



Exploring Anthropometric Correlates of Performance Across Playing Positions in Youth Male Water Polo

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Abstract

This study aimed to identify position-specific anthropometric differences in anthropometric status and to evaluate anthropometric predictors of performance level in youth male water polo players. The participants were youth male water polo players (n = 104, age: 17-19 years) from Croatia and Montenegro. In addition to playing position (goalkeeper, outer player, inner player/center) and performance level (high-level group vs. top-level group/members of National team), 21 anthropometric variables were included. Analysis of variance and discriminant canonical analyses were performed to define differences among playing positions in terms of anthropometric status. Logistic regressions with performance-level as a criterion (outcome) was performed to identify associations between anthropometric variables and outcome for each playing position. Centers who were taller (OR = 1.23, 95% CI: 1.04--1.45), had lower subscapular skinfold (OR = 0.84, 95% CI: 0.67--0.98), and had larger chest circumferences were more likely to be grouped in top-level group (OR = 1.15, 95% CI: 1.03--1.31). The greater likelihood for being grouped into top-level group was evidenced for those outer players who were taller (OR = 1.20, 95% CI: 1.04--1.41), had longer arms (OR = 1.21, 95% CI: 1.01--1.44), and had lower values of chest skinfold (OR = 0.57, 95% CI: 0.32--0.83), triceps skinfold (OR = 0.80, 95% CI: 0.66--0.98), and subscapular skinfold (OR = 0.75, 95% CI: 0.47--0.89). Anthropometric variables were not significantly associated with performance level in goalkeepers. Talent, skill, and tactical awareness remains essential for all water polo players, but identified anthropometric attributes should be considered when selecting players for successful performance at each playing position.

Keywords: *anthropometry, adolescent, athletic performance, anatomical locations*



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Introduction

Owing to the necessity of constant swimming and the fact that physical contact between players is permitted, water polo is considered a highly physically demanding sport (Kontic et al., 2017; Perazzetti et al., 2023; Uljevic et al., 2013). Water polo players cover significant distances during matches, with position-specific demands, and the game requires a combination of aerobic and anaerobic fitness, with blood lactate levels >8 mmol/L indicating high-intensity efforts (Melchiorri et al., 2010). Specific anthropometric characteristics, physiological parameters, and throwing velocity are important factors in player performance, whereas heart rate monitoring during matches reveals the importance of aerobic capacity (Chirico et al., 2021; Galy et al., 2014).

In water polo, the interplay between “outer” and “inner” players is crucial for a team’s success. Each of these roles demands a unique set of skills and physical attributes. The outer players (drivers/wings) need to be quick and agile to drive toward the goal, create passing lanes, and defend against counterattacks. On the other hand, inner players (Center Forward/Center Back) engage in intense physical wrestling near the goal, requiring strength to hold their position and power to shoot or defend. Finally, the goalkeeper in water has a unique combination of physical and mental attributes, with taller goalkeepers having an advantage in covering the goal and blocking the shots. As a result of specific game duties, a specific anthropometric structure and body structure are essential for successful game performance (Dimitric et al., 2022; Ferragut et al., 2011)

Research on male water polo players’ anthropometric characteristics and body composition reveals distinct profiles across playing positions (Fritz et al., 2022; Kovacević et al., 2023). In general, centers are massive and tall players, and body length (including body height and arm span) is an important characteristic of goalkeepers (Fritz et al., 2022). In regard to the association with performance level, larger palm size and chest girth were associated with higher performance level when low-level and high-level teams were compared, indicating the importance of specific anthropometric indices in the selection of successful players (Pooya et al., 2016). However, when high-level teams were compared in terms of their anthropometrics, no significant differences were detected (Gardasevic et al., 2021; Vasiljevic et al., 2021).

The aims of this study were (i) to identify position-specific anthropometric differences in anthropometric status and (ii) to evaluate anthropometric predictors of performance level in youth male water polo players. Initially, we hypothesized that (i) the studied anthropometric variables would significantly distinguish playing positions (outer players, inner players, and goalkeepers) and that (ii) significant correlations between the anthropometric variables and performance level would be established for each of the three playing positions.

Methods

Participants

The participants in this study were 104 youth water polo players from Croatia and Montenegro. At the time of the experiment, they were all 17–19 years old. All players had been engaged in water polo training and competition for more than 8 years and were members of Croatian and

Montenegrin clubs, including the national champions of both countries for the observed season. All players were members of teams who competed in national championships but also in regional water polo leagues, which is known as one of the best team-level competitions in the world. Within the sample, we included all members of the youth national teams of Croatia and Montenegro (altogether 39 players).

The study was approved by the Ethical Board of the Faculty of Kinesiology, University of Split. Players were initially invited to participate via the national Water Polo Federations of Croatia and Montenegro. Participants above the age of 18 years provided informed consent, whereas for those younger than 18 years, parental consent was provided.

Variables and measurement

In this study, the variables were primary playing position, performance level, and anthropometric indices. The playing position was reported by players’ coaches and included the left wing, left driver (flat), right wing, right driver (flat), center (hole set), point, and goalkeeper. For the purpose of this study, playing positions were later grouped into goalkeepers, outer players (wings, drivers), and inner players—centers/hole sets and points. The performance level was checked with the national water polo federations of Croatia and Montenegro, and all players who were on the list for the national team over the last three years were grouped into the top-level group (national team members), whereas the others were clustered into the high-level group (club members).

Anthropometric characteristics included the following variables: body height (cm), body mass (kg), palm diameter/palm size (cm), arm length (cm), arm span (cm), leg length (cm), foot length (cm), chest skinfold (mm), triceps skinfold (mm), subscapular skinfold (mm), abdominal skinfold (mm), thigh skinfold (mm), arm circumference (cm), calf circumference (cm), thigh circumference (cm), chest circumference (cm), abdominal (waist) circumference (cm), elbow breadth (cm), wrist breadth (cm), knee breadth (cm), and ankle breadth (cm). Anthropometric variables were measured with Seca stadiometers and scales (Seca, Birmingham, UK), a skinfold caliper (Holtain, London, UK), and measuring tapes and anthropometers (Martin France). All the measurements were taken by experienced and licensed evaluators and were performed according to the standards for anthropometry assessment (Norton & Eston, 2018).

Statistics

All variables were checked for normality of distributions via the Kolmogorov-Smirnov test, and descriptive statistics included calculations of means and standard deviations. Differences among playing positions were checked by analysis of variance (ANOVA), with consecutive post hoc tests when appropriate. Multivariate analysis of differences in anthropometric status among playing positions comprised of calculation of the canonical discriminant analysis.

The association between anthropometric indices and performance level was defined by performing logistic regression for binarized criteria (high-level players, coded as “1” vs. top-level players, coded as “2”). Odds ratios (ORs) with corresponding 95% confidence intervals (95% CIs) are reported.

Logistic regressions were calculated separately for goalkeepers, outer players, and inner players (centers).

Statistica ver 13.5 (Tibco Inc. Palo Alto, CA, USA) was used for all calculations, and a p-level of 95% was applied.

Results

Descriptive statistics and univariate differences among playing positions in terms of anthropometric variables are presented in Table 1. Playing positions significantly differed in almost all the anthropometric variables. Significant ANO-

VA differences were found for body height, mass, lengths of body segments, all skinfold measures, all circumferences, and three of the four breadths. Post hoc analysis revealed significant differences between the outer players and the remaining two positions in length, body height, and girth measures, with goalkeepers and centers being taller, having longer body segments, and having thicker bone segments than the outer players. Compared with goalkeepers and outer players, center players had significantly greater values of skinfold measures and circumferences.

Table 1. Descriptive statistics for anthropometric variables with univariate differences among playing position (ANOVA – analysis of variance)

	Inner players (Centers) n = 35	Goalkeepers n = 19	Outer players n = 50	ANOVA
	Mean±SD	Mean±SD	Mean±SD	F test (p)
Body height (cm)	189.83±5.81 #	189.68±6.78 #	183.83±4.96	14.61 (0.001)
Body mass (kg)	91.51±8.79 #, \$	82.04±8.38	80.14±7.2	21.85 (0.001)
Palm diameter (cm)	24.7±1.37	24.04±0.97	23.68±1.12	7.64 (0.001)
Arm length (cm)	82.64±5.8 #	83.14±4.2 #	79.2±3.9	7.82 (0.001)
Arm span (cm)	197.96±7.07 #	198.98±7.26 #	191.4±6.47	13.49 (0.001)
Leg length (cm)	100.19±6.89 #	101.65±4.89 #	97.48±5.99	3.94 (0.02)
Foot length (cm)	28.65±1.15 #	28.21±1.06 #	27.37±1.28	12.23 (0.001)
Chest skinfold (mm)	10.29±3.2 #, \$	8.65±2.46 #	9.21±2.43	2.7 (0.07)
Triceps skinfold (mm)	12.37±6.24	9.93±2.56	11.65±3.34	1.88 (0.16)
Subscapular skinfold (mm)	14.19±3.64 #, \$	10.89±2.76 #	12.07±2.93	7.89 (0.001)
Abdominal skinfold (mm)	16.52±5.78 #, \$	10.94±3.61 #	13.49±4.97	8.08 (0.001)
Thigh skinfold (mm)	10.24±2.27 \$	8.54±1.32 #	10.01±2.18	4.53 (0.01)
Arm circumference (cm)	33.49±2.38 #, \$	30.59±2.21	31.64±1.81	13.9 (0.001)
Calf circumference (cm)	39.46±2.18 \$	36.35±4.48 #	38.07±2.88	6.58 (0.001)
Thigh circumference (cm)	59.06±3.63 #, \$	55.5±3.11	56.14±3.57	9.25 (0.001)
Chest circumference (cm)	106.15±4.83 #, \$	99.2±5.69	101.7±4.71	14.33 (0.001)
Waist circumference (cm)	90.55±5.79 #, \$	83.46±5.35	84.38±5.45	15.74 (0.001)
Elbow breadth (cm)	7.68±0.68 #	7.61±0.63	7.35±0.39	4.27 (0.02)
Wrist breadth (cm)	5.93±0.27 #	5.97±0.34 #	5.76±0.31	4.97 (0.01)
Knee breadth (cm)	10.18±0.48 #	10.33±0.45 #	9.95±0.51	4.84 (0.01)
Ankle breadth (cm)	7.48±0.54	7.62±0.45	7.45±0.55	0.66 (0.52)

Legend: # denotes significant post hoc differences compared with outer players, \$ denotes significant post hoc differences compared with goalkeepers

The multivariate differences in anthropometric status obtained via discriminant canonical analysis are presented in Table 2. Discriminant analysis revealed two significant functions (discriminant roots). In general, the first function explained the differences between the centers and the remaining two playing positions (goalkeepers and outer players), whereas the second function revealed differences between goalkeepers and outer players in the study variables. Accordingly, body mass, chest circumference, and thigh circumference, together with certain skinfold measures, explained the differences between centers and the remaining two playing positions. When these differences are interpreted in general, center players are characterized by an endomorphic body built, which is clearly the overall morphological/anthropometric structure that distinguishes them from other players. The second function is characterized by negative projections of length measures

and body height and positive projections of circumference measures. According to the positioning of the group centroids (positive projection of the centroid of the outer players and negative projection of the centroid of the goalkeepers), when these playing positions are compared, the goalkeepers are taller and have longer limbs (more ectomorphic), whereas the outer players are more muscular (mesomorphic).

The associations between the anthropometric variables and performance level for center players are presented in Figure 1, with several anthropometric indices being significantly associated with outcome. Specifically, those centers who were taller (OR = 1.23, 95% CI: 1.04--1.45), who had lower subscapular skinfold values (OR = 0.84, 95% CI: 0.67--0.98), and had larger chest circumferences (OR = 1.15, 95% CI: 1.03--1.31) were more likely to be grouped into top-level performance group.

Table 2. Multivariate differences in anthropometric status among playing positions calculated via discriminant canonical analysis

	Root 1	Root 2
Body height	0.43	-0.49
Body mass	0.75	-0.12
Palm diameter	0.43	-0.14
Arm length	0.27	-0.39
Arm span	0.36	-0.52
Leg length	0.14	-0.32
Foot length	0.48	-0.33
Chest skinfold	0.25	0.09
Triceps skinfold	0.15	0.18
Subscapular skinfold	0.43	0.17
Abdominal skinfold	0.41	0.23
Thigh skinfold	0.17	0.33
Arm circumference	0.57	0.23
Calf circumference	0.34	0.26
Thigh circumference	0.49	0.08
Chest circumference	0.57	0.23
Waist circumference	0.64	0.07
Elbow breadth	0.26	-0.23
Wrist breadth	0.21	-0.32
Knee breadth	0.14	-0.36
Ankle breadth	-0.02	-0.14
Centroid: Centers	1.20	-0.01
Centroid: Goalkeepers	-0.62	-1.56
Centroid: Outer players	-0.61	0.60
Canonical R	0.66	0.62
Wilks Lambda	0.34	0.61
p-level	0.00	0.00

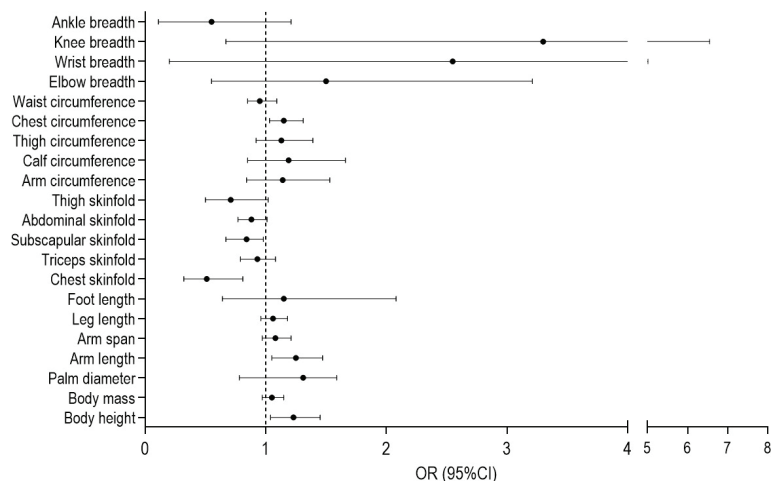


Figure 1. Anthropometric correlates of the performance level for inner players/centers - the results of the logistic regression for binarized criterion (high-level vs. top-level center players)

The correlations between the anthropometric variables and performance level for goalkeepers are presented in Figure 2. Notably, none of the observed anthropometric variables were significantly associated with performance level for goalkeepers.

When logistic regression was calculated for outer players, the greater likelihood for being grouped into top-level

group was evidenced for those players who were taller (OR = 1.20, 95% CI: 1.04--1.41), had longer arms (OR = 1.21, 95% CI: 1.01--1.44), and had lower values of chest-skinfold (OR = 0.57, 95% CI: 0.32--0.83), triceps-skinfold (OR = 0.80, 95% CI: 0.66--0.98), and subscapular-skinfold (OR = 0.75, 95% CI: 0.47--0.89) (Figure 3).

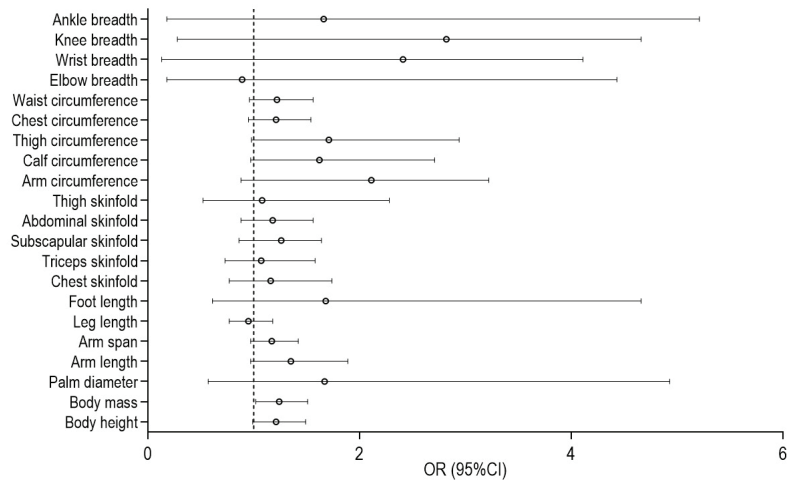


Figure 2. Anthropometric correlates of the performance level for goalkeepers - the results of the logistic regression for binarized criterion (high-level vs. top-level goalkeepers)

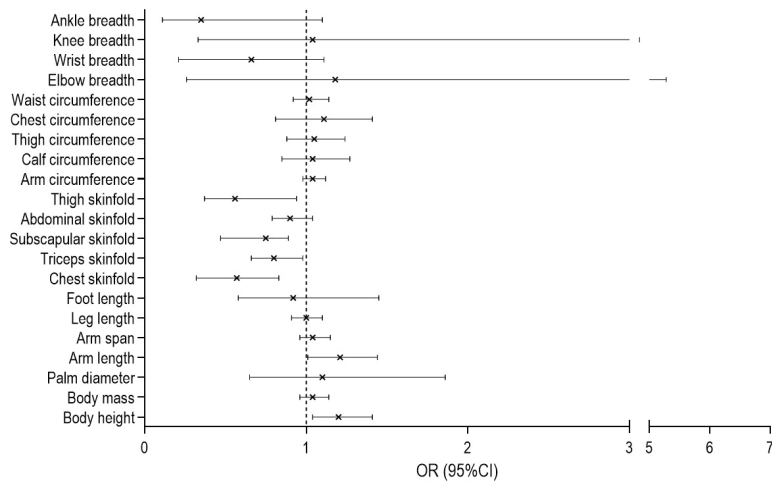


Figure 3. Anthropometric correlates of the performance level for outer players - the results of the logistic regression for binarized criterion (high-level vs. top-level outer players)

Discussion

There are several important findings with respect to the study aims. First, anthropometric status strongly discriminates playing positions in youth water polo. Second, anthropometric indices are correlated with quality level for the backs and out players but not for the goalkeepers. Therefore, our first study hypothesis can be fully accepted, whereas the second study hypothesis could be partially accepted.

Anthropometric indices and playing positions

Our results highlighted distinctive anthropometric structures of three playing positions in youth male water polo players. Among other characteristics, inner players (backs) and goalkeepers are taller and have longer body segments (i.e., leg length and arm length). Further, centers have stronger bones (observed by the diameters of the bone segments) when compared to outer players. Additionally, centers have greater skinfolds (more body fat) and larger circumferences (girths) of specific anatomical locations than do outer players and goalkeepers. These results agree with previous studies performed with Croatian juniors and data obtained from senior-level players (Kondric et al., 2012; Lozovina et al., 2009; Uljevic et al., 2014). In general, such anthropometric structures are connected to players' game duties and are discussed accordingly.

With respect to the anthropometric specifics of goalkeepers, longer body segments are beneficial for several reasons, including (i) increased reach, (ii) enhanced blocking, (iii) improved deflection, (iv) dominating presence, and (v) aerial advantage. Specifically, (i) longer arms and legs translate to a wider reach, allowing goalkeepers to cover a larger portion of the goal. This makes it harder for shooters to find open spaces and increases the likelihood of blocking shots. Additionally, (ii) with greater reach, goalkeepers can effectively increase their blocking area without needing to move as much. This is crucial in water polo, where quick reactions and explosive movements are essential (Martinez et al., 2015).

Importantly, (iii) even if a shot is not blocked completely, longer limbs increase goalkeepers' chances of deflecting the ball, altering its trajectory and potentially preventing a goal. Apart from these clear and understandable performance-specifics, some psychological factors are also important. Specifically, (iv) a goalkeeper with long limbs creates a more imposing presence in the goal, which can intimidate shooters and make them hesitate or rush their shots, and this psychological advantage can be just as important as the physical benefits. Finally, (v) in situations where the ball is lobbed toward the goal, a goalkeeper with long arms

can extend higher to catch or punch the ball away, giving them an advantage in aerial duels (Platanou & Thanopoulos, 2002).

The contribution of longer limbs and overall body height in centers is also related to their game duties (Kondric et al., 2012; Uljevic et al., 2014). However, in explaining this, it is important to differentiate offensive and defensive game duties. Considering offensive advantages, the contribution of longer limbs to leverage and reach is likely crucial since longer limbs provide greater leverage when shooting, and such an anthropometric structure allows for more powerful shots. Players with longer limbs can extend further to catch passes and shoot even when tightly guarded, and because of the contact nature of the water polo this is highly important. Longer legs enable the center forward to rise higher out of the water when shooting, giving them a better angle to shoot over the goalkeeper's head. Longer arms help in controlling the ball in close quarters, making it harder for defenders to steal or block. In general, longer limbs provide an advantage in the physical battles for positions that occur near the goal, which is highly specific for inner players. In other words, inner players can use their reach to hold off defenders or create space for themselves (Idrizović et al., 2013).

The defensive duties of inner players are specific and naturally connected to their anthropometric structure (Kondric et al., 2012). For example, longer arms are crucial for blocking shots from the opposing centers, whereas players in defense who have longer arms can also more efficiently deflect passes intended for the center forward, disrupting the offense. Furthermore, longer limbs allow the inner players (specifically, center back) to cover a larger area around the goal, making it harder for the offense to find open passing lanes or shooting opportunities. With their height and reach, center backs can effectively challenge shots even when they are not directly in front of the shooter, whereas their long reach gives them an advantage in stealing the ball from the opposing center forward or intercepting passes (Idrizović et al., 2013).

Our results on differences among playing positions, with centers having relatively larger bone diameters, are relatively novel. To explain these results, we should first highlight the link between bone diameter and some conditioning capacity. Specifically, it is well documented that larger bone diameters generally correlate with greater skeletal muscle mass and strength (Torres-Costoso et al., 2020). In water polo, this is crucial, especially for centers that engage in intense physical battles and need to generate power for shooting and wrestling. As said, longer and thicker limbs provide better leverage, which is essential for both shooting and defending. This translates to more powerful shots and a greater ability to hold off opponents.

A larger (i.e., more massive) bone structure can contribute to increased stability in the water, making it harder for opposing players to push them off balance. Finally, we must mention one possible link that is not directly related to specific game performance but is also highly important. Specifically, since water polo is a high-impact contact sport, stronger bones with greater density can help reduce the risk of fractures and other injuries (Hart et al., 2020). This is particularly important for center players simply because those players are often in contact with and wrestle from the opponent and are therefore at greater risk of being injured.

Skinfold measures are frequently used as indicators of the overall body fat content, especially in athletes (Ljubojevic et al., 2020; Sermaxhaj et al., 2021). Studies have shown that anthropometric indices are important correlates of athletes' performance levels and are also associated with positions specific to various team sports, including water polo (Gardasevic et al., 2020). With respect to water polo, our findings on higher skinfold measures (i.e., more body fat) in center players are not novel and have already been reported in males and females and for different age categories (Fritz et al., 2022; Nikšić et al., 2020). However, to the best of our knowledge, studies rarely specifically underscore the background of these findings. The context of these results can be explained from three perspectives, emphasizing conditioning, energetic, and biomechanical specificities.

It has already been reported that center players' performance is heavily oriented toward strength and power. These conditioning capacities allow them not only to hold their position effectively but also to wrest for the ball and execute powerful shots. For such purposes, lean muscle mass is essential. However, a certain amount of body fat can contribute to overall mass and power. This is particularly the case in manifestations of absolute power and strength, where additional body mass will be clearly beneficial (Stanelle et al., 2021). While center players are often in a situation to express absolute strength and power (i.e., pushing the opponent from themselves, for example), this might also lead to a slightly higher body fat percentage than positions that prioritize speed and agility.

Finally, one highly specific biomechanical reason related to water polo sports should be briefly explained. Body fat can increase buoyancy. This added buoyancy can be advantageous for centers that need to maintain a strong and stable position in the water, especially when wrestling with opponents. However, one can argue that a higher body fat percentage can decrease swimming speed, and for that reason, more body fat would deteriorate center performance. However, although fast swimming is important in water polo, studies have highlighted that this capacity is more characteristic of outer players than centers (Kondric et al., 2012; Uljevic et al., 2014).

Anthropometric indices and performance-level

While the first set of analyses allowed us to identify the characteristics of three playing positions with regard to anthropometric status, the second set of analyses was performed to evaluate possible associations that may exist between anthropometric indices and players' performance levels. As introduced, the associations were established for each playing position separately, since differences in anthropometric status (please see previous discussion) would not allow meaningful analysis for the total sample. As evident, anthropometric characteristics were significantly associated with performance level when analyses were performed for inner and outer players, whereas there was no significant association between anthropometrics and the performance level of goalkeepers. We will discuss the latter finding first.

Goalkeepers possess highly specific anthropometric characteristics, which have already been discussed from the perspective of their game duties, and there is no doubt that certain characteristics are highly beneficial and therefore could be associated with their performance level as well. However, there are several possible reasons for the lack of association between anthropometrics and performance level in the goalkeepers

observed here. The first explanation is related to the fact that we sampled excellent teams from regions where the quality of water polo sport is high.

As a result, the goalkeepers we have sampled were well advanced in their quality, and what is also important, has already been selected. This means that at this competitive level and age, goalkeepers are already balanced in basic selective parameters, including anthropometrics. In other words, all goalkeepers observed in this study had all necessary anthropometric components that are important for successful goalkeeping (Platanou & Thanopoulos, 2002). Some differences between them still persist, but those differences are likely not the key factor for their differentiation in performance level, at least not the one we evidenced here. Therefore, it is probable that other qualities (i.e., explosiveness, reaction time) are more distinctive and play a significant role in differentiating between the performance levels of goalkeepers of this age and status.

The second explanation for the lack of association between anthropometrics and performance level in goalkeepers could be the relatively small number of participants and the unbalanced number of players in each observed performance group. Specifically, each team included 1--2 goalkeepers. Since we sampled players from two countries, the top-performance group consisted of only six players vs 13 players in high-level group. Simply statistically, the unbalanced number of players in two performance-level groups poses several problems. In most of the statistical analyses of differences, a smaller sample size dominates because the statistical power (i.e., the ability to detect a real difference between groups) is largely determined by the smallest group size, and having one much smaller group limits the overall power of the analysis. Additionally, statistical tests assume equal variances across groups. Unequal group sizes make the tests more sensitive to violations of this assumption, potentially leading to inaccurate results (Huck, 2008).

The performance level of the centers is determined by specific anthropometric structures, including long body segments (i.e., body height and arm span), large chest circumferences, and lower levels of body fat. Inner players in water polos have specific game duties, which are naturally accompanied by a very specific anthropometric status, as already discussed. This refers primarily to the need for them to be efficient in the contact game but also to manage to control space relatively well owing to their longer limbs (Uljevic et al., 2014). While the importance of body length has already been discussed when we overviewed the differences among playing positions, in the following text, we focus on other significant predictors of performance level in centers.

What is specific for centers in modern water polo is the need to move relatively well, regardless of the fact that swimming is not the main requirement of their game (Kontic et al., 2017). The circumference of the chest directly determines the vital capacity of young water polo players. Increased vital capacity not only increases working capacity under conditions of repeated anaerobic work but also clearly directly affects the amount of air in the lungs and total lung capacity and indirectly affects a player's buoyancy. In this way, the player is in a better position to accomplish his tasks and is enabled to work more efficiently, whether it is in attack or defense.

A larger chest implies several other factors that may be beneficial for centers. For example, a strong upper body, including the chest muscles, provides the power needed to hold

off defenders, create space, and receive passes. Additionally, the chest muscles are involved in generating force for throwing the ball, allowing centers to shoot with greater velocity and accuracy. A larger chest volume often correlates with a broader overall physique. This increased body mass and wider base can enhance stability in the water, making it harder for defenders to push the center off balance.

Centers spend a significant amount of time treading water, often while wrestling with defenders (Kondric et al., 2012). A strong upper body, including well-developed chest muscles, helps with more efficient treading and reduces fatigue. Finally, water polo matches are physically demanding. Greater muscle mass in the chest and upper body can provide more endurance and resistance to fatigue, allowing centers to perform at a high level throughout the game. Certain psychological factors could be associated with better performance in centers with larger chests. First, there is no doubt that a physically imposing presence, including a large chest, can intimidate opponents and give the center a psychological edge. Moreover, feeling strong and physically capable can increase a center's confidence, which can positively influence its performance.

In explaining this correlation between body fat and performance level in outer players, it is important to highlight once again that water polo is a physically demanding sport that requires a combination of strength, speed, agility, and endurance (Uljevic et al., 2013). For outer players, who are primarily involved in swimming, passing, and shooting, maintaining low levels of body fat is crucial for optimal performance for several reasons.

The first reason is related to specific conditioning capacities and their importance for outer players. Excess body fat increases drag in the water, slowing down swimming speed and making it harder to change direction quickly (Dopsaj et al., 2020). Leaner players experience less resistance, allowing them to move more efficiently and react faster to the dynamic flow of the game. Additionally, lower body fat translates to a higher muscle-to-fat ratio, which improves acceleration and quick bursts of speed needed for sprints, steals, and defensive maneuvers. The fact that carrying excess weight (e.g., more body fat) requires more energy and oxygen should not be underestimated. Therefore, leaner players utilize oxygen more efficiently, allowing them to sustain high-intensity efforts for longer periods without fatiguing.

Another important mechanism is thermoregulation. While water polo matches can be long and intense, they generate significant body heat. A lower body fat percentage allows for better heat dissipation, preventing overheating and maintaining performance levels (Rech et al., 2021). This is particularly important for outer players since those players spend more time in the game (i.e., they are not substituted often as centers). Furthermore, excess body weight (i.e., ballast mass as a result of body fat) places extra stress on joints, increasing the risk of injuries. Leaner players are less prone to joint problems and can recover faster from physical exertion. Owing to the necessity of swimming for longer distances during match and training, this mechanism is more specific for outer players than for other playing positions.

Limitations and strengths

This was a cross-sectional study; therefore, causalities cannot be definitively interpreted. For example, there is a certain possibility that body fat level is a result of specific

game duties and training characteristics for certain playing positions (i.e., longer swimming distances can reduce body fat). Therefore, prospective studies are needed to identify cause-effect relationships more specifically. This study highlighted only anthropometrics and their possible associations with the game position and performance level of water polo players.

The sample of participants consisted of high-level players, and performance levels included the identification of differences between groups of highly successful players. Therefore, this is one of the rare studies where analyses allowed the identification of factors that contribute to the differentiation of high-level and top-level youth players. Additionally, the sample of variables included a comprehensive set of anthropometric variables, and consequently, the specific anthropometric structure for each playing position and performance level was clearly identified.

Conclusion

The anthropometric variables did not distinguish goalkeepers according to their performance level. Most likely, the goalkeepers in this study were already selected on the basis of necessary anthropometric and body-built attributes, and in this stage of their sport careers, other indices are more important in determining their quality.

Tallness, length of body segments, and lower values of body fat are found to be significant predictors of success in outer players. Therefore, the body height and length of body segments should be used as selection parameters for this position in the water polo. Moreover, body fat can be effectively reduced through an appropriate diet and specific types of training. Therefore, by optimizing their body composition, outer players can maximize their performance and contribute more effectively to their team's success.

While talent, skill, and tactical awareness are essential for all water polo players, body height, arm length, chest circumference, and lower body fat can provide physical advantage for centers. This highlights the importance of considering specified physical attributes in player selection and development, particularly for this demanding position.

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