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Research article

Sport-Specific Motor Fitness Tests in Water Polo: Reliability, Validity and Playing Position Differences

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Abstract
Sport-specific motor fitness tests are not often examined in water polo. In this study we examined the reliability, factorial and discriminative validity of 10 water-polo-specific motor-fitness tests, namely: three tests of in-water jumps (thrusts), two characteristic swimming sprints (10 and 20 metres from the water start), three ball-throws (shoots), one test of passing precision (accuracy), and a test of the dynamometric force produced while using the eggbeater kick. The sample of subjects consisted of 54 young male water polo players (15 to 17 years of age; 1.86 ± 0.07 m, and 83.1 ± 9.9 kg). All tests were applied over three testing trials. Reliability analyses included Cronbach Alpha coefficients (CA), inter-item-correlations (IIR) and coefficients of the variation (CV), while an analysis of variance was used to define any systematic bias between the testing trials. All tests except the test of accuracy (precision) were found to be reliable (CA ranged from 0.83 to 0.97; IIR from 0.62 to 0.91; CV from 2% to 21%); with small and irregular biases between the testing trials. Factor analysis revealed that jumping capacities as well as throwing and sprinting capacities should be observed as a relatively independent latent dimensions among young water polo players. Discriminative validity of the applied tests is partially proven since the playing positions significantly ($p < 0.05$) differed in some of the applied tests, with the points being superior in their fitness capacities in comparison to their teammates. This study included players from one of the world's best junior National leagues, and reported values could be used as fitness standards for such an age. Further studies are needed to examine the applicability of the proposed test procedures to older subjects and females.

Key words: Field testing, differences, position specific, factor analysis.

Introduction

Water polo is an Olympic team water sport which has been played for over a century. While the rules of the game have evolved considerably over this time, the sport has consistently remained, physiologically, a highly demanding activity (Smith, 1998). The game is oriented toward two goals positioned in the swimming pool, while the playing team consists of six field players and one goalkeeper. The offensive positions include: one centre (a.k.a. two- metre offense, 2-metres, hole set, set, hole man, bucket, pit player or pit-man), two wings (located on or near the 2-metre), two drivers (perimeter players, also called "flats", located on or near the 5-metre), and one point (usually just behind the 5 metre), positioned farthest from the goal. Defensive positions are often positioned the same, but just switched from offence to defence. Studies to date have mainly focused on the physiological load of the water polo game (Melchiorri et al., 2010), differences between water polo playing positions in anthropometry and some motor tests (Ferragut et al., 2011a; 2011b; Lozovina et al., 2009; Tan et al., 2009b; Vila et al., 2010), the intensity of the game (Lozovina et al., 2003), or sport-tactics and related statistics of the water polo game (Escalante et al., 2011; 2012; 2013; Lupo et al., 2012; Platanou, 2004).

Sport-specific tests are increasingly popular in modern sports and are mostly developed to simulate characteristic sport performances, with the main idea of them being similar to real-life sport situations. It is generally accepted that these tests are more appropriate than standard tests (general fitness tests) for assessing athletes' capacities that are challenged during a real competition (Meckel et al., 2009), the appropriate variables for sport-specific selection and orientation (Sattler et al., 2012), and the physical qualities that are useful for discriminating between different positions in team sports (Kondric et al., 2012; Melchiorri et al., 2009; Tan et al., 2009b; 2010). Although accepted in most sports today, it is beyond question that sport-specific tests are even more important for water sports because the physical fitness test data that are observed 'on land' (i.e., jumps, throws, sprinting ability, and anaerobic/aerobic endurance capacity tests) have limited application in water (Kondric et al., 2012; Peric et al., 2012; Sajber et al. 2013). Surprisingly, sport-specific tests in water polo are not frequently studied with regard to their reliability and validity. Several studies have investigated swimming endurance capacities and sport-specific test protocols of such a kind (Melchiorri et al., 2009; Mujika et al., 2006; Tan et al., 2009a). However, there is evident lack of studies which investigated motor tests specific to water polo (Gobbi et al., 2011; Platanou, 2005; Tan et al. 2010). Although undoubtedly important with regard to the basic idea and experimental and measuring approach, these studies: (I) dealt with only one type of the several possible jumping performances which occur in water polo (see below for more details); and (II) apart from jumping, other specific motor capacities are important in water polo (sprint swimming, throws, precise ball handling, dynamometric force etc.).

The aim of this study was to study the reliability and factorial validity of ten specific water-polo motor tests. In addition, we investigated position-specific differences in the studied variables. As far as we are aware, this is one of the first studies to systematically investigate different motor-fitness sport specific tests in water polo with regard to their reliability, factorial and discriminative validity. Due to the general sport science and professional consensus about the need for sport-specific investigations among youth (Konig et al., 2001; Vanderford et al., 2004), we deemed it particularly important to study the problem among young talented water polo players.

Methods

Sample

The sample of subjects consisted of 54 young male water polo players (all 15 to 17 years of age; 1.86 ± 0.07 m of

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body height (BH), and 83.1 ± 9.9 kg of body weight (BW)). All subjects had been active in the sport of water polo for 7–9 years and were members of three top-level teams from Croatia, including the national champions for this age category in the 2011–12 competitive seasons. At the moment of the testing all subjects trained 10-15 hours per week. The sample was grouped according to the playing positions into centers (n = 5), points (n = 11), and outer players (n = 38; including wings and drivers). More precisely, in water polo drivers and wings are in general very similar playing positions. It results in frequent switch between these two playing positions during the match. Therefore, for this age category, athletes are not specifically position-oriented as a wings or drivers.

Variables and testing

Apart from BH, BW, and calculated body mass index (BMI), the sample of variables included three types of in-water jumps (thrusts), two specific water polo sprint swims (10 and 20 metres), three types of specific water polo shots (overarm throws), one test of passing accuracy (precision), and a characteristic dynamometric semi-tethered force test.

The in-water jump tests were constructed with regard to specific water polo game situations. The first jump was the standard on-water thrust (STANDARD-T). This is the most convenient in-water jump in water polo and mainly consists of a one-arm vertical thrust from a standard defensive position (Figure 1a). The second test, the side-thrust (SEMILAT-T), is a specific variation of the standard thrust performed semi-laterally. The test starts in a semi-lateral floating position (Figure 1b) and the athlete has to reach as high as possible during a semi-lateral thrust. A movement pattern of this kind is characteristic in defensive actions when an athlete tries to reach for the passing ball, and/or in the offence during power play situation (i.e. team in the defence has a man-down). The third test consists of a vertical in-water jump with a starting position where the arms are in front of the body (Figure 1c). Basically, a one-arm maximal reach jump is performed but the force needed for the thrust is only produced by leg movements and an extension of the torso. Such performance is characteristic when player have to perform the thrust immediately with no preparation (QUICK-T). All tests are measured using previously suggested procedures (Platanou, 2005). In short, we used a board with a scale marked in centimetres and a digital video camcorder (Sony DCR-TRV280, with 990x digital zoom; Sony Inc. Japan) to record the jump height which was later determined and noted for the three testing trials. Camcorder was located on the opposite side of the swimming pool (30 meters from the measuring board). Such positioning allowed us to minimize the technical error of measurement which will appear as a result of parallax difference (disambiguation) (Hirshfeld, 2002). In short, due to the variance in the angular position of two stationary points (i.e. camera height and athlete's jump height) significant difference between real-jump-height and observed-height could appear if camera was closer. Digital zoom of 900x allowed us to record the achievement accurately.

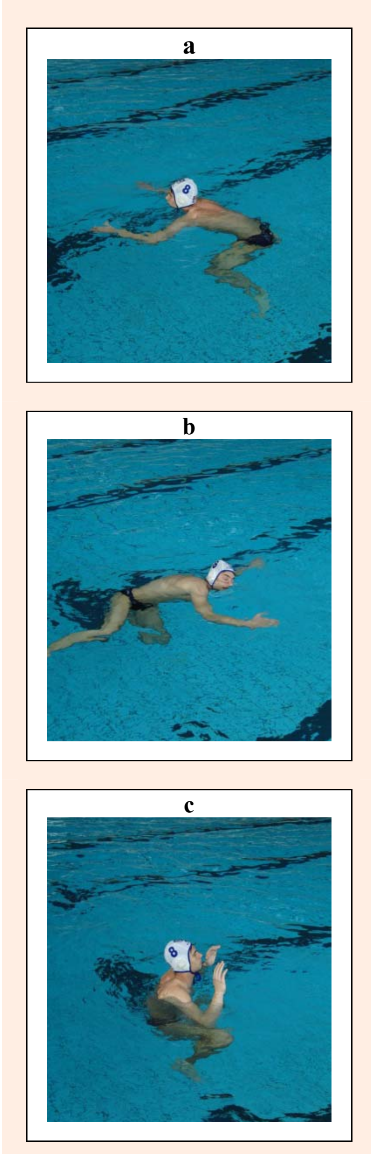

Figure 1. Starting positions for three different water jumps: STANDARD-T (a), SEMILAT-T (b), and QUICK-T (c).

Specific water polo swimming sprints were performed over distances of 10 (S10) and 20 metres (S20). Both tests commenced upon a sound signal (similar to sprinting to obtain possession of the ball at the start of a game). The subjects started from the pool (no jump from the start block and/or push from the block) 10 or 20 metres from the finishing block. The subjects were allowed to start from either a front-on or side-on position as long as their head remained behind the laser beam which marked the 0-metre point (start). The Longines swimming timing apparatus was used for both tests.

The semi-tethered dynamometric test (DYN) consisted of maximum intensity swimming using an eggbeater kick with a fast elastic line fixed to a special belt. An 'eggbeater kick' is a hands-free form of treading water that allows a swimmer to remain vertical and/or move in a vertical position. The eggbeater kick is a style of kicking in which the athlete's legs alternate between one-legged breaststroke kicks. This form provides continuous support because there are no breaks in the kick. The skill consists of alternating the circular movements of the legs that produce an upward force on the swimmer in the water, keeping the swimmer afloat in a vertical position and enabling them to move in any direction while in a vertical position. The legs appear to move in a circular pattern, such as an alternating circumduction of the hips that is accompanied by knee flexion/extension and medial to lateral rotation. Swimming force was recorded with the use of a tensiometric dynamometer coupled to a MAX-5 device (JBA Staniak, Poland) via a WTP 003 amplifier and Max_5.1 computer software. The subjects were instructed to perform the eggbeater kick as hard as possible and to achieve the maximal possible dragging force. The maximal force achieved was kept as a result for each of the examinees.

Throwing velocity was measured by three tests, which are constructed in order to simulate three most specific shots in water polo game (Lupo, Tessitore, Minganti, & Capranica, 2010). In the first test, an athlete performed a drive shot (DRIVE-S). He was instructed to lift the ball from the water surface and throw it into the goal net as fast as possible. The second test was done following three consecutive dummy or baulking shots, the shot known as a shot after two fakes (2FAKE-S). Throughout the third test the ball was passed and the examinee had to perform a maximal throw as quickly as possible after receiving the ball (PASS-S). To assure equal assistance, the passing was done by the same assistant two from the 2-metres distance. All throwing velocities were measured using the Speedster Radar Gun Bushnell.

Accuracy (precision) of the ball passing was evidenced throughout the test where an athlete had to shoot at the target (an floating ring of 85 cm diameter) placed on the water's surface at a distance of 8 metres from the examinee. The score was recorded as the time necessary to perform 5 successful throws.

All of the tests were done over three trials and, after a reliability analysis the personal best/average result (see below for more details) was retained as the final achievement.

The testing was done over three days. On the first day, the subjects were tested regarding anthropometrics, jumps and dynamometric semi-tethered swimming. On the second day, the precision and swimming speed were tested. On the third day, the subjects performed shooting (velocity) tests. All tests were carried out in the morning, from 8 am to 11 am, after a standard warm up which consisted of 10–15 minutes of swimming combined with convenient in-pool warm up exercises (thrusts, turns, intensive strokes etc.). The pause between testing trials ranged from 3 to 5 minutes, and the rest between the same-day tests was 10–15 minutes.

Statistical analysis

Descriptive statistical parameters (mean, standard deviation, minimum and maximum) were calculated for each individual trial (each item) and for the overall results (case-specific best or average results). An analysis of variance (ANOVA) for repeated measures and a Tukey post-hoc test were used to detect any systematic bias between the trials (items) for each test. Average inter-item correlation coefficients (IIR) and Cronbach's alpha reliability coefficients (CA) were used to determine the between-subject reliability of the jumping tests. Within-subject variation for each of the tests was determined by calculating the coefficient of variation (CV). Jumps and dynamometric results were presented as raw scores and standardised scores. To standardise the jumping capacities the raw scores were divided by the subjects' body height. The raw dynamometric results were standardised by dividing them by the subjects' body weight.

To determine the factorial validity of the applied tests we calculated correlation coefficients and corresponding factor analysis. In the factor analysis the intercorrelation matrix for all of the tests was factorised using a principal-components factor analysis. The number of significant components was determined using the Kaiser-Guttmann criterion. The correlations between tests and factors were used to determine the factorial validity of the tests. Two sets of validity analyses were performed. In the first analysis, the raw scores of the jumps and dynamometrics were used. In the second factor analysis, standardised jumps and dynamometric results were included in the analysis.

The differences between playing positions in their specific motor-fitness were calculated by a nonparametric Kruskall Wallis analysis of variance with consecutive Mann Whitney U test (MW test).

All of the coefficients were considered significant at 95% ($p < 0.05$).

Results

The reliability of the specific jumping performances was high, with similar reliability parameters for all three variables. There were no significant differences between the testing trials for any of the on-water jumps. Dynamometric testing showed high reliability with no significant differences among the trials. Of all sport-specific tests investigated in this study, the lowest reliability was found for the characteristic of ball passing accuracy. Also, ANOVA found significant differences between the testing trials which clearly indicate instability of the measurement. However, there is no evident trend of changes between the testing trials. The reliability of both specific sprint swimming tests is high. However, for both tests ANOVA indicated a significant difference in the testing results between trials. Post-hoc analysis revealed significant differences between 1st and 2nd, and 1st and 3rd trials for S20, and 1st and 2nd trial for S10. While the reliability coefficients were found to be high for all three throwing velocity tests there is an evident trend of a decrease in the velocity for the 2FAKE-S with significant post-hoc differences between 1st and 3rd trial (Table 1).

Although most of the correlations between the raw scores of the sport-specific tests reached statistical significance, only those higher than 0.70 will be interpreted as important with regard to their applicability (i.e. a correlation of 0.70 denotes approximately 50% of common variance). In short, it is evident that the thrusts (body jumps) are highly inter-correlated, and the same applies to the throws. Other correlations, although statistically significant, are not interpretable (Table 2).

Factor analysis extracted three significant latent dimensions. The first is defined by high projections of the body jumps. The second is highly correlated to throws, while the third latent dimension is characterized by significant projections of sprinting variables and precision performance (Table 3).

Nonparametric analysis of variance (Table 4) indicated a significant difference between playing positions in three anthropometric variables. MW test found centers and points as significantly higher than outer players; while centers are significantly heavier than points and outer players. In general, points dominate in most of the motor variables studied, although statistical significance only reached an appropriate level for the jumping capacities where according to MW test points significantly dominated over centres.

In general we can highlight several key findings of this study. First, most of the sport-specific tests studied were found to be reliable, and the factor analysis revealed three independent latent motor dimensions motor capacities which could be named as jumping capacity, throwing capacity and sprint swimming capacity. Also, the results indicate than young water polo players vary in some fitness capacities with regard to their primary playing position in the water polo game. These topics will be discussed in more depth in the following text.

Table 1. Reliability parameters for the specific motor tests (CA – Cronbach Alpha; IIR – average inter trial correlation; CV – coefficient of the variation; ANOVA – analysis of the variance F test value; * denotes significant coefficients).

	Mean	Minimum	Maximum	Std.Dev.	CA	IIR	CV	ANOVA
STANDARD-T$_{trial1}$	137.86	111.41	196.04	18.08				
STANDARD-T$_{trial2}$	136.74	106.43	190.27	16.70	0.95	0.89	0.08	1.15
STANDARD-T$_{trial3}$	136.04	113.68	182.65	15.27				
STANDARD-T (cm)	141.40	117.99	196.04	17.34				
SEMILAT-T$_{trial1}$	137.07	110.17	169.16	14.85				
SEMILAT-T$_{trial2}$	136.07	110.31	169.89	14.78	0.97	0.91	0.07	2.80
SEMILAT-T$_{trial3}$	135.08	107.48	170.79	14.80				
SEMILAT-T (cm)	139.84	110.31	170.79	15.02				
QUICK-T$_{trial1}$	128.73	100.73	171.76	14.52				
QUICK-T$_{trial2}$	127.93	100.57	175.95	14.10	0.96	0.88	0.09	0.30
QUICK-T$_{trial3}$	128.51	100.24	167.70	14.24				
QUICK-T (cm)	132.07	100.73	175.95	14.10				
DYN$_{trial1}$	29.67	18.50	42.20	5.65				
DYN$_{trial2}$	29.45	19.00	45.20	5.79	0.96	0.89	0.07	1.90
DYN$_{trial3}$	28.96	18.30	43.20	5.87				
DYN (W)	30.93	20.00	45.20	5.73				
PRECISION$_{trial1}$	27.78	13.94	50.66	8.79				
PRECISION$_{trial2}$	24.63	11.53	47.06	8.97	0.83	0.62	0.21	4.5*
PRECISION$_{trial3}$	27.00	8.23	52.05	9.75				
PRECISION (s)	27.78	13.94	50.66	8.79				
S20$_{trial1}$	11.49	10.30	13.03	.61				
S20$_{trial2}$	11.69	10.46	13.03	.67	0.93	0.83	0.02	9.30*
S20$_{trial3}$	11.70	10.53	13.44	.66				
S20 (s)	11.38	10.30	12.69	.58				
S10$_{trial1}$	5.76	5.03	7.35	.48				
S10$_{trial2}$	5.86	5.03	7.42	.51	0.95	0.88	0.03	3.70*
S10$_{trial3}$	5.82	4.91	7.84	.54				
S10 (s)	5.66	4.91	7.35	.48				
DRIVE-S$_{trial1}$	65.44	53.00	76.00	5.54				
DRIVE-S$_{trial2}$	66.13	49.00	78.00	5.45	0.96	0.90	0.02	2.20
DRIVE-S$_{trial3}$	65.69	50.00	75.00	5.27				
DRIVE-S (km/h)	67.11	53.00	78.00	5.33				
2FAKE-S$_{trial1}$	65.04	46.00	75.00	5.76				
2FAKE-S$_{trial2}$	64.43	47.00	75.00	5.64	0.97	0.91	0.03	3.70*
2FAKE-S$_{trial3}$	64.17	46.00	72.00	5.93				
2FAKE-S (km/h)	65.85	47.00	75.00	5.73				
PASS-S$_{trial1}$	62.24	43.00	71.00	5.84				
PASS-S$_{trial2}$	62.00	42.00	71.00	5.89	0.95	0.86	0.04	1.04
PASS-S$_{trial3}$	62.61	42.00	72.00	6.23				
PASS-S (km/h)	64.17	43.00	72.00	5.55				

STANDARD-T – standard in-water maximal vertical jump (thrust); SEMILAT-T – in water maximal vertical jump (thrust) performed from the semilateral floating position; QUICK-T – in water maximal vertical jump (thrust) performed with no preparation; DYN – dynamometric test performed throughout eggbeater kick; PRECISION – test of throwing (passing) precision (accuracy); S20 – sprint swimming over 20 meters distance; S10 – sprint swimming over 10 meters distance; DRIVE-S –throwing velocity throughout drive shot; 2FAKE-S – throwing velocity throughout shot performed after two fakes; PASS-S – throwing velocity of the shot performed after receiving a passed ball

Table 2. Correlation analysis of the specific motor tests and anthropometric variables (* denotes significant correlations)

	STANDARD-T	SEMILAT-2	QUICK-T	DYN	PRECISION	S20	S10	DRIVE-S	2FAKE-S	PASS-S
SEMILAT-T	.79*									
QUICK-T	.76*	.78*								
DYN	.41*	.44*	.42*							
PRECISION	-.19	-.30*	-.24	-.41*						
S20	-.43*	-.44*	-.32*	-.37*	.29*					
S10	-.44*	-.48*	-.46*	-.46*	.40*	.59*				
DRIVE-S	.36*	.49*	.30*	.44*	-.18	-.35*	-.28*			
2FAKE-S	.36*	.40*	.31*	.47*	-.43*	-.39*	-.30*	.81*		
PASS-S	.41*	.55*	.43*	.46*	-.31*	-.50*	-.41*	.87*	.86*	
BH	.46*	.56*	.58*	.62*	-.41*	-.19	-.39*	.41*	.50*	.49*
BW	.34*	.46*	.44*	.66*	-.31*	-.19	-.33*	.38*	.39*	.41*
BMI	.08	.15	.10	.40*	-.09	-.10	-.14	.18	.10	.15

STANDARD-T – standard in-water maximal vertical jump (thrust); SEMILAT-T – in water maximal vertical jump (thrust) performed from the semilateral floating position; QUICK-T – in water maximal vertical jump (thrust) performed with no preparation; DYN – dynamometric test performed throughout eggbeater kick; PRECISION – test of throwing (passing) precision (accuracy); S20 – sprint swimming over 20 meters distance; S10 – sprint swimming over 10 meters distance; DRIVE-S –throwing velocity throughout drive shot; 2FAKE-S – throwing velocity throughout shot performed after two fakes; PASS-S – throwing velocity of the shot performed after receiving a passed ball; BH – body height; BW – body weight; BMI – body mass index

Discussion

Standard vertical jumping procedures are known to be important in sports and jumping performance tests are therefore frequently studied for their reliability and validity. Investigators have regularly reported high reliability parameters of the various jumping performance tests (Markovic et al., 2004; Slinde et al., 2008). However, studies in most cases investigated general and not sport-specific testing procedures. A recent parallel analysis of the general and sport-specific jumping test procedures noted that the sport-specific tests are more applicable to a real-life sport situation than the standard ones (Sattler et al. 2012), which has been found to be even more important for water sports (Peric et al., 2012). In general, the reliability parameters of the on-water jumps we studied are similar to those presented previously for on-land jumping tests, where CA coefficients ranged from 0.93 to 0.98; with ICC ranging from 0.50 to 0.97 (Markovic et al., 2004; Sattler et al., 2012; Slinde et al., 2008). Yet for the purpose of this investigation it is more important that the reliability parameters are similar to those recently presented for synchronised swimming on-water jumps (Peric et al., 2012).

Similar to jumps, the reliability and validity of on-land sprinting capacities are frequently studied in running (Hopker et al., 2009; Mirkov et al., 2008). However, there is an evident lack of studies dealing with this capacity in water. As far as we are aware, only Tan and his co-authors (2010) reported reliability parameters of the different sprint swimming in water polo, with similar reliability values to those we have found herein (their CV values ranged from 1.8 to 3.2%).

Throwing velocity is considered one of the most important factors of a water polo performance (Alcaraz et al., 2011; Alcaraz et al., 2012; Smith, 1998), and biomechanical indices of different water polo throwing techniques have also been reported (Davis and Blanksby,

Table 3. Factor analysis of the specific motor tests (F - factor structure; EV – factor variance; PT – total percentage of the variance explained).

	F1	F2	F3	F1	F2	F3
STANDARD-T	-.74	.47	.28			
SEMILAT-T	-.81	.36	.24			
QUICK-T	-.71	.51	.25			
DYN	-.68	-.02	-.25			
STANDARD-T$_{rel}$				-.17	.06	-.74
SEMILAT-T$_{rel}$				-.25	-.38	-.61
QUICK-T$_{rel}$				-.11	-.38	-.72
DYN$_{rel}$				.93	.18	.10
PRECISION	.49	.07	.64	.89	.05	.31
S20	.65	-.07	.31	.89	.25	.26
S10	.66	-.26	.44	.12	.88	.13
DRIVE-S	-.74	-.53	.30	.25	.85	.16
2FAKE-S	-.76	-.55	.06	.06	.87	.11
PASS-S	-.83	-.44	.16	.15	.07	.64
FV	5.09	1.47	1.08	2.67	2.64	2.07
PT	.51	.15	.11	.27	.26	.21

STANDARD-T – standard in-water maximal vertical jump (thrust); SEMILAT-T – in water maximal vertical jump (thrust) performed from the semilateral floating position; QUICK-T – in water maximal vertical jump (thrust) performed with no preparation; DYN – dynamometric test performed throughout eggbeater kick; PRECISION – test of throwing (passing) precision (accuracy); S20 – sprint swimming over 20 meters distance; S10 – sprint swimming over 10 meters distance; DRIVE-S –throwing velocity throughout drive shot; 2FAKE-S – throwing velocity throughout shot performed after two fakes; PASS-S – throwing velocity of the shot performed after receiving a passed ball; $_{rel}$ denotes relative values of the sport-specific motor fitness tests

Table 4. Analysis of the differences between playing positions in the specific motor tests and anthropometric variables (KW – Kruskal Wallis H value; * denotes significant differences).

	Centres (n = 5)		Points (n=11)		Outer players (n=38)		
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	KW (H)
STANDARD-T	134.78	10.31	147.34	7.58	140.55	19.66	6.95*
SEMILAT-T	139.39	22.54	145.73	11.70	138.20	14.76	2.69
QUICK-T	133.87	15.61	133.70	9.97	131.36	15.16	.69
DYN	24.43	4.30	27.83	7.68	28.20	9.54	4.74
PRECISION	34.02	9.13	33.28	5.13	29.85	5.18	.98
S20	11.65	0.48	11.26	0.47	11.39	0.62	1.90
S10	5.82	0.31	5.62	0.45	5.64	0.51	1.22
DRIVE-S	67.40	6.62	68.18	3.89	66.76	5.60	.52
2FAKE-S	64.00	5.66	65.82	3.68	63.71	6.00	.82
PASS-S	67.20	6.18	68.27	4.00	64.97	5.98	3.09
BH	190.48	8.46	188.13	4.02	183.51	6.58	7.73*
BW	92.70	11.67	86.82	7.36	80.73	9.40	6.95*
BMI	25.50	2.28	24.51	1.59	23.93	2.15	2.55
STANDARD-T$_{rel}$	.71	.04	.78	.05	.76	.09	6.89*
SEMILAT-T$_{rel}$	.73	.10	.77	.06	.75	.07	1.53
QUICK-T$_{rel}$	.70	.06	.71	.05	.71	.07	.38
DYN$_{rel}$	.36	.07	.38	.06	.37	.05	.34

STANDARD-T – standard in-water maximal vertical jump (thrust); SEMILAT-T – in water maximal vertical jump (thrust) performed from the semilateral floating position; QUICK-T – in water maximal vertical jump (thrust) performed with no preparation; DYN – dynamometric test performed throughout eggbeater kick; PRECISION – test of throwing (passing) precision (accuracy); S20 – sprint swimming over 20 meters distance; S10 – sprint swimming over 10 meters distance; DRIVE-S – throwing velocity throughout drive shot; 2FAKE-S – throwing velocity throughout shot performed after two fakes; PASS-S – throwing velocity of the shot performed after receiving a passed ball; BH – body height; BW – body weight; BMI – body mass index; $_{rel}$ denotes relative values of the sport-specific motor fitness tests

1977; Elliott and Armour, 1988). But, as far as we aware, this is the first study to investigate the reliability of the different throwing variables in water polo. In studies which investigated on-land throwing variables with regard to reliability parameters, authors reported practically identical reliability parameters as we found in our study (Harasin et al., 2006). However, our respected colleagues found no systematic bias between testing trials in any of the tests they investigated, whereas we have found a systematic decrease in 2FAKE-S. Most probably, the additional load which is put on the examinee during this performance (i.e. where the examinee performed two consecutive dummy passes before the throw) negatively influences the power capacities which are directly responsible for the throwing capacity.

The lowest reliability parameters were found for the passing accuracy test. Although this motor capacity is highly important in numerous team sports, like basketball, handball, and/or water polo, it has been systematically studied almost exclusively in sports like shooting and archery (Callaway and Broomfield, 2012) where accuracy and precision are probably the most important factors of success. Therefore, it is not surprising that authors in these studies found higher reliability parameters than we did here (ICC was found to be higher than 0.96). To the best of our knowledge, only one study investigated team sport athletes with regard to the stability of their precision performance, and in this investigation Russell and his co-authors (Russell et al., 2010) studied accuracy in soccer and reported similar reliability measures as we found (CVs were from 10 to 23%). Evidently, accuracy should be judged as a relatively unstable performance, which is indirectly supported in a recent investigation by the same group of authors (Russell et al., 2011) where they noted the negative effects of fatigue on accuracy (a decrease of 25% in passing and shooting accuracy), while this was not the case for other motor qualities.

Factor analysis defined three independent specific motor latent dimensions which could be named: shooting capacity, jumping capacity and sprint swimming capacity. This finding offers clear support to one of the main ideas which led to this investigation (i.e. we had hypothesised that motor manifestations in water are highly specific). Mainly, previous studies dealing with the same fitness capacities in 'on-land' situations mainly concluded that sprinting, jumping and throwing variables (i.e. ballistic movements) are highly intercorrelated (Markovic, 2006; Robbins and Young, 2012). This is mainly explained by the similar physiological background of all three abilities (the need for the fast application of force). Meanwhile, it seems that those capacities are not strongly interrelated when observed on water. The explanation is probably to be found in the differential influence of the body composition measures. In short, recent studies on synchronised swimmers (Peric et al., 2012; Sajber et al., 2013) found that it is not rare for body composition indices (mainly body fat and lean body mass) to oppositely influence 'on-land' and 'in-water' motor manifestations mainly because of buoyancy. In short, a lean body mass is negatively and body fat is positively related to buoyancy, while buoyancy is a factor which positively influences some of the motor manifestations performed in water (Peric et al., 2012). Also, a recent study which investigated female water polo players concluded that none of the measured morphological indices (including a lean body mass and fat mass) is significantly related to throwing velocity (McCluskey et al., 2010). On the contrary, out of water, body fat is a type of 'ballast' and is therefore negatively related to motor-capacities when observed on land (Dellagrana et al., 2010; Silvestre et al., 2006). As a result, it is logical to conclude that the underlying mechanisms of the relationship between anthropometrics and motor variables in water are not the same as those observed on land. This has led to the previously defined independency of the jumps, throws and sprints performed in water polo, a fact which was recently indicated for female water polo players (McCluskey et al., 2010). As far as we are aware, the factor structure of the fitness status in water polo has not been studied so far. However, recent studies on handball (team handball) have found a very similar structure of the characteristic motor status (Katic et al., 2007). In short, in that investigation by means of factor analysis the authors isolated five motor dimensions, three of which are practically equivalent to those we found for water polo (throwing, jumping and sprinting). One could argue that these results directly indicate the independence of the said capacities on the ground as well (note that we have previously discussed differences between variables when measured on land and in-water motor manifestations), but in the handball study the authors used a non-orthogonal factor solution (Direct Oblimin) which directly implies the existence of a correlation between significant latent dimensions. On the contrary, in the study presented here we used an orthogonal factor solution (Varimax) with a zero correlation between the isolated dimensions.

Previous studies already noted the superior fitness of points against other positions in water polo (Kondric et al., 2012). This is mainly interpreted by the characteristic game duties which keep those players relatively far from the goal (during offence), but also in the very specific and highly important game tasks throughout the offence (i.e. points are directly responsible for controlling the opponents' centre constantly including stressful body contact, they often have to swim at maximal speed after the contact, etc.). As a result, points develop their fitness capacities generally and not specifically. Therefore, the fact that points dominate in most of the motor capacities observed in this investigation, and are significantly superior against centres in jump capacity did not surprise us. Although one could expect that, due to their larger body dimensions centres should achieve superior results in shooting variables, it seems that the shooting capacity of young water polo players is not significantly related to morphological indices (i.e. centres do not dominate in the shooting capacities although advanced in the BH and BW). We tried to study this more precisely and correlated the body dimensions (BH and BW) with shooting variables and found low correlations between morphological anthropometric indices and shooting capacities (the correlation ranged from 0.32 to 0.48). Consequently, it may be concluded that other underlying physiological mechanisms (most probably the type of muscle fibres), and/or the shooting technique is responsible for the shooting capacities among young water polo players. In a recent study, authors investigated position-specific fitness profiles among somewhat older players (i.e. 17-18 years of age) (Kondric et al., 2012) and found a non-significant difference in the dynamometric force produced throughout swimming. Consequently, the fact that we have found no significant differences among the playing positions in the same capacity (dynamometric force produced during the eggbeater kick) was somewhat expected. This is chiefly related to the fact that we studied dynamometric force in a forward movement momentum (athletes were in the breast stroke position during the test). On the other hand, the characteristic movement of the centre players is oriented 'backwards' to the opponent. It almost certainly influenced their relative low results in the dynamometric swimming regardless of their clear advantage in body height and body weight, especially in comparison to outer players.

Study limitations

Study limitations are related mainly to the disproportionate number of subjects in three playing positions. However, for this age category (15-16 years of age) there is no strict differentiating for the playing positions so the number of subjects in each group is a logical consequence of this situation. Next, we have used only "on water testing" procedures, but we did it intentionally. First, we deemed particularly important to focus on real sport situations and consequent motor fitness capacities. Second, according to previous studies, on-water tests are rarely highly correlated to standard (on-ground) ones, and therefore such approach in defining concurrent validity of the fitness tests for water sports (i.e. correlating on-ground and in-water-tests), seems to be inappropriate.

Conclusion

The sport-specific tests studied herein were found to be reliable and valid for the purpose of defining the motor fitness status of young water polo players. Their applicability with regard to discriminative validity is partially proven since some of the tests we used differentiated playing positions in fitness status. In further studies, tests should be applied to other age-groups (older athletes) and among females in order to define their overall applicability to the sport of water polo.

This study included players from one of the world's best National leagues the reported values should be used for the purpose of defining fitness standards in young male water polo players.

Once again, the point players were found to have superior fitness capacities compared to their peers. Although mainly explained by their varied game duties and consequent broad fitness development, there is a certain possibility that points are initially (i.e. at the start of their sport career) oriented toward this playing position on the basis of their existing superior fitness capacities. This issue should be more precisely studied in the future through longitudinal follow-up studies.

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Key points

- Here presented and validated sport specific water polo motor fitness tests are found to be reliable in the sample of young male water polo players.
- Factor analysis revealed existence of three independent latent motor dimensions, namely, in-water jumping capacity, throwing ability, and sprint swimming capacity.
- Points are found to be most advanced in their fitness capacities which are mainly related to their game duties which allowed them to develop variety of fitness components.

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