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RELATIONSHIP BETWEEN ANTHROPOMETRIC PARAMETERS AND THROWING VELOCITY IN WATER POLO PLAYERS

Vila H¹, Ferragut C¹, Argudo FM², Abralde JA¹ , Rodríguez N¹, Alacid F³

¹Catholic University San Antonio (UCAM), Murcia, Spain. ²Autonomous University of Madrid (UAM), Madrid, Spain. ³University of Murcia (UMU), Murcia, Spain.

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ABSTRACT

Water polo is a collective sport and efforts of high intensity are made in less duration, where the players must swim, jump, and send the ball with moments of rest or low intensity. The necessity of greater, stronger, and faster players is supported by the development in the anthropometric characteristics. The aim of this study was to establish the importance of the anthropometric factors in the throwing velocity (v), evaluated on 22 players pertaining to Spanish Selection of water polo. The references to the anthropometric profile were measured according to the protocol of the International Working Group of Kinanthropometry (ISAK), considered by literature as those recommended to characterize a population of sportsmen. The conditional evaluation was centered on the evaluation of the specific v of three types of shootings, in the swimming pool and from the distance of 5 m. The v were measured with radar (Inc., Flat StalkerPro), with a frequency of registry of 100 Hz and with 0.045 sensitivity of $m \cdot s^{-1}$. The results show that the higher v is reached with the throwing without goalkeeper and the lower v in the throwing with goalkeeper. The corporal size through the Body Mass Index (BMI) ($r=0.5$), circumference of the arm ($r=0.5$), biacromial breadth ($r=0.5$) and the femur breadth ($r=0.6$) correlate with the throwing v with goalkeeper in players of water polo. The corporal size is confirmed as an important factor to arrive at the high performance in water polo ($p<0.05$).

Key words: somatotype, body fat, muscle mass, specific velocity upper limbs

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Corresponding author. Departamento de Ciencias de la Actividad Física y del Deporte. Universidad Católica San Antonio de Murcia. Avda. de los Jerónimos S/N. 30.107 Guadalupe. Murcia.

Tel.: 968.27.88.24. Fax: 968.30.70.66

E-mail: aabraldes@pdi.ucam.edu

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INTRODUCTION

Water polo is a collective sport and efforts of high intensity are made in less duration, where the players must swim, jump, and send the ball with moments of rest or low intensity; it is also a contact sport where the players conduct battles against their adversaries like blockades, beatings, contacts, and pushes (Smith, 1998; Van der Wende, 2005). The necessity of greater, stronger, and faster players is supported by the development in the anthropometric characteristics and the optimization of the training of the specific physical capacities (Aleksandrović et al., 2007; Lozovina & Pavicic, 2004; Mészáros et al., 1998).

Although water polo shows a great amount of important skills, surely one of the most decisive is throwing (Smith, 1998; Van der Wende, 2005). The speed of the ball toward the goal post is an essential characteristic in this sport and depends on the muscular force, technique, and suitable synchronization of different corporal segments (Joris et al., 1985). The knowledge to combine the speed of the ball and the precision in the throwing is one of the most important factors with a decisive effect on the final result, since the faster and fitter the ball is, the more difficult it is for defenders and goalkeeper to intercept it. For that reason, there are studies that have been centered on the biomechanics analysis of the throwing of a penalty (Ball, 1996; Clarys et al., 1992; Clarys & Lewillie, 1970; Davis & Blanksby, 1977; Elliott & Armour, 1988; Feltner, 1996; Feltner & Nelson, 1994; Feltner & Taylor, 1997; Whiting et al., 1985; Van der Wende, 2005; Stirn & Strojnik, 2006), but studies that include goalkeeper, and goalkeeper and players are minimum (Van der Wende, 2005; Davis & Blanksby, 1977).

The studies in water polo that relate the force and the throwing velocity (v) of the upper limbs are few (Bloomfield et al., 1990; McMaster et al., 1990). In fact, little has been studied about the determination of the force and throwing v of the upper limbs, in players of water polo. McMaster (1990) analyzed it through isokinetics measurements, with the purpose of detecting problems in muscular imbalances, and Bloomfield et al. (1990) analyzed the relation between the force and the throwing v , and its relation with anthropometric parameters. There are no studies in water polo that analyze ways that make specific the throwing v by specific positions, with neither tactical elements nor their relation with the anthropometric variables. Although, this kind of studies has been conducted in other sports like handball (Gorostiaga et al., 2005; Joris et al., 1985; Van den Tillaar, 2004). It's important to notice that in handball, kinetic chain its very important for throwing velocity, because players are on the floor and the situation is different in water polo where players are in the water.

The corporal composition in the athletes, especially among top elite athletes, has been attracting great interest in the scientific community, because it contributes clear information about the structure of the sportsman at a certain moment and quantifies the modifications caused by the training. Good proof of this is the great amount of works that have been published describing the anthropometric profile of populations of different sports (Lozovina & Pavicic, 2004; Tsekouras et al., 2005; Gabbett, 2005; Sands et al., 2005). Through different studies, one was able to define an ideal profile in each sport, and through them, today there is no doubt that determining physical characteristic is bound to the maximum sport yield. The optimal yield will therefore require certain physical characteristics that will vary based on the sport and based on

the category in which they compete; in fact it seems that the proposed athletic ideal prototype for a century is being replaced by a totally different one, being characterized by a high specialization (Norton & Olds, 2001). These authors shuffle the hypothesis that with each sport and even within the same sport, the position that the athlete occupies requires unique physical and physiological attributes that will allow him/her to obtain a better sport yield. In this sense also, there are a few studies that analyze anthropometric and conditional characteristics in water polo (Aleksandrović et al., 2007; Frenkl et al., 2001; Mészáros et al., 1998; Tsekouras et al., 2005) and that discuss specific positions (Platanou, 2006; Pavicic et al., 2000).

This work does not express the inherent limitations and difficulties in this area of investigation, not only as far as the objective, method, and system of common scientific laws that regulate the game are concerned, but also in the small number of works that make possible the confrontation of motivations, ideas, and results.

The aim of this study was: to establish the importance of the anthropometric factors in the throwing *v*.

MATERIAL AND METHODS

The subjects studied were 22 players of the Male Spanish National Team (Table 1) with a mean age, weight, height, and body mass index of 24.77 ± 5.69 years, 89.24 ± 11.57 kg, 187.41 ± 6.63 cm and 25.36 ± 2.54 kg.m⁻², respectively.

Table 1. Mean and standard deviations values ($\bar{x} \pm sd$) correspondent to anthropometric characteristics of Spanish Water Polo players.

	Age (years)	Experience (years)	Height (cm)	Weight (kg)	Arm Spam (cm)	Hand length (cm)
Total Players	24.77±5.69	12.77±3.83	187.41±6.63	89.24±11.57	195.08±7.77	21.20±1.00

All the sportsmen and the technical team were informed about the tests, as well as the possible risks and benefits of the same. This study was approved by the Institutional Review Committee of the San Antonio Catholic University and was carried out according to the Declaration of Helsinki.

For the measurements, the norms and techniques were followed as recommended by the International Working Group of Kinanthropometry (Ross & Marfell-Jones, 1995) and the criteria of the ISAK. The evaluation of the anthropometrics characteristics was made in parameters considered important for the sport yield, in general, and for water polo, in particular (Aleksandrović et al., 2007; Bloomfield et al., 1990; Platanou, 2005; Platanou & Geladas, 2006; Smith, 1998; Tsekouras, 2005; Carter & Ackland, 1994).

The weight and curves were accurately moderate with an SECA scale and height meter (SECA Germany) of fractions of 100 g for the weight and 0.1 cm for the stature. The perimeters were moderate by triplicate, with a millimeter inextensible fiber glass tape measure Holtain (Holtain Ltd. United Kingdom). The diameters (Wrist Breadth and Humerus Breadth, Femur Breadth and Biacromial Breadth) were determined with paquimeter Holtain of 1 mm precision (Holtain Ltd. United Kingdom). In the corporal composition, the body fat percentage was evaluated through the formula of Yuhasz (1974), the muscular percentage through the formula of Martin (1990) and the Body

Mass Index (BMI). For somatotype, anthropometric method used by Heath and Carter (1975) was followed.

The throwing v was also evaluated. This was made with a previous warm up of 15 min centered on specific aspects for the shooting. The production of specific explosive force of the upper limbs was evaluated in a discovered swimming pool, by means of a radar (Inc., Flat StalkerPro), with a frequency of registry of 100 Hz and with 0.045 sensitivity of $\text{m}\cdot\text{s}^{-1}$, placed after goal post (Figure 1). Two shootings were made to maximum intensity from the line of penalty (5m) without goalkeeper; the other two shootings were made in the same conditions as the previous one but with goalkeeper. Both cases had no possibility of promising to be before the throwing, and the other two from the same zone but with previous displacement and always in perpendicular direction of goal post. Of the three series of shootings, the best shot was chosen. To motivate, the players were immediately informed about the results. The goalkeeper did not participate in this test. Between each series of shootings, an interval of 3 min of rest was left to avoid the possible interferences owing to fatigue. All the shootings took place with balls prescribed for the senior category (Mikasa 6000).

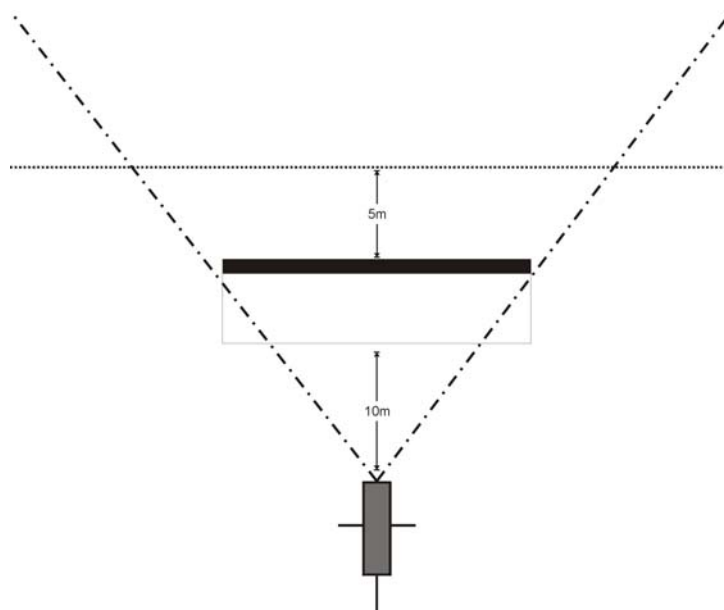


Figure 1. Schematic representation of the radar situation during measures

The data was stored in a database created to this end and later treated by means of a commercial statistical program (SPSS for Windows, Version 15.0). The probability distribution of the different variables was analyzed by calculating the basic descriptive statistics (average, standard deviation), and the tests of hypothesis (test of Kolgomorov–Smirnov and Lilliefors) and test of homogeneity of Levene were accomplished.

Relationships between the variable, throw v , and handgrip strength with body composition have been shown. The criterion variables were examined using Pearson product–moment correlation coefficients. Statistical significance was set at $p < 0.05$.

RESULTS

The subjects characteristics are shown in Table 1. Mean and standard deviation of fat and muscular percentage appears in Table 2. The anthropometric characteristics are shown in Tables 3, 4, 5.

Table 2. Mean and standard deviations values ($\bar{x} \pm sd$) correspondent to fat and muscle percentage characteristics of Spanish Water Polo players.

	Yuhasz (%)	BMI (kg/cm²)	Muscle Mass (%)	Σ 4 Skinfolds (mm)
Total Players	10.63±2.06	25.36±2.54	53.23±7.12	36.46±9.56

Table 3. Mean and standard deviations values in cm ($\bar{x} \pm sd$) correspondent to breadths of Spanish Water Polo players.

	Humeros Breadth	Wrist Breadth	Femur Breadth	Biacromial Breadth	Biiliocrystal Breadth
Total Players	7.26±0.65	6.12±0.40	10.18±0.59	44.58±2.67	35.52±2.00

Table 4. Mean and standard deviations values in cm ($\bar{x} \pm sd$) correspondent to girths (upper limbs) of Spanish Water Polo players.

	Arm girth	Arm Girth Flexed and tensed	Forearm girth	Wrist girth	Chest girth	Waist girth
Total Players	34.76±2.62	37.31±2.43	29.54±1.73	17.61±0.84	106.10±6.06	86.46±5.92

Table 5. Mean and standard deviations values in cm ($\bar{x} \pm sd$) correspondent to girths (lower limbs) of Spanish Water Polo players.

	Gluteus girth	Superior thigh girth	Thigh girth med	Calf girth	Ankle girth
Total Players	100.92±4.79	60.01±3.74	56.52±3.37	37.69±2.14	23.32±1.60

The somatotype of water Polo players is located in the balanced mesomorphy (Table 6). The somatograph of the Spanish water polo team are represented in figure 2.

Table 6. Mean and standard deviations values ($\bar{x} \pm sd$) correspondent to somatotype characteristics of Spanish Water Polo players.

	Endomorphy	Mesomorphy	Ectomorphy
Total Players	2.91±0.80	5.46±1.26	2.16±0.93

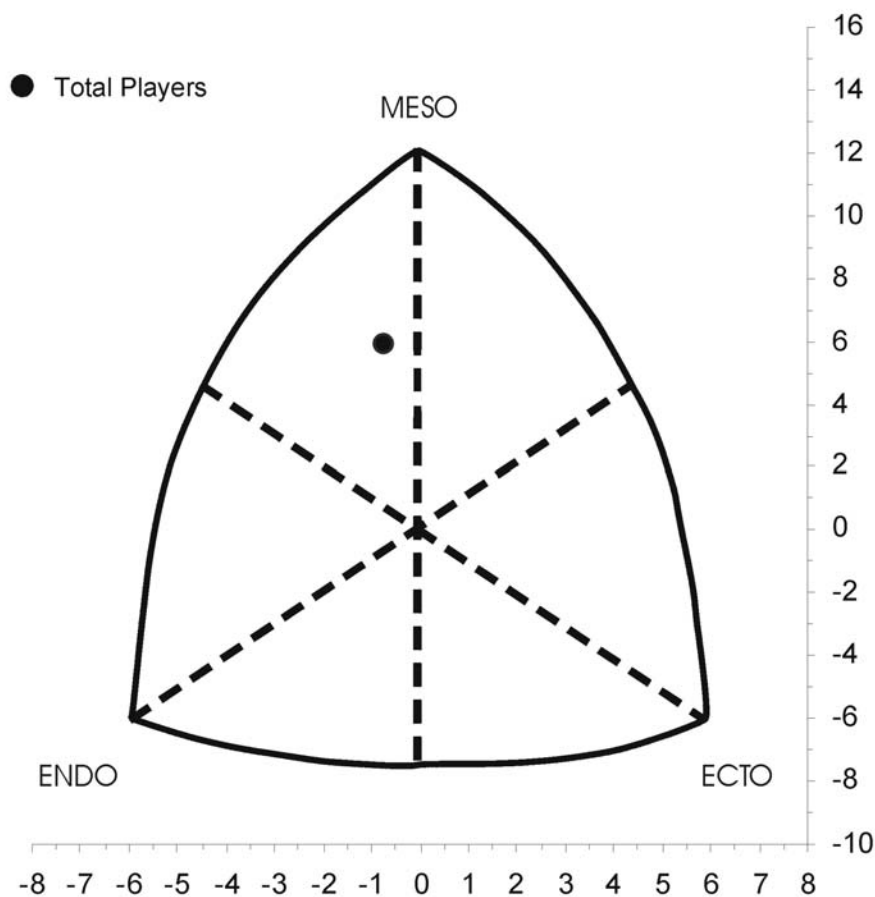


Figure 2. Somatograph

We found similar velocities between the different shot types (± 73 ($\text{m}\cdot\text{s}^{-1}$)). There is no difference in throwing v among the different shot types. Mean and standard deviation values of the throwing v are shown in [Table 7](#).

Table 7. Mean v ($\text{m}\cdot\text{s}^{-1}$) and standard deviations values ($\bar{x} \pm sd$) correspondent to different shot type.

	Shot without goalkeeper	Shot with goalkeeper	Dynamic shot
Throwing v	73.89 \pm 4.07	72.31 \pm 3.50	73.10 \pm 3.14

The shot with goalkeeper is the one that presents better correlations with the anthropometric variables (BMI, 4 Skinfolds, 2 circumferences, 2 breadth and hand grip), although these correlations are moderated. All of the correlations are shown in [Table 8](#).

Table 8. Correlation coefficients (*r*) of anthropometric variables that are correlated with Throwing *v* in different situations in Water Polo players. *Statistically different ($p \leq 0.05$)

Characteristic anthropometric	Shot without goalkeeper	Shot with goalkeeper	Dynamic shot
BMI (kg/cm ²)	r=0.114	r=0.477*	r=0.229
Axilar (mm)	r=0.203	r=0.460*	r=0.374
Iliac Crest (mm)	r=0.376	r=0.490*	r=0.432
Supraespinal (mm)	r=0.404	r=0.490*	r=0.432
Abdominal (mm)	r=0.203	r=0.465*	r=0.433
Arm girth relaxed (cm)	r=0.188	r=0.472*	r=0.262
Arm girth flexed and tensed (cm)	r=0.212	r=0.479*	r=0.247
Femur Breadth (cm)	r=0.497*	r=0.572*	r=0.337
Biacromial Breadth (cm)	r=0.363	r=0.531*	r=0.324
Acromiale-Radiale (cm)	r=0.509*	r=0.205	r=0.325
Dynamometric Max (N)	r=0.310	r=0.501*	r=0.279

DISCUSSION

This work shows the anthropometric characteristics of the Spanish male water polo team. These physical characteristics reflect the various and physical intense demands of the sport, and can be used by coaches in guiding athletes to specialise in playing in the various positions.

The Spanish water polo team shows mean values of height and weight of 187.41 cm and 89.24 kg respectively. These values are in line with the values reported by Mazza et al. (1994). They analyzed the 1991 world championship teams and they reported height and weight means of 186.6 cm and 86.1 Kg respectively. Same values are reported by other authors (Smith, 1998; Lozovina & Pavicic, 2004). Smith (1998), reported that Greek national team has mean height of 184.2 cm and Lozovina et al. (2004), that analyzed 65 elite male water polo players from the top of Croatian clubs, found similar values (189.5 cm and 85.9 kg). These values are slightly higher than Spanish players. This data is important because a taller height and a more or less heavier body are favourable in many kinds of sports, if the athletes other physical and physiological abilities are at a similar level (Mészáros et al., 1998). In a study published in Spain with male water polo players (Enseñat Solé et al., 1992) studied the anthropometric characteristics of young water polo players. We found lesser values in height and weight, maybe because of the mean age of the sample. Enseñat Solé, Matamala Cura & Negro Claret (1992) studied players between 13 and 16 years, and these players are in growth stage.

Spanish male water polo team shows a fat percentage similar to values reported by Mészáros, Soliman, Othman & Mohácsi, (1998), but are lesser than published Avlonitou, (1991), Cazorla & Montpetit, (1988) and Dlin et al. (1984), these authors shows values of fat percentage of 14.3%, 12.1%, 11.2%. However, Block et al. (1989), reported 8.4% fat in Berkeley varsity team, these values are lower than our values. Despite this disparity, and according to Wilmore (1983) relative body fat content is significantly greater in water polo sport competitors than in land competitors. Smaller body density due to the larger body fat content is an advantage in water sports. In most other sports, however a higher than necessary fat percentage may affect physiological performance adversely.

The BMI in Spanish water polo team was 25.36 (kg/cm²), these values are higher than others values published (Lozovina & Pavicic, 2004; Block et al., 1989). Spanish water polo team shows higher values in muscle percentage than those reported by Mészáros et al. (1998) (46,9%) and Enseñat Solé et al. (1992) (45.2%). This difference in muscle percentage in Enseñat Solé et al. (1992) values can be explained due to the youth of its players. According with these values, Mészáros et al. (1998) found smaller body bone and muscle ratios in water polo players than in other sports players. Both of these characteristics are influencing body density. In their opinion, a player with heavy skeletal system (and having consequently greater body density) would generally not be successful in water polo.

The mean biacromial breadth in the Spanish water polo team was 44.5 cm, biiliocrystal breadth was 35.5, biepycondilar femur was 10.1 and biepycondilar humerus was 7.2 cm. All these values are higher than reported by Lozovina & Pavicic (2004) in 1995 Croatian players. Hand length in the Spanish water polo team is similar to Croatian water polo players in 1980 and it is higher than found in 1995 Croatian water polo players. This difference is very interesting because Lozovina & Pavicic (2004) reported that this difference between those generations is probably a consequence of the changes in playing conditions. Changes in rules in 1995 promoted the use of technologically improved ball material allowing it to retain its stable characteristic for the full duration of the game, conversely before this rule change, the ball was heavier and its diameter larger. We can't appreciate this reason because our players presented higher values in hand length than Lozovina's water polo players (Lozovina & Pavicic, 2004).

Somatotype of the Spanish water polo team is located the Endo- mesomorphy. The predominance of the mesomorphy and endomorphy component for this sport is confirmed, and is in accordance with the studies of Enseñat Solé, Matamala Cura & Negro Claret (1992) and Carter (1975).

The v component of accurate, overhead water polo throws, especially in the act of goal shooting, is an important ingredient of successful scoring ability. An increased throwing v reduces the time in which the goalkeeper may detect the path of the ball and deflect (Bloomfield et al., 1990). The greater speed reached was in the shot without goalkeeper; when a tactical situation is included (goalkeeper), the speeds have been smaller (Van der Wende, 2005). It is necessary to present that a fast throw is not always the most suitable for certain occasions, often precision is more important (Van der Wende, 2005). But the speed that a player is able to apply continues to be important, and, without high levels, the high performance is not reached. There were studies that analyze the throwing v (Bloomfield et al., 1990; Davis & Blanksby, 1977; Elliott & Armour, 1988; Feltner & Nelson, 1996; Van der Wende, 2005; Whiting et al., 1985), the values reached for the Spanish water polo team, have been higher than the other values reported, although the ways by which they have been obtained are different (3D, digitalisations, radar) and can influence the results.

Of all the variables studied, only ten showed significant correlations with throwing v with goalkeeper; with throwing v without goalkeeper, we get correlated femur breadth and acromio-radiale length and no correlation with the dynamic shot. In the study presented by Van den Tillaar (2004), conducted in handball players, we have found strong correlations between throwing v weight and height, but correlations have not been made in this study. Correlations were found with BMI, which relates both

variables (weight and height); so one might say that the size of the body has an impact on the throwing v with goalkeeper in water polo players. The positive correlation of throwing v with goalkeeper with the circumferences and component mesomorphy indicates that the muscle mass (force levels) is another component that reflects positively on the throwing v specific to the game. These data coincide with the study presented by [Van der Wende \(2005\)](#), in which the circumference of the arm moderately correlated with the throwing v .

The diameter of the femur has correlated positively and significantly with the shot with and without goalkeeper. This can relate to the importance of the train in stabilizing the lower limbs to shot ([Davis & Blanksby, 1977](#); [Elliott & Armour, 1988](#)), as the diameters can be identified or associated with higher levels of force.

The different lengths studied were correlated with the speed of delivery, as suggested by [Van der Wende \(2005\)](#).

The significance of the shot in biacromial diameter for water polo player is confirmed in this study. Since it is a variable which values the length of the shoulders and relates to the lever at the time of making the movement of skills and throw, this movement (rotation of the trunk and shoulders) is important for speed throwing ([Van der Wende, 2005](#); [Elliott & Armour, 1988](#)).

The three releases studied were with the shot goalkeeper from 5 m, which is more real over the course of the game, both as a specific skill (penalty shot), and in positional game situations (body more or less stable and oriented goal). In this connection, it is necessary to move forward in the design of new situations shot between 4 and 7 m and tactics with more complex situations.

The anthropometric factors studied do not correlate with the throwing v without goalkeeper and dynamics, making it necessary to attempt clarifying what factors are involved in this throwing v , especially in the dynamics, because it is used for a counterattack, the high level not usually being a normal phase of the game, but at lower levels of play.

CONCLUSION

The higher speed is reached with the throwing without goalkeeper and the lower speed in the throwing with goalkeeper. The corporal size through the BMI, circumference of the arm, biacromial diameter of the femur correlate with the throwing v with goalkeeper in players of water polo. The corporal size is confirmed as an important factor to arrive at the high performance in water polo.

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