Position-Specific Anthropometry and Throwing Velocity of Elite Female Water Polo Players

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Abstract

Martínez, JG, Vila, MH, Ferragut, C, Noguera, MM, Abraldes, JA, Rodríguez, N, Freeston, J, and Alcaraz, PE. Position-specific anthropometry and throwing velocity of elite female water polo players. *J Strength Cond Res* 29(2): 472–477, 2015—This study was conducted with the following aims: (a) to describe the effect of playing position on anthropometrics and throwing velocity in elite female water polo players and (b) to observe any relationships between anthropometric parameters and throwing velocity. To achieve these aims, we analyzed a total of 46 female elite players (age: 22.5 ± 5.1 years; height: 172.0 ± 6.9 cm, body mass: 67.4 ± 7.5 kg) members of the top 4 teams of the Spanish Honour Division women league (21 offensive wings players, 17 center, and 8 goalkeepers). Wings were significantly shorter and had smaller arm spans than goalkeepers and center players. Goalkeepers demonstrated longer forearm lengths than wing and center players. No other significant differences were evident between positions in terms of anthropometric, strength, or throwing velocity variables The somatotype of the offensive wing players was mesomorphic, whereas centers were endomorph (classified as endomesomorphic). Height, arm span, muscular mass, biepicondylar breadth of the humerus, arm girth (relaxed and tensed), and forearm girth were related to throwing velocity. In conclusion, only a small number of anthropometric differences exist between players of different positions in elite female water polo. Shorter players with smaller arm spans may be better suited to the wings, whereas athletes with longer forearms may be better suited to the goalkeeper position. Taller, more muscular athletes with wider arm spans, broader humeri, and wider arms (relaxed and flexed) tended to throw with increased velocity. Trainers should focus on increasing the modifiable characteristics (muscle mass and arm girths) that contribute to throwing velocity in this population.

Key Words somatotype, body composition, hand grip, dynamic shot

Introduction

Water polo is a complex team sport characterized by intermittent and high-intensity activity (23). The objective of the game is to score as many goals as possible by dribbling, passing, and throwing the ball in the goal while swimming or treading water. Consequently, elite water polo players require significant technical and tactical abilities, as well as physical and anthropometric characteristics appropriate to the unique demands of this water-based sport (1,15,17,23,25,28).

A number of different playing positions exist within the sport of water polo and with them, come markedly different game demands: (a) goalkeepers are required to tread water between the goals and block shots made toward the goal, (b) Centers are required to engage in physical struggles with their opponent to hold key positions in the pool, and (c) Wings are required to do large amounts of swimming up and down the sides of the pool to create scoring opportunities for their team and prevent those of their opponents.

Given these differences, we believe that to optimize team performance, athletes in different positions ought to possess different physical attributes that reflect the requirements of their playing position (11,22,25). Interestingly, however, no study to date has sought to describe the anthropometric differences between water polo players from different playing positions.

Furthermore, throwing is considered to be one of the most important aspects of performance in water polo (2,12,15,23,24). In particular, throwing velocity is an important component for success, as faster throws reduce the time defenders and goalkeepers have to save the shot (27,28). Although much research has focused on the biomechanics

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of shooting in water polo (4,8–10,16,28,30) and the influence of goalkeepers and defenders on shooting success (1,2,11,28), no previous investigations have sought to describe differences in shooting ability of players from different positions. Furthermore, with only a handful of articles focusing on female water polo players (1,15,20), much paucity in the literature remains for this population.

Consequently, the aims of this study were to (a) describe the effect of playing position on anthropometrics and throwing velocity in elite female water polo players and (b) observe any relationships between anthropometric parameters and throwing velocity. This was conducted with the intended purpose of providing information to guide team selection processes and inform training practices within this athletic population such that players could be selected for positions that suited their physical profile and trainers could develop their athletes appropriately to meet game demands.

Methods

Experimental Approach to the Problem

A cross-sectional study design was implemented such that participants were assessed in their club setting during the precompetitive phase of the season (late April/early May) in a single session.

Subjects

Forty-six elite female players (21 offensive wings players, 17 center, and 8 goalkeepers; Table 1) participated in this study. Players were required to be members of one of the top 4 Spanish Honour Division teams that participated in the Cup of the Queen including 26 players from the Junior and Senior Spanish selection (Silver medals in the Olympic Games in London 2012). Participants and coaches were informed about the experimental protocol procedures and provided verbal and written consent before testing. The study was approved by the San Antonio Catholic University Committee on research involving human participants and complied with the Declaration of Helsinki. Participants completed a playing history questionnaire providing information including date of birth, specific position, and number of years playing water polo before being grouped according to their specific playing positions: 21 offensive wings players, 17 center, and 8 goalkeepers.

Players then completed an assessment of their physical characteristics including anthropometrics, strength, and throwing velocity.

Players had their height and body mass measured on a leveled platform scale (Seca, Hamburg, Germany) with an accuracy of 0.01 kg and 0.001 m, respectively. Arm span was then measured using a diameter steel tape (Lufkin Executive Thinline, W606PM, TX, USA; Table 1).

Twenty-one anthropometric parameters were then measured using the International Society for the Advancement of Kinanthropometry method (13) and comprised of 11 girths (arm relaxed, arm flexed and tensed, forearm, wrist, chest, waist, gluteus, upper thigh, middle thigh, calf, and ankle; Table 2), 6 lengths (chest depth, chest width, humerus length, forearm length, hand length, and hand width; Table 2), and 4 bone breadths (biacromial, biepicondylar humerus, biepicondylar-femur, and wrist; Table 2). Girths were measured using a diameter steel tape, whereas lengths were measured using an anthropometer (GPM, Zurich, Switzerland). Three repeated measures for each of the 21 anthropometric dimensions were obtained by 1 accredited level II and 3 accredited level I ISAK anthropometrists, after that, the average of them was calculated. The technical error of measurement was <1% for all bone breadths and body girths. All unilateral measures were taken on the dominant (throwing arm) side. These parameters we selected to determine the anthropometric profile of the players in accordance with previous work in this population (3,5,7,18,19,23,26).

Several variables were then derived: (a) the body mass index (BMI; Table 1) was calculated as mass (in kilograms) divided by height (in square millilmeter), (b) fat-free mass (FFM; Table 1) (%) using the method described by Lee (14), and (c) selected anthropometric measures were used to determine somatotype following the methods described by Carter (6).

Table 1. Player characteristics by specific positions (mean ± *SD*).

	Wings	Centers	Goalkeepers
Age (y) (range, 18–30)	21.6 ± 3.7	22.0 ± 4.7	25.9 ± 5.0
Mass (kg)	63.6 ± 7.9	67.6 ± 7.6	71.0 ± 6.9
Height (cm)	167.2 ± 6.0*	171.6 ± 6.2	177.0 ± 8.5
Arm span (cm)	171.4 ± 6.6*	174.8 ± 8.2	182.0 ± 8.0
Experience (y)	7.9 ± 3.9	7.7 ± 3.5	10.9 ± 3.4
Fat-free mass by Lee (kg)	23.7 ± 3.0	23.9 ± 2.2	24.5 ± 1.8
Body mass index ($kg \cdot m^{-2}$)	22.6 ± 2.2	22.9 ± 1.8	22.7 ± 1.7

*$p \leq 0.001$.

Maximum Isometric Grip Strength

Maximum isometric hand grip strength was then recorded using a handheld hand grip dynamometer (T.K.K. 5401; Takei Scientific Instruments Co., Ltd, Niigata, Japan) to the nearest 1 N (Table 3). The participants were familiarized with the dynamometer, performing 3 warm-up repetitions the same day of the testing, with 3-minute rest between each trial. The players then performed 2

Table 2. Anthropometric characteristics of water polo players (mean ± *SD*).

	Wings	Centers	Goalkeepers
Breadth (cm)			
Biepicondylar humerus	9.38 ± 0.48	9.57 ± 0.60	9.63 ± 0.28
Wrist breadth	4.99 ± 0.62	5.17 ± 0.31	5.18 ± 0.31
Biepicondylar femur	6.37 ± 0.39	6.52 ± 0.37	6.54 ± 0.36
Biacromial breadth	38.00 ± 1.80	36.96 ± 7.26	39.95 ± 2.46
Girth (cm)			
Arm girth relaxed	29.31 ± 3.06	28.82 ± 2.03	28.71 ± 2.08
Arm girth flexed and tensed	30.76 ± 2.70	30.47 ± 1.82	30.63 ± 2.24
Forearm girth (maximum relaxed)	24.47 ± 1.50	24.29 ± 1.18	24.46 ± 1.29
Wrist girth (distal styloid)	15.53 ± 0.69	16.02 ± 2.29	15.51 ± 0.67
Chest girth	88.13 ± 8.91	92.15 ± 5.53	93.21 ± 2.27
Waist girth	72.11 ± 5.06	73.23 ± 3.80	76.20 ± 3.25
Gluteal girth	97.13 ± 6.34	100.08 ± 5.88	102.06 ± 5.02
Upper tight girth	59.11 ± 5.54	60.21 ± 3.10	60.86 ± 3.88
Middle tight girth	51.31 ± 4.05	51.07 ± 2.53	52.20 ± 2.16
Calf girth	35.23 ± 3.41	35.73 ± 2.57	36.01 ± 1.25
Ankle girth	21.76 ± 1.29	22.35 ± 1.28	22.56 ± 1.42
Length (cm)			
Anteroposterior chest	21.15 ± 3.39	20.10 ± 2.41	23.83 ± 6.30
D_Trans_Thorax	24.75 ± 4.82	26.70 ± 5.12	25.03 ± 6.16
Hand width	19.58 ± 1.24	20.36 ± 1.56	20.37 ± 1.38
Arm length	31.17 ± 1.56	31.09 ± 1.41	32.73 ± 3.15
Forearm length	24.68 ± 1.34*	24.94 ± 0.94*	27.75 ± 1.06
Hand length	18.07 ± 1.29	18.23 ± 1.39	19.21 ± 1.66

*$p \leq 0.001$.
D_Trans_Torax = transverse distance of the thorax.

repetitions at maximum intensity with the dominant hand, again with 3 minutes of rest between trials. Testing was performed in a standing position with the dynamometer set parallel to the body. In this position, the player was requested to exert maximal grip force without arm or wrist flexion (1). The best trial was used for further analysis.

Throwing Velocities

To assess throwing velocity, a radar gun (StalkerPro, Inc., Plano, TX, USA) with a record data frequency of 33 Hz was used. The radar was placed 10 m behind the goal post and aligned with the penalty line. The players were instructed to perform 6 maximal throws under 3 different conditions (2 shots in each condition) from the 5-m penalty line. The 3 conditions included: (a) no goalkeeper, (b) with goalkeeper only, and (c) with 3 swimming strokes to the shooting line and with goalkeeper. Participants then completed a standardized warm-up comprised of 5 minutes of light-moderate intensity swimming followed by 5 minutes of throwing, progressively increasing in intensity until maximal intensity was reached. The participants were then instructed to throw a standard water polo ball (mass = 450 g; circumference = 70 cm) as fast as possible through a standard goal, using 1 hand and their own technique. For each throwing condition, each participant performed trials until 2 successful throws were recorded (that is, the shot went into the goal), up to a maximum of 3 trials of 3 consecutive throws. A 2- to 3-minute rest elapsed between sets of throws and 20–30 seconds elapsed between throws within the same set to minimize the fatigue effect and reduce the risk of injury to the participants. For motivation, players were immediately informed of their performance. The best shot was selected for the analysis (1).

Statistical Analyses

Statistical analyses were performed using SPSS package (17.0 version; SPSS, Inc., Chicago, IL, USA). All data are expressed as mean values ± *SD*s. A 1-way analysis of variance together with a Tukey's HSD post hoc test was used to determine whether significant differences existed among playing positions. Pearson's correlation coefficients were also used to correlate anthropometry with throw velocities. The $p \leq 0.05$ criterion was used for establishing statistical significance.

Table 3. Mean ± *SD* values of hand grip strength (N) and throwing velocity ($m \cdot s^{-1}$) of female water polo players according to their play position.

	Wings	Centers	Goalkeepers
Hand grip strength (N)	320.3 ± 45.8	307.3 ± 58.5	305.4 ± 35.2
Throwing without goalkeeper ($m \cdot s^{-1}$)	15.95 ± 1.15	16.15 ± 1.13	
Throwing with goalkeeper ($m \cdot s^{-1}$)	15.77 ± 1.28	15.73 ± 0.96	
Dynamic throw ($m \cdot s^{-1}$)	15.77 ± 1.27	15.52 ± 1.13	

Results

Wing players were significantly shorter and had smaller arm spans compared with goalkeepers and center players (Table 1). Goalkeepers

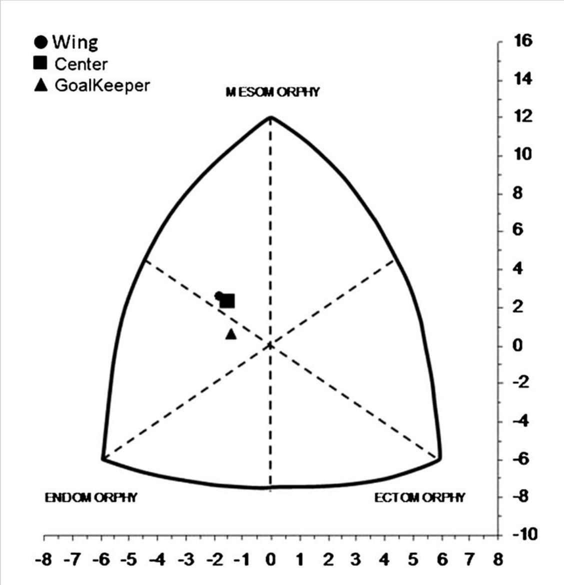

Figure 1. Representation of the somatotype in elite female water polo players.

demonstrated significantly longer forearms compared with wing and center players (Table 3). No other significant differences were found in terms of anthropometrics between positions (Tables 1 and 2).

The offensive wings (4.1-4.5-2.3) and centers players (3.9-4.3-2.3) presented with a mesoendomorph somatype, whereas the goalkeepers (4.1-3.7-2.7) presented with an endomorph somatype (Figure 1).

Handgrip strength and throwing velocity was similar across the different playing positions (Table 3). Furthermore, no significant velocity differences were evident between the different throwing conditions.

Forearm girth correlated significantly with throwing velocity across all throwing conditions (Table 4). Height and arm span were significantly correlated to throwing velocity with and without a goalkeeper; however, this relationship was not evident in the condition where swimming strokes took place before the shot. Fat-free mass correlated significantly with throwing velocity during throws made with a goalkeeper (both static and dynamic conditions) but failed to reach significance during the static condition without a goalkeeper. The biepicondylar breadth of the humerus correlated significantly with static throwing velocity without a goalkeeper and with dynamic throwing velocity with the goalkeeper present, but not during static throwing with the goalkeeper present. Handgrip strength did not correlate significantly with throwing velocity under any throwing condition.

Discussion

This is the first study to describe the anthropometric characteristics of elite female water polo goalkeepers relative to other positions and is the first study to describe throwing velocity across different positions in female water polo players at the national level.

Goalkeepers were taller, had longer arms, and presented with a more endomorphic somatotype compared with center and wing players. They also showed a nonsignificant trend toward being older than field players. These positional differences are advantageous for performance given the specific demands placed on the goalkeeper. Specifically, an endomorphic somatotype may provide enhanced buoyancy in the water, potentially reducing the energy demands placed on the goalkeeper throughout the large amounts of treading water that are required in this position. The taller frame and longer arms also provide benefit to the goalkeeper in their primary task of blocking shots from the opposition by increasing the coverage they have of the goal area. Although these differences have not previously been demonstrated in water polo, they have been shown to benefit goalkeepers in other sports, such as soccer (21).

Interestingly, no significant anthropometric or strength differences were observed between wing and center players. There was a tendency in this study for center players to be taller, heavier, and have

Table 4. Coefficient correlation values obtained between anthropometric variables and throwing velocity in the 3 tested conditions.

	Without goalkeeper	With goalkeeper	Previous displacement
Height	$r = 0.44$*	$r = 0.36$*	ns
Arm span	$r = 0.50$†	$r = 0.43$*	ns
Muscular mass by Lee	ns	$r = 0.44$*	$r = 0.39$*
Biepicondylar humerus breadth	$r = 0.40$*	ns	$r = 0.46$*
Arm relaxed girth	ns	ns	$r = 0.41$*
Arm flexed/tensed girth	ns	ns	$r = 0.46$*
Forearm girth	$r = 0.41$*	$r = 0.40$*	$r = 0.44$*
Hand grip strength	ns	ns	ns

*$p \leq 0.05$.
†$p \leq 0.001$.
ns = non-significant.

longer arm spans than wing players; however, these differences were not significant. The failure to find significant positional differences between centers and wings is consistent with previous work in Australian water polo players (25), in which only height was different between these 2 positions in players involved in the national league. In this study, it was only among international level players that significant differences were evident for body mass, skinfold (SUM7), and relative jump height. This is also consistent with previous work involving Spanish international female water polo players (11), which showed significant positional differences between centers and wings in terms of body mass, foot length, BMI, muscle mass, girths (waist, gluteus, upper thigh, and calf), and skinfolds (subscapular and axillar). With the exception of goalkeepers, our data confirm that anthropometric specialization only reaches significance among players at the international level.

Throwing velocity was also unaffected by position in this study. Although the maximal throwing speeds were significantly lower than those reported for international level female water polo players during static throws with (56.7 ± 4.0 km·h^{-1} vs. 72.3 ± 3.5 km·h^{-1}) and without (57.8 ± 4.1 km·h^{-1} vs. 73.9 ± 4.0 km·h^{-1}) a goalkeeper, as well as during throws with previous displacement (56.7 ± 4.3 km·h^{-1} vs. 73.1 ± 3.1 km·h^{-1}), the similarities between positions in regards to throwing velocity was consistent (11). This suggests that throwing velocity is not significantly different between positions regardless at the national or international level. This finding is not surprising, as both centers and wings are required to shoot toward the goal to score and as such, require a high degree of throwing velocity.

Interestingly, across the different throwing conditions, the greatest velocities were attained during shots without a goalkeeper. In cases where a tactical element was present, velocity was reduced (28). The velocities reported in this study were similar to those of recent investigations (15,20) yet higher than those presented by Elliot and Armour (9). This suggests an improvement in throwing performance in elite female water polo players over the course of the past 2 decades.

A number of parameters were significantly correlated with throwing velocity. Body height, arm span, and the girth of the forearm were positively and moderately correlated to throwing velocity with and without a goalkeeper. This positive correlation of the height and arm span to the ball velocity is consistent with previous studies involving male and female handball players (27,29,31). For throws without a goalkeeper, the biepicondylar humerus diameter also correlated with throwing velocity. These results are consistent with studies involving male water polo players (12). The absence of correlation between this variable with throwing velocity with goalkeeper could be explained with the reduction in velocity when this situation occurs. Furthermore, there was no correlation found between throwing velocity and the length of the biacromial breadth, which contrasts results from Platanou and Varamenti (20) in female water polo players and with studies of male water polo players (11). These different results could be due, in the female participants, throwing velocity was lower and the biacromial breadth higher in the Platanou and Varamenti study (20) when they were compared with the current data (~15.5 m·s^{-1} and ~39 cm, respectively; vs. ~16.0 m·s^{-1} and ~37.5 cm).

During throws made with previous displacement of the player (simulating a real game situation), the lean mass, the biepicondylar humerus breadth, the girth of the relaxed arm, the tensed arm, and forearm showed positive and significant correlations with throwing velocity. These findings are consistent with McCluskey et al. (15) study. Owed to the relationship between lean mass and strength, this suggests that upper-body strength is considered to be an essential component of throwing velocity in female water polo players. The different length variables investigated (anteroposterior chest, torax, hand width, arm, forearm, and hand length) were not correlated with previous displacement throwing velocity, as has been suggested previously (5,28).

Interestingly, the results of this study contrast previous work in the following ways: (a) handgrip strength did not correlate with throwing velocity under any throwing condition. This relationship exists in male water polo players (11,12,28) and suggests that the size of the ball may not be ideal for female players (9); (b) Different studies confirm the importance of the lower-body strength during the shot (9,11,28). McCluskey et al. (15) conclude that "lower-body power was a significant predictor of higher throwing velocity in highly skilled female water polo players." In this study, a significant relationship between the upper lean mass with ball velocity was found. However, no other significant correlations were found (i.e., lower lean mass), indicating that the role of the lower-limb strength is of minor importance for Spanish water polo players. This could be due to the low levels of strength in female water polo players as expressed by Platanou and Varamenti (20), or it could be due to a relative inability to effectively use the kinetic link principle to pass momentum through each of the segments that contributed to their reduced end point velocity (9). In any case, it is necessary to conduct more studies that include an assessment of the lower-body strength and/or a kinematic analysis of the sequential muscular activation to better know the relation between the speed of throw and the anthropometric characteristics of female water polo players.

Practical Applications

This study showed elite female water polo goalkeepers to be taller, have longer arms, and different somatotypes compared with field players. This has significant implications for team selection and training practices of this population. Specifically, nonmodifiable characteristics such as height and arm length should influence goalkeeper selection and the talent identification process, whereas the training practices of goalkeepers should allow for the development of a degree of fat mass to improve buoyancy while playing this position. Anthropometric differences between center and wing players were minimal, demonstrating that specialization was not significant. Previous research has shown that international players demonstrate a greater degree of anthropometric specialization. Coaches of national level players should focus on developing their players to suit their specific position through the implementation of a greater volume and more position-specific training to achieve optimal physical characteristics for each position. Throwing velocity was shown to be similar between center and wing players. Both positions are required to shoot toward goal; therefore, all field players in water polo ought to further develop their capacity to throw with a high degree of velocity. Throwing training under conditions where the goalkeeper is present, and following a number of swimming strokes is also indicated, to attenuate the decrease in velocity that has been shown to result from the introduction of these tactical elements.

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