Original Article

Water polo throwing speed and body composition: an analysis by playing positions and opposition level

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ABSTRACT

Ferragut, C., Abraldes, J.A., Manchado, C., & Vila, H. (2015). Water polo throwing speed and body composition: an analysis by playing positions and opposition level. *J. Hum. Sport Exerc.,10*(1), pp.81-94. The aim of this study was to develop an anthropometric profile on highly skilled male water polo players by specific playing positions. Also, to identify significant relationships between these features an overhead throwing speed in highly skilled male Water Polo players by specific playing positions. Methods: A total of 94 male water polo players (24.5±5.3 yrs) who were playing in the Spanish King´s cup were studied. Subjects were grouped according to their specific playing positions: 15 goalkeepers, 45 offensive wings, 20 center backs and 14 center forwards. Anthropometric assessment was made following ISAK protocols. Hand grip and throwing speed in several situations were also assessed. A one-way analysis of variance (ANOVA) was used to determine if significant differences existed among the four playing positions. Pearson product-moment correlation coefficients (r) were used to determine the relationships of all anthropometric measures with throwing speed and hand grip. The total player's somatotype was endomorphic-mesomorphic (2.9–5.8–2.3). Center forwards exhibit important anthropometric differences compared with the other specific playing positions in elite male water polo players, but no differences were found in throwing speed by specific playing positions in each throwing conditions. Moreover, a higher number of relationships between anthropometric and throwing speed were found in wings and also in center backs but no relationships were found in center forwards. The data reflects the importance of muscle mass and upper body in the throwing skill. Coaches can use this information in order to select players for the different specific positions. **Key words**: BODY COMPOSITION, SUCCESS IN WATER POLO, BALL VELOCITY.

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INTRODUCTION

From the point of view of physical performance water polo is a complex, intermittent sports game which requires efforts of maximum intensity over a short period of time when players swim and throw the ball at high speed followed by low intensity or rest moments (Geladas & Platanou, 2000; Mujika et al., 2006; Rodriguez & Iglesias, 2000; Smith, 1998; Van der Wende, 2005). Several studies have reported that for water polo players, in addition to the technical skills and tactics, their anthropometric characteristics as well as highs levels of force, power and throwing speed constitute determining factors in their competitive success (Bloomfield et al., 1990; Hoff & Almasbakk, 1995; Lupo et al., 2010; McMaster et al., 1990; Wallace & Cardinale, 1997). As a result of all these studies it is deduced that the physical prevailing requirements for water polo players are aerobic resistance, explosive force in the upper and lower limbs (player speed and throwing speed of the ball) and maximal force and muscular power (required in contact actions against the opponents) (Geladas & Platanou, 2000; Platanou, 2005; Rodriguez & Iglesias, 2000; Smith, 1998; Tan et al., 2009; Van der Wende, 2005; Wallace & Cardinale, 1997).

Throwing is considered one of the most important technical skills in a competitive team water polo as it is a major determinant of all actions taken by the players (Bloomfield et al., 1990; Feltner & Taylor, 1997; McCluskey et al., 2010; Van den Tillaar, 2004).

The speed of a water polo throw is not only dependent on muscular strength but also on other aspects such as body segments coordination and technical skills (Elliott & Armour, 1988; Feltner & Nelson, 1996; Feltner & Taylor, 1997; Van der Wende, 2005). Speed is a relevant aspect of success because the faster the ball is thrown at the goal the less time defenders and goalkeeper have to save the shot (McCluskey et al., 2010; Van der Wende, 2005).

Ball control in Water Polo is another skill that is essential in the game. This control is linked to the ability to grip the ball, which is important in the back swing and therefore the corresponding forward swing and its release speed (Van der Wende, 2005). Thus, hand grip becomes an important aspect for coaches, and it is necessary to control it.

In addition, the body composition of athletes has been the focus of interest in the scientific community. Research published since the 1928 Olympic Games (Bayios et al., 2006; Can et al., 2004) shows correlations between different sports and physical constitution as a factor to consider in order to achieve success in a particular sport. It has been reported that in some sports a clear physical prototype exists as the necessary basis for reaching the highest possible levels of performance (De Garay et al., 1974). Moreover it seems that the body prototype proposed by researchers one decade ago is being substituted by another prototype based on specialization (Norton & Olds, 2001). These authors postulated that for each sport, and also within the same sport, each position occupied in the playing field requires unique physiological and physical attributes in order to achieve the highest possible performance. These issues are also important in water polo because each specific position requires its own skills according to its task (Lozovina et al., 2009; Platanou & Geladas, 2006; Tan et al., 2009; Tsekouras et al., 2005).

The intermittent nature of this sport, together with the limitations imposed by the aquatic environment, makes the assessment of physiological capabilities of water polo player's technically difficult (Hohmann & Frase, 1992). However, the development of a comprehensive battery of tests that would include both anthropometric and physiological measurements would offer a more integrated profile of the elite water polo player (Tsekouras et al., 2005).

Research about the anthropometric profile and throwing speed for players of water polo are scarce (Bloomfield et al., 1990; Ferragut et al., 2010; McCluskey et al., 2010; Vila et al., 2009), and there is a notable absence of studies examining the throwing speed for the various playing positions.

Therefore the purpose of this study was to investigate the anthropometric characteristics, throwing speed and maximal hand grip of elite male water polo players and to examine the different characteristics required for the different playing positions (wing, center back, center forward and goalkeeper).

MATERIAL AND METHODS

Participants

94 injure free male water polo players (24.5±5.3 yrs) who were playing in the Spanish King´s cup (The King's Cup is the second major competition in Spain and the Spanish league is one of the strongest in the European League) were studied. Subjects were grouped according to their specific playing positions: 15 goalkeepers, 45 offensive wings, 20 center backs and 14 center forwards.

The study was approved by the San Antonio Catholic University Committee for research involving human subjects and carried out according to the Declaration of Helsinki. All participants received verbal and written information about the study and gave informed written consent before anthropometric and conditional assessment. Additional background information was provided by each player, including date of birth, specific playing position and the number of years playing water polo. The participants performed the tests shortly before King's Cup championship. All the subjects were well hydrated and they were instructed to consume food and to drink as usual during breakfast the day when the measured were realized.

Measures

The International Society for the Advancement of Kinanthropometry (ISAK) (Stewart et al., 2011) protocol was used to determine the anthropometric profile of the water polo players.

Subjects were measured in their club setting during a single measurement session. Unilateral measurements were taken on the right side of the body. Participants wore light clothing (slip) and were barefoot.

Physical characteristics were measured in the following order: height, body mass, arm span, skinfolds, body girths and skeletal breadths. The anthropometric program included about 31 measurements. Height and weight measurements were made on a levelled platform scale (Seca, Barcelona, Spain) with an accuracy of 0.01 kg and 0.001 m, respectively. Nine skinfolds (triceps, subscapular, biceps, axilar, abdominal, iliac crest, suprailiac, front thigh and medial calf) were measured using the Holtain Skinfold Calliper with 10 g.mm-2 of constant pressure and an accuracy of 0.2 mm. Ten limb and trunk girths (arm relaxed, arm flexed and tensed, forearm, waist, chest, gluteal, upper thigh, medial thigh, calf and ankle) were measured using a Lufkin metal tape, (Lufkin Executive Thinline, W606PM, USA) and six skeletal breadths (biacromial, biepicondylar-humerus, biepicondylar, biiliocristal, Antero-Posterior chest depth and bitrochanteric) were measured using an anthropometer (GPM, Switzerland) with an accuracy of 0.01 cm. Five lengths were measured using an anthropometer (GPM, Switzerland) with an accuracy of 0.01 cm in upper limbs (arm length, forearm length, arm span, hand length and hand width).

Double measures for each anthropometric dimension (triple measures for skinfolds) were obtained by one accredited level II and three accredited level I ISAK anthropometrists. The technical error of measurement was <2% for all skinfolds and <1% for all bone breadths and body girths.

Several variables were derived: a) The body mass index (BMI) was calculated as weight (kg) divided by height squared in meters (m2); b) Sum of four (triceps, subscapular, suprailiac and abdominal) and six skinfolds (triceps, subscapular, suprailiac, abdominal front thigh and medial calf); c) Fat free mass (FFM) (Kg) using the method described by Lee (Lee et al., 2000); d) Selected anthropometric measures were used to determine somatotype following the methods described by Carter (Carter & Heath, 1990).

Throwing speed was assessed with a radar gun (StalkerPro Inc., Plano, TX, USA), with 100 Hz frequency of record and with 0.045 m•s-1 sensitivity, placed behind the goal post and in a perpendicular direction to the player. This test has been shown to have very good test-retest reliability Intraclass correlation coefficient (ICC) of 0.96 and a coefficient of variation (CV) of 2.4%. The experimental protocol was conducted in a short course outdoor swimming pool with a mean depth of 2.0 m and the water temperature at 27.5ºC.

Prior to the throwing speed assessment, subjects performed a 15 min warm up focused on specific aspects of throwing ability. Three series of three maximal intensity shoots, with a 3 min rest interval, were conducted using a standard water polo ball (Mikasa 6000): (i) from the penalty line (5.0 m) without any opposition: shooting at goal without the presence of the goalkeeper; (ii) from the penalty line with the opposition of only the goalkeeper and (iii) from the penalty line with previous displacement in perpendicular direction to the goal post with the opposition of the goalkeeper. In each serie of three shoots, players were immediately informed of the accomplished results, being only the best trial chosen for data analyses.

Additionally, maximal isometric hand-grip force was recorded using handheld hand-grip dynamometry (T.K.K. 5401, Tokyo, Japan), with a sensitivity of 10 N. This test presents an ICC of 0.95 and 0.91 for both left and right hands respectively and a CV of 4.9%. The study subjects were familiarized with the dynamometer with three repetitions to warm up. The players performed 2 repetitions at maximum intensity with the dominant hand. They did it at a standing position with the dynamometer set parallel to the body. In this position the player was asked to exert maximal grip force without arm or wrist movement. The best trial was used for further analysis. For motivational purposes, players were immediately informed of their performance. Three minutes rest elapsed between trials in order to minimise the effects of fatigue.

Statistical analysis

Standard statistical methods were used to calculate the mean and standard deviations. All data is expressed as mean ± standard deviation (all data were checked for distribution normality and homogeneity with the Kolgomorov-Smirnov, Lilliefors and Levene tests). A one-way analysis of variance (ANOVA) was used to determine if significant differences existed among four playing positions (goalkeepers, offensive wings, center backs and center forwards). The Tukey-Kraemer multiple comparison procedure for unbalanced data (Kramer, 1956) (unequal group sizes) was used as a pot hoc test. Pearson product-moment correlation coefficients (r) were used to determine the relationships of all anthropometric measures with throwing speed and hand grip. The reliability of the hand grip was assessed using ICC (ICC= 0.93). The CV of the field tests was also calculated, and was under 5% for all tests. The $p \leq 0.05$ criterion was used for establishing statistical significance.

RESULTS

General anthropometric and training background characteristics by specific playing position are presented in Table 1. It can be assessed that center forwards are significantly heavier and show higher values of arm span, than goalkeepers, and wings ($p \leq 0.05$). Additionally center backs are heavier than wings and goalkeeper (p≤0.05) but lighter than center forwards (p≤0.05), and center forwards are taller than wings (p≤0.05). Significant differences were found among center forwards compared with wings and goalkeepers (p≤0.05) for BMI and only with wing for sum of 4 and 6 skinfolds (Table 1). Nevertheless, center forwards exhibit higher muscular mass than wings and goalkeepers (p≤0.05).

Table 1. Mean and standard deviations values ( ) correspondent to anthropometric characteristics of male water polo players according to their playing position. Significant differences between groups (p£0.05): (*) with wing; (‡) with center forward; (†) with center back

	Wing (n=45)	Center back (n=20)	Center forward (n=14)	Goalkeeper (n=15)	Total (n=94)
Age (yrs)	24.5±5.3	24.2±4.2	26.0±5.6	24.0±5.2	24.6±5.1
Training Experience (yrs)	14.6±5.7	13.4±4.1	14.8±5.7	12.9±3.5	14.1±5.0
Body Mass (kg)	82.8±9.1†	89.6±8.2*	98.0±10.0*†	81.2±9.8†‡	86.3±10.7
Body Height (cm)	184.1±6.2	187.3±6.2	190.5±5.9*	185.3±8.1	185.9±6.9
Arm span (cm)	191.9±6.8	195.7±5.8	201.0±5.8*	190.3±9.6‡	193.8±7.7
Body Mass Index (Kg/m^2)	24.4±2.0	25.6±2.4	27.0±2.4*	23.6±1.5‡,†	24.9±2.3
Σ 4 Skinfolds (mm)	54.2±15.0	58.5±17.5	71.3±19.2*	57.9±17.6	58.2±17.3
Σ 6 Skinfolds (mm)	68.0±16.1	73.1±21.2	89.2±25.8*	71.0±19.6	72.7±20.4
Muscle Mass (Kg)	35.5±3.0	37.4±3.6	40.5±3.5*	35.3±5.4‡	36.6±4.0
Upper limb length (cm)	82.2±3.8	84.1±4.7	85.1±2.7	80.7±4.3	82.8±4.2
Forearm length (cm)	27.3±1.9	28.3±2.5	28.1±1.5	27.1±2.1	27.6±2.0
Hand length (cm)	20.2±2.0	20.4±1.7	21.3±1.3	19.7±1.5	20.3±1.8
Hand width (cm)	22.1±1.5	22.6±1.9	23.7±1.7*	21.9±1.7‡	22.4±1.7
Biacromial breadth (cm)	42.2±2.1	43.1±2.7	44.0±2.2	42.7±2.5	42.7±2.4
Biepicondylar humerus (cm)	7.8±0.5	7.8±0.3	7.8±0.6	7.6±0.4	7.8±0.5
Biiliocristal breadth (cm)	28.3±2.2	29.7±2.7	30.7±2.2*	27.7±1.9‡	28.9±2.5
Bitrochanteric breadth (cm)	33.0±2.1	34.3±1.7	34.1±1.9	32.1±3.1†	33.3±2.2
Biepicondylar femur (cm)	10.1±0.6	10.5±0.6	10.5±0.4	10.2±0.5	10.3±0.6

Significant differences for hand width (Table 1) were found (p≤0.05) among center forwards compared with wings and goalkeepers.

No significant differences were found in biacromial, femur and humerus breadth among different specific playing positions. Nevertheless, center forwards show significant differences compared with wings and goalkeepers in biiliocristal breadth (p≤0.05). Center backs exhibit higher values of bitrochanteric breadth (p≤0.05) compared with goalkeepers (Table 1).

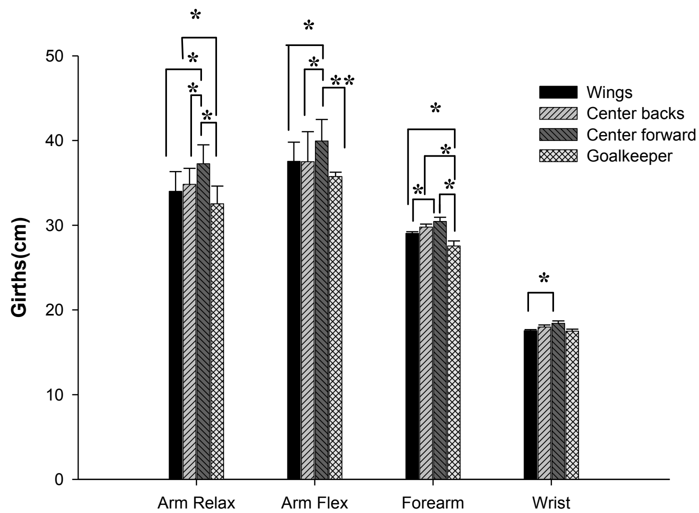

Figure 1. Upper body girths values. Significant differences among playing positions (*) $p \leq 0.05$

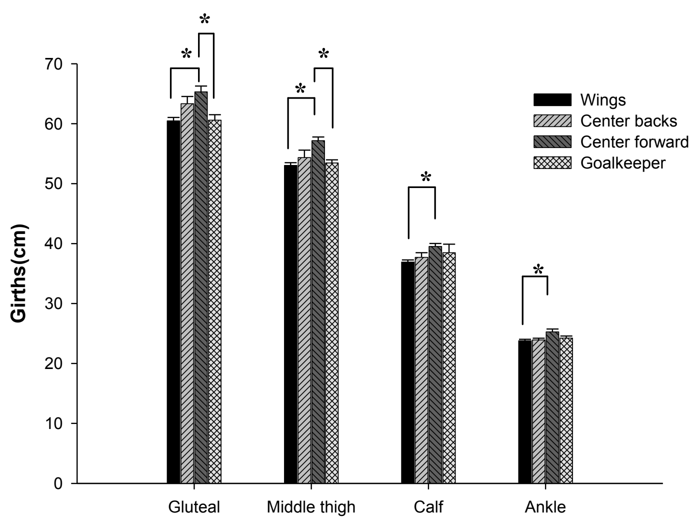

Figure 2. Lower body girths values. Significant differences among playing positions (*) $p \leq 0.05$

Center forwards exhibit greater values of arm relaxed girth than wings ($p \leq 0.01$), center backs ($p \leq 0.05$) and Goalkeeper ($p \leq 0.001$). Likewise, center backs presents higher values of arm relaxed girth than goalkeepers ($p \leq 0.05$). Related to arm flexed girth, center forwards show higher values than wings ($p \leq 0.05$), center backs ($p \leq 0.05$) and goalkeepers ($p \leq 0.001$). Additionally, center forwards show significant differences with wings in forearm girth ($p \leq 0.05$) and goalkeepers exhibit lesser values in forearm girth compared to the other specific playing positions ($p \leq 0.05$). It is also remarkable that center forward show higher values in wrist girth than wings ($p \leq 0.05$) (Figure 1).

Furthermore, center forwards exhibit higher values in chest girth compared to the other specific playing positions ($p \leq 0.005$).

Related to lower body girths, center forwards present significant differences in waist girth related to the other specific playing positions (p≤0.05).

Likewise, center forwards show significant differences with wings and goalkeepers in gluteal girth (p≤0.005), upper thigh girth (p≤0.05) and middle thigh girth (p≤0.05). However, center forwards only show significant differences in calf and ankle girth with wings (p≤0.05).

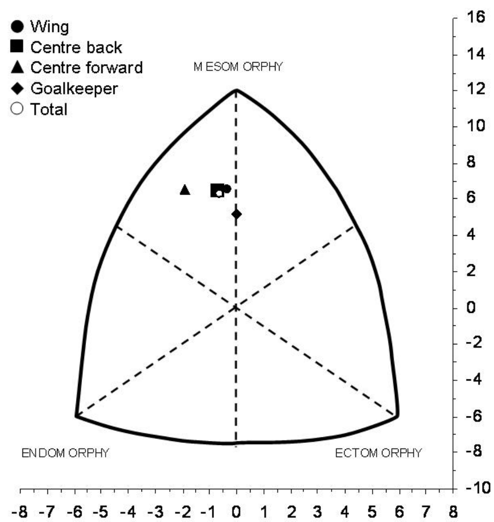

Figure 3. Somatotype distribution of elite male water polo players

General water polo player somatotype in this study was characterized as a balanced mesomorphic (2.9–5.8–2.3). Related to specific playing positions, significant differences were found among center forwards compared with wings, center backs and goalkeeper players in the endomorphic component. Mesomorph is the main component for all playing positions and ectomorph is the least common component of all playing positions. Additionally, significant differences were found between center forwards and goalkeepers in the ectomorphic component.

Table 2. Mean and standard deviations values ( ) of somatotype of male water polo players according to their play position. Significant differences between groups (p£0.05): (*) with center forward

Position	n	Endomorph	Mesomorph	Ectomorph
Wing	45	2.7±0.6*	5.8±1.1	2.4±0.8
Center back	20	2.9±0.9*	5.8±1.3	2.1±1.0
Center forward	14	3.7±1.3	6.0±1.1	1.8±0.8
Goalkeeper	15	2.8±0.6*	5.4±1.3	2.8±0.8*
Total	94	2.9±0.8	5.8±1.1	2.3±0.9

Hand grip scores of male water polo players are shown in Table 3. Center forwards exhibit higher hand grip values than wings and goalkeepers (p≤0.001). Center backs exhibit higher hand grip values than goalkeepers (p≤0.001).

Table 3. Mean and standard deviations values ( ) of hand grip (N) and throwing speed (m.s-1) of male water polo players according to their play position. Significant differences between groups (p£0.05): (*) with center forward; (†) with center back

Position	n	Hand-grip (N)	5 m. without goalkeeper ($m.s^{-1}$)	5 m with goalkeeper ($m.s^{-1}$)	5 m. with goalkeeper and previous displacement (m.s-1)
Wing	45	540.5±5.5*	21.3±3.7	20.8±3.6	20.7±3.9
Center back	20	575.4±5.3	21.4±4.4	20.8±4.3	20.5±4.3
Center forward	14	598.6±5.2	20.7±3.8	20.2±3.5	19.9±2.7
Goalkeeper	15	506.1±6.8*†	---	---	---
Total	94	551.0±6.3	21.1±4.7	20.6±4.4	20.4±4.5

Throwing speed in the different situations is shown in Table 3. There are no differences in throwing speed among different specific playing positions.

Table 4. Correlation coefficient values obtained between anthropometric variables and throwing speed in the three tested conditions. Results are expressed by water polo specific playing position

Specific Positions	Anthropometric characteristics	Throwing without goalkeeper	Throwing with goalkeeper	Dynamic shot
Center back (n=17)	Arm girth flexed and tensed girth	0.522*	ns	ns
	Hand Grip	0.501*	ns	ns
Wing (n=39)	Height	ns	0.364*	0.450**
	Body Mass	0.389*	0.441**	0.493**
	Arm Span	0.326*	0.382*	0.335*
	Iliac Crest skinfold	0.321*	0.337*	ns
	Abdominal skinfold	0.321*	0.372*	0.339*
	Muscular Mass	ns	0.468*	0.504**
	Arm relaxed girth	0.361*	0.433**	0.534**
	Arm flexed and tensed girth	ns	0.383*	0.510**
	Forearm girth	ns	0.367*	0.476**
	Wrist girth	0.394*	0.372*	0.442**
	Chest girth	ns	ns	0.427**
	Waist girth	ns	0.317*	ns
	Biacromial breadth	0.462**	ns	ns
	Chest AP breadth	0.390*	0.352*	0.386*
	Biiliocristal breadth	ns	ns	0.429**
	Arm length	ns	0.384*	0.358*
	Hand grip	ns	0.355*	0.353*

Table 4, presents the correlation coefficients of the anthropometric variables that significantly correlated with throwing speed in the three tested conditions:

Center backs show a significant correlation between arm flexed and tensed girth (r=0.522*) with throwing speed without goalkeeper.

Wings present significant correlations with several anthropometrics characteristics. There is a significant correlation between wing´s weight and arm span with throwing speed in the three tested situation. Furthermore, wing´s height showed a significant correlation with throwing speed with goalkeeper (r=0.364*) and dynamic shot (r=0.450**).

Regarding to breadths, wings present significant correlations between biiliocristal breadth, biacromial breadth and Antero-Posterior chest depth with throwing speed (see table 4). They also present correlations between throwing speed with several girths, skinfolds and muscular mass (see table 4).

No significant differences were found in the center forward between throwing speed and anthropometric characteristics in any of the shots evaluated.

Hand grip shows significant correlations with throwing speed but only in wings and center backs. Hand grip correlates with throwing speed with goalkeeper (r=0.355*) and dynamic shot (r=0.353*) in wings, but in center back, hand grip only presents a significant correlation with throwing speed in throwing without goalkeeper (r=0.501*).

DISCUSSION

In water polo, each playing position requires different skills that should be reflected in player´s body composition. The main goal of this study is to establish the anthropometric profile of elite male water polo players by playing position.

Mean height and weight of the players in this study (185.9 cm y 86.3 kg) are in line with recent published studies in water polo (Lozovina & Pavicic, 2004; Platanou & Geladas, 2006; Tsekouras et al., 2005). These studies reported mean height and weight about 183-185.5 cm of height and 85.2 kg of weight, but are lesser than those reported by others studies (Dopsaj & Alesksandrovic, 2009; Ferragut et al., 2011; Lozovina et al., 2009; Melchiorri et al., 2010; Mészáros et al., 1998; Mujika et al., 2006; Pavlik et al., 2005; Tsekouras et al., 2005) which that points to values of 188.1-193.3 cm for height and 88.8-96.8 kg for weight.

By playing positions it is established that smaller and lighter players are wings and goalkeepers, while higher values for height, weight and arm span are shown by center forwards and center backs. These results do not agree with those published by Platanou and Geladas (Platanou & Geladas, 2006) and by Dopsaj and Aleksandrovic (2009) for the playing position of goalkeeper. Those researchers reported that Goalkeepers are the highest players in a water polo team and they do not find differences in weight for this playing position. Results are in line with the anthropometric characteristics for each position published by other researchers (Lozovina et al., 2009; Smith, 1998). It has to be noticed that taller players perform better in the position of center forward in the playing field because their added height allows for a greater field of vision. Heavier weight can be a benefit for center forward and center back players in order to fight for position advantage in a one on one situation.

Goalkeepers show lower values of arm span than center forwards, but no differences were found comparing goalkeepers with other specific positions. This result was not expected because the goalkeeper seems to be a specific position where arm span is essential in order to reach over every space of the goal post (Dopsaj & Alesksandrovic, 2009; Lozovina et al., 2009; Smith, 1998).

Regarding BMI, the results obtained show that the average body mass index of the top Spanish senior water polo players is 24.9. The data taken from available literature report that elite water polo players from Hungary have an average index of 24.99 (Mészáros et al., 1998), elite water polo players from Serbia have an average index of 25.91 ± 2.09 (Dopsaj & Alesksandrovic, 2009), from Croatia of 23.90 ± 1.40 (Lozovina & Pavicic, 2004), and from Greece of 26.70 ± 1.70 (Tsekouras et al., 2005).

As it is well known (WHO, 1995), BMI is a measurement of the relative percentages of fat and muscle mass in the human body. Players spend approximately half of the time of a game in a vertical position, during which they are usually found in some kind of a duel with an opponent player (Lozovina et al., 2009; Smith, 1998). From the point of view of hydrostatics and hydrodynamics a bigger body volume provides better conditions for flotation (Andreoli et al., 2004). These two factors (the vertical position and duel play in the function of hydrostatic and hydrodynamic principles of body behaviour in water) are possible because the difference in the BMI aspect was not established. From an anthropomorphological point of view this implies that body volume and body constitution are categories which are the same or at least very similar for all water polo players regardless their field positions. Furthermore, it seems that a higher value level of BMI is not a limiting factor for efficient water polo playing (Dopsaj & Alesksandrovic, 2009).

Male players were similarly homogeneous in body composition (sum of 4 and 6 skinfolds) with respect to playing position, the only exception being the center forwards who had a greater body composition than wings. Goalkeepers and wings show lower values of muscular mass than center forwards. These results are in line with other investigations (Lozovina et al., 2009; Smith, 1998).

Wings exhibit lesser values of fat free mass than center forwards. This is in agreement with specific position requirements because wings rarely have contact with defence players and furthermore the agile movement and the ability to accelerate and decelerate rapidly are essential for this specific playing position (Lozovina et al., 2009; Smith, 1998). Greater weight and muscular force can be advantageous characteristics in order to fight for spatial occupation within 2-4 m against the defenders. Therefore greater muscular mass can be considered an important characteristic for center forwards and center backs.

As for the variables that evaluate upper body lengths, the specific positions of center back, center forward, wing and goalkeeper positions show similar values for all lengths studied. Nevertheless, there are differences among center forwards with wings and goalkeepers in hand width. These results are in line with playing characteristics of the team, where arm span and hand length are important in order to be successful at throwing skills (Visnapuu & Jurimae, 2007). Greater upper body length allows center forwards to receive, adapt and drive the ball among the defenders and gives advantage in fight situations. Wings have other needs, different from other specific positions in which upper body lengths do not seem to be so important. This is due to the fact that wing players play outside the center field; further from the defence and they must throw the ball towards the goal post.

Circumference measures demonstrate the difference between specific buoyancy position and other specific positions, especially attacking and goalkeeper positions. The center forwards showed the greatest girths measures due to the contact play that requires greater strength levels. As the upper leg girth is a crucial strength indicator it is quite conceivable that the center forwards differ from other positions in this particular variable because the position requires more strength than any other position (Dopsaj & Alesksandrovic, 2009; Lozovina et al., 2009).

When we analyzed the somatotype according to playing position the center backs and center forwards display an endomorphic-mesomorphic somatotype, where mesomorph and endomorph are predominant. For wings and goalkeepers the somatotype was balanced mesomorphic, where the main component was mesomorph. The principal component in all the specific playing positions was mesomorph. This somatotype is according to elite water polo player's physical characteristics, muscle mass being important. Ectomorph displayed the lowest values. These results are in accordance with other papers published about male water polo players (Lozovina et al., 2009; Vila et al., 2009).

Throwing speed in water polo is important in order to achieve sporting success because the faster the ball is thrown at the goal the less time defenders and goalkeeper have to save the shot (Lozovina et al., 2009). Other studies of elite male water polo players reported mean throwing speeds of 16.5 – 20.5 m.s-1 (Bloomfield et al., 1990; Elliott & Armour, 1988; Feltner & Taylor, 1997; Ferragut et al., 2011; Whiting et al., 1985). The speed reached by our male water polo players are similar to those reported in other studies.

A priori, significant differences among the specific playing positions in strength and throwing speed could be expected to be found. The results confirm the differences between goalkeepers and field players. But there are no differences between field players except in hand grip strength between center forwards and wings. Our results are consistent with (Van der Wende, 2005) but are not in line with Melchior et al (Melchiorri et al., 2010). These authors reported lower mean values in throwing speed in center forward than center backs and other field players, but we could not find differences in none of the three shoots analysed.

Grasping the ball is essential in water polo. This grasp is associated with the ability to grip it well. A good grasp is related with the ball speed when throwing (Visnapuu & Jurimae, 2007; Wallace & Cardinale, 1997). Water polo players exhibit a mean hand grips strength value of 550.5 N. By specific positions, center forwards are the players that show higher values of hand grip, but these differences only get statistical significance when center forwards are compared with wings and goalkeepers. These results are in line with those reported by Visnapuu and Jurimae (2007). These authors conclude that height, weight and BMI, just like hand skill, can influence hand grip strength.

Additionally, several connections were observed, by specific positions. A higher number of relationships were found for wings, and no relationships were found for center forwards.

Center backs only present correlations in arm flexed and tensed girths and hand grip, proving that anthropometric variables indicative of strength, such upper arm girths are associated with throwing speed (McCluskey et al., 2010).

Surprisingly, wings show the highest number of correlations; those results are not in line with Ferragut et al. (2011), who found the highest number of correlations in center forward. This could be due the few subjects analyzed in that paper.

Several correlations between throwing speed and girths were found in wings, and most of them were in the upper body, this could be due to the particular relevance of muscular strength in throwing speed and the importance of the trunk in order to stabilizing the body during shoot in this specific playing position (McCluskey et al., 2010).

Two skinfolds (iliac crest and abdominal) show a significant and positive correlation with throwing speed in wings suggesting the importance of upper body skinfolds in throwing speed in wings.

CONCLUSIONS

These results provide normative physiological and anthropometric data according to specific playing position for elite Spanish league male water polo players. Coaches can use this information in order to select players for the various specific positions with a higher probability of reaching a peak performance levels and so improve team success. Coaches also use this information to design training routines with greater efficiency because they can better develop the skills for success for each specific position.

Moreover, suggest that water polo players use different patterns of movement to get maximal shot velocity by specific playing positions. This is essential information for coaches that can design new training routines related with physical preparation.

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