback with much more pronounced measures of longitudinal and transverse dimensionality of the skeleton than in water polo players who played in other positions (goal keepers, wings, and outside). Regarding volume and body weight, significant differences were found between water polo players who played in the center position with significantly more pronounced measures than water polo players who played in other positions as well as significant differences between center and fullback and other positions in terms of body weight, chest circumference, and forearm circumference. Regarding subcutaneous adipose tissue, skin folds were significantly more pronounced in water polo players who played in the center position than water polo players who played in other positions (Lozovina, Đurović, Katić, 2009). Height, weight, and BMI, just like hand skills, can affect hand grip strength. In addition, several connections were observed at specific positions. A larger number of wing relationships were found, and no relationships were found for attackers in the middle. The central back represents only correlations in the swollen and taut ranges and the handshake, confirming that anthropometric variables indicate strength and such upper arm folds are related to throwing speed (McCluskey et al., 2010). In order for players to be as tired as possible and to be more efficient in the game, in their research (Melchiorri et al. 2020) they proved differences in player playing time, which are significant for fatigue that can automatically affect general motor preparation and chest development.

This depends on the strategy of the coach, and in most cases, preference is given to more experienced players who have fully developed their performances, which is not the case for younger players.

We aimed at developing an anthropometric profile of highly qualified male water polo players according to specific playing positions. Additionally, to recognize the significant relationships between these characteristics, we examined the high throwing speed of highly qualified male water polo players in certain playing positions. A total of 94 male water polo players (24.5 ± 5.3 years) who played in the Spanish King's Cup were studied. The subjects were grouped according to their specific playing positions: 15 goal keepers, 45 offensive wings, 20 central backs, and 14 central strikers. Anthropometric assessment was performed according to ISAK protocols. Hand holding and throwing speed were also assessed in several situations. One-way analysis of variance (ANOVA) was used to determine if there were significant differences between the four playing positions. Pearson product and moment correlation coefficients (r) were used to determine the relationship of all anthropometric measures to throwing speed and handshake. The total playing somatotype was endomorphic–mesomorphic (2.9–5.8–2.3). The center-forward strikers showed important anthropometric differences compared to other specific playing positions in elite men's water polo players, but no differences in throwing speed were found by specific playing positions in all throwing conditions. Moreover, a greater number of relationships between anthropometry and throwing speed were found in the wings and in the central back, but no relationships in the middle forward were found. These data reflect the importance of muscle mass and upper body for throwing skill. Coaches can use this information to select players for different specific positions. The longer length of the upper body allows attackers to receive, adjust, and drive the ball among the defenders and provide an advantage in combat situations. The wings have other needs that are different from other specific positions in which the length of the upper body is not as important. This is due to the fact that the players from the wing play outside the center of the field away from the defense and have to throw the ball towards the goal. There are differences between center forwards and wings and goal keepers regarding arm width. These results are aligned with the team's playing characteristics, where arm span and arm length are important for successful throwing skills. Water polo players show an average hand grip strength of 550.5 N. According to specific positions, central strikers are players who show higher hand grip values, but these differences only gain statistical importance when central strikers are compared to wings and goal keepers (Ferragut, Abraldes, Manchado, and Villa, 2015). The aims of this study were to examine the anthropometric and physical performance characteristics of professional handball players classified by playing position. Twenty-one competitors (age: 25.2 ± 5.1 years) were categorized as backs, pivots, wings, or goal keepers. Measures included anthropometrics (body

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height and mass), scores on the Yo-Yo Intermittent Recovery Test (total distance covered, TD), repeated sprint ability (6 repetitions of 2 x 15-m shuttle sprints with a recording of the best time for a single trial, RSAbest) and performance on a complex handball test (HBKT) of throw slap (TS) and throw jump (TJ) with and without precision. The anthropometric data revealed a significantly lower body height for wings and pivots than for goal keepers. Wings, pivots, and goal keepers were significantly shorter than backs but had a similar BMI. The TD was greater for the wings (2.400 m) than for backs (1.832 m) and pivots (2.067 m). Wings also achieved a better RSAbest (5.41 s) than backs (5.68 s) or pivots (5.82 s). Body height was significantly related to throw slap (TS) and jump (JT) (r = 0.53, p <0.01; r = 0.51, p <0.01 respectively). No significant difference (p = 0.675; η2 = 0.009) was observed between JT with precision and JT without precision (Schwesing et. al, 2016). Gardašević et al. (2020) confirmed that when players have better statistics in terms of subcutaneous adipose tissue for triceps skin fold, biceps skin fold, and thigh skin fold, they showed a better result in the Montenegrin national team compared to the Croatian National Team. Dopsaj et al. (2018) confirmed that morphological parameters (body height and body weight) are of considerable importance in the selection of U15 water polo players.

Using discriminant analysis, we found that the largest global differences between players playing in different positions in the team were due to the variables of abdominal circumference, upper arm circumference, chest circumference, body weight, abdominal skin fold, thigh circumference, back skin fold, and lower leg circumference (AOBTR, AOBNL, AOBPR, AMAST, AKNTRB, AOBNK, AKNLE, and AOBPK). Thus, variables that reflect the volume and weight of the body and the variables of subcutaneous adipose tissue also tell us about the importance of this segment of the population of top young water polo players. Finally, we can conclude that variables have been identified that read voluminosity and subcutaneous adipose tissue and that tell us about the uniformity and importance of these indicators for water polo players. The position of the centroids of the groups clearly showed differences in measures of morphological characteristics between groups of players classified according to positions in the field, which was confirmed by discriminant analysis. The centroids of the group centers (1.44) and goal keepers (−1.19) were the most distant, which showed that the centers and goal keepers are the most different and that they are relatively different from other groups of players. The remaining centroids of the attacker and back groups were grouped to show a slightly smaller difference (Popo et al., 2018).

Conclusion

This study included a sample of 208 water polo players, who were participants in the 34th LEN European Water Polo Championships. Morphological characteristics play a vital role in determining the success of athletes as confirmed by the results of our study in which statistically significant differences in morphological characteristics were found. The highest body height and BMI were recorded in central defenders, while attackers had the highest body weight. These results were expected because the modern water polo game requires players who have a great longitudinal skeleton because the morphological characteristics for specific motor abilities show 42% variability; thus, bigger water polo players have greater strength and better accuracy for throwing the ball. Significant differences in body composition between the players' positions showed the importance of careful assignment of such positions and developing specific training for professional handball players. These results can be very useful for developing and optimizing position training regimes and for determining anthropometric characteristics that are important for achieving success of a particular position in the game. Performance capacities are obviously different for different player positions; thus, coaches should develop position-specific training programs that depend on the specific anthropometric characteristics of players.

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