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THE RELATIONSHIP BETWEEN THROWING VELOCITY WITH AND WITHOUT LEG MOVEMENTS AND ISOKINETIC MUSCLE STRENGTH IN ELITE WATER POLO PLAYERS

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Abstract:

The purpose of this study is to analyze the relationship isokinetic strength that the elite water polo players produced with lower and upper limbs (with leg movements) and only upper limbs (without leg movements) and the velocity of the shoot. Eighteen elite male players of Turkish professional water polo first league aged between fifteen and thirty-three took part in the study voluntarily. The physical characteristics of the players were taken and throwing velocities of overhead, back hand and sweep throw were measured from position 2, 3, 4 and 6. Isokinetic strength measurements were made within different joint moves (trunk, shoulder, knee, hip). In two separate shooting protocols (with and without leg movements) the shooting velocity were measured in different positions. A significant difference was found between with and without leg movement in different throwing velocity shoots were recorded in different shooting positions ($p<0.01$). It was seen that the average of the velocity of with leg movements shoot was higher than the without leg movements shoot. In terms of shooting positions, 2nd position when the relationship between the velocity of with leg movement shoot and isokinetic muscle strength was considered, trunk flexion, shoulder extension, left hip

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abduction, left knee flexion as relevant $p<0.05$, a relationship with right knee extension was found ($p<0.01$). 3rd position, a positive relationship ($p<0.05$) was recorded between trunk flexion, shoulder flexion, left hip abduction, right knee extension and left knee flexion. In 4th position, between the with leg movement shoot and trunk flexion, shoulder flexion, right hip extension, left hip extension, right hip flexion, left hip flexion, right knee extension, left knee extension, left knee flexion and left hip abduction. A positive relationship ($p<0.01$) between with leg movement (back) shoots thrown from 6th and trunk flexion, shoulder extension, shoulder flexion, left hip extension, right hip flexion, left hip abduction, right knee extension and left knee extension. Also a positive relationship ($p<0.05$) between the with leg movement backhand shoots thrown in 6th position, and right hip extension and left hip flexion. A positive relationship ($p<0.05$) was seen between the shoots thrown from part 6th position with leg movement sweep shoots and trunk flexion and left hip extension. When the relationship between the velocity of without leg movement shoot and isokinetic strength is overviewed according to the positions, in 2nd position there is a relationship between without leg movement shoot and trunk flexion and shoulder extension, with the shoulder flexion a positive relationship was seen ($p<0.01$). In 3rd position, there is a positive relationship ($p<0.01$), was recorded in the trunk flexion, a positive relationship ($p<0.05$) was seen in shoulder extension and shoulder flexion. In 4th position, a positive relationship ($p<0.01$) was found with the trunk flexion. A positive relationship ($p<0.01$) was found with the without leg movement backhand shoots that were thrown from the 6th position and trunk flexion, shoulder extension, shoulder flexion. A positive relationship ($p<0.05$) was recorded with the without leg movement sweep shoots and trunk flexion and shoulder extension. In conclusion, the isokinetic strength produced by the lower and upper limbs' relation with the velocity of with leg movement shoots thrown from different parts was found. The isokinetic strength produced by the upper limbs' relation with the velocity of without leg movement shoots thrown from different parts was found. The isokinetic strength's (produced by the upper limbs) contribution to the velocity of the shoot in without leg movement shoot is higher than with leg movement shoots. The results of the study upper limbs strengths' (trunk flexion, shoulder flexion, shoulder extension) are more effective in the velocity of the shoot.

Keywords: water polo, throwing velocity, isokinetic

1. Introduction

Water polo is a sport in which technical-tactical features and basic and supporting bio-motor abilities are used excessively. Players use the lower and upper limbs intensively in water polo. Scissors, jumping, rotation, foot tapping movements for lower extremity; movements such as holding-pushing, block, shoot, pass are forces that require strength and skill for the upper limb (Smith, 1991).

Despite its history and evolution, water polo has not been studied enough probably because of the limited publicity and the difficulties that arise during the collection of data under water. Physiological measurements, such as heart rate monitoring (Hollander et al., 1994; Pinnington et al., 1986) and/or capillary blood lactate analyses (Hollander et al., 1994; Rodriguez, 1994; Sardella et al., 1990) have provided indications of the cumulative cardiovascular and metabolic demands of the identified activities during games, yet biomechanical observations of throwing and shooting support the empirical observations that water polo players require moderately high levels of muscular strength and power (Tan, 2009).

The force production of the legs during the shoot in the water is incomplete in terms of body support when compared to other branches on land. Suspension in the water prevents the reaction force generated by the player from being transferred to the body and the ball. During the shoot in the water polo, according to other branches on land, the leg movements have different purposes. The lower trunk and legs play a supporting role, contributing to the strength production by the protection of balance and the transport of body weight out of the water. In preparation for the shooting, the egg beater kick increases the frequency of the legs, helps to lift the body out of the water (Ball, 1996), and the shoot in the water polo is done with repeated scissor movements.

The movement of the scissors in the water polo closet is an important skill that the player uses to float in the water and perform other movements. It consists of circular movements of the legs and produces the force to hold the player above the water in the vertical position. The legs appear to be in circular motion, with knee joint, index flexion/extension and medial/lateral rotation. As the right leg moves clockwise during the foot stroke, the left leg makes a circular movement clockwise. The involvement of the upper limbs in these dynamic movements determines the whole shooting shoot.

Thus, the data obtained as a result of the isokinetic evaluations are used to determine the muscle forces (Dauty and Rochangar, 2001; Olyaei et al., 2006) produced by the athletes in the upper and lower limbs, the relationship of the sports skills to the neuromuscular structure, the identification of risk factors (Markou and Vagenas, 2006), the determination of muscle imbalances (Wong et al., 2000) play an important role (Hazır et al., 1993).

In water polo, the relationship between shoot speed and isokinetic force production (Platanou and Varamenti, 2011; Varamenti and Platanou, 2008), which is one of the main factors influencing the end result, is limited during field conditions and specific exercises. In one of the studies, the shooting speed and force differences between the groups with the shooting speed and shoulder internal-external rotation forces were investigated in two groups of female water polo players (Varamenti and Platanou, 2008), in another study, the shooting speed and shoulder internal - external rotation forces and speed - power correlations have been examined (Platanou and Varamenti, 2011).

There are studies in the literature that examine the relationship of isokinetic forces of the knee, shoulder and hip joints with shooting speed in different branches (Bayios et al., 2001; Dutta and Subramanium, 2002; Fleck et al., 1992; Van den Tillaar and Ettema,2004; Zapartidis et al., 2007). In the shoot in the water polo, it was not found in the study literature showing that the legs are important to the upper limb transfers by raising the legs outside the water (the force produced by the lower extremity) and the upper extremities, but only with the upper extremity producing forces.

For this reason, the purpose of this study is; male water polo players to investigate the relationship between the isokinetic forces produced by the upper and lower limbs (with leg movements) and only upper limbs (without leg movements) and the velocity of the shoot measured in two different shoot protocols (with and without leg movements) in five different joint movements.

2. Materials and Methods

2.1 Participants

18 male water polo players (mean body mass 76.51±14.74 kg, mean stature 178.86±7.42 cm) aged 15-33 in the national professional Water Polo 1st League participated in the study voluntarily. The design of the structure is in compliance with the "*Declaration of Ethical Principles for Medical Research including Human Subjects*" and was approved by the Medical Faculty Clinical Research Ethics Committee of the local university. Informed consent forms were obtained from each subject prior to the study.

2.2 Experimental Design

Throwing velocity measurements of the 18 participants of the study were taken on three separate training days, the isokinetic tests were completed on further training days. All measurements were taken during the preparation period at the beginning of the season and all tests were completed in one week.

2.3 Throwing Velocity Measurements

Bushnell Sports Radar (Sports Radar, Bushnell, USA), which has a velocity range of 16-177 km·h^{-1} and can detect velocities up to 27 meters with an error margin of ± 2 km·h^{-1}was used for the throwing velocity measurements of the players. For the measurements carried out at the Olympic Swimming Pool of the local university, a regular water polo field was set before the test, which was used for training purpose and all the throws were sent to the regular water polo goal.

Shoot applications were created from two different protocols (with and without leg movements). In the first protocol; shoot with the leg movements, the players' foot scissor movements were included (Figure 2). In the second protocol; in the unsteaded shoots, the shoot (where the feet were fixed), in which the footscissors were not involved, was thrown, the subjects' ankles, the knee and the hitch were fixed with the tie and only the upper extremity was used to shoot (Figure 3). Since one of the primary data the study focused on was the throwing velocity, there was no goalkeeper at the goal and the players were asked to throw the ball to a point they wanted by focusing well and at the highest possible velocity. Goal bound throws and those bouncing off the goal post were included for evaluation. Throws sent into the goal by bouncing off the water or those not thrown in the desired form were not evaluated.

In their study, Özkol ve ark (2013) found that among the 6 positions, throws were mostly taken from p2, p3, and p4. In this respect, p2, p3 and p4 for overhead throw (OHT) and p6 for back hand throw (BHT) and sweep throw (ST) were chosen for the experimental procedure of this study. The 18 players were divided into 3 groups of 6 randomly, regardless of their playing positions in the game. The measurements of each group were completed on separate training days. Each player took 3 throw from these specified positions (p2, p3, p4, p6-back hand, p6-sweep) respectively (Figure 1-4-5). Sixty-second rest was given after each throw for each player, meanwhile, the player was allowed to have passive passes in the water without getting tired. After completing the throws of 6 players belonging to one position, it continued with the other position respectively. Prior to the throws from specific positions, the players warmed up by 800 m water polo specific swimming, 10-15 minutes passing, and throwing to the goal from different positions and forms for 10 minutes. In order to reduce the margin of error of the throws taken by the players and to determine the correct velocity the radar was located behind the goal at a 0° angle to the throwing position (direct line) (Figure 1). Velocities were detected in km·h^{-1} by the sports radar and recorded simultaneously and the best of the three trials was included in the evaluation.

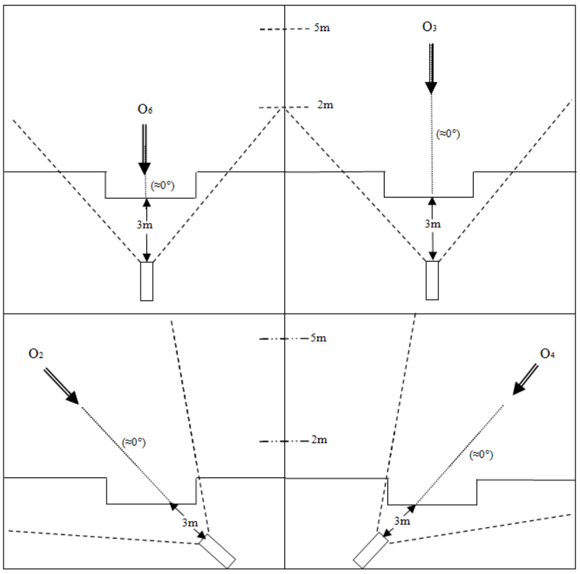

Figure 1: Schematic display of throwing positions by radar, O_2, O_3, O_4, O_6 = throwing positions

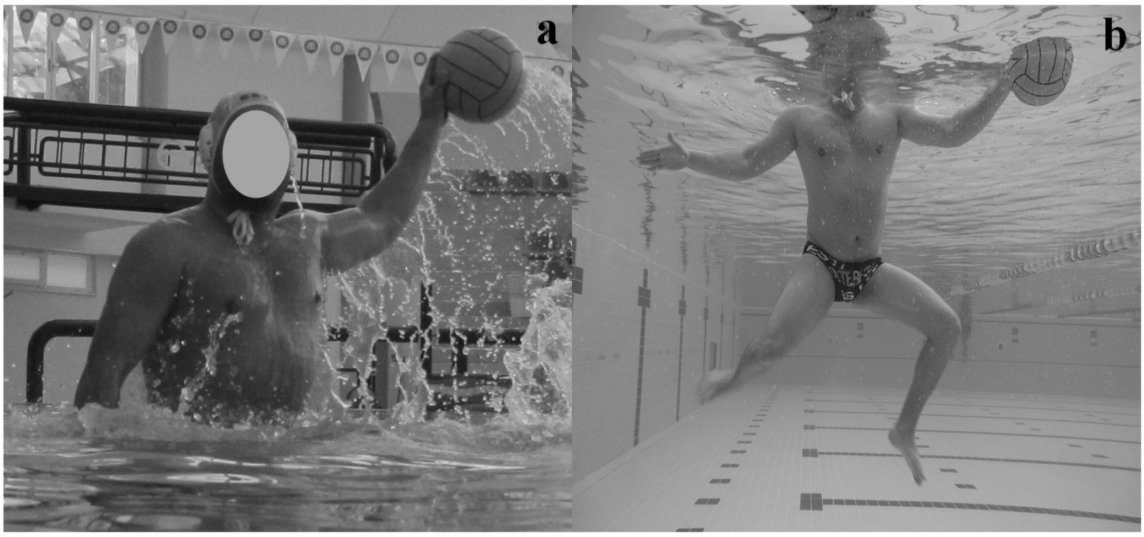

Figure 2: With leg movement shoot, (a) trunk, (b) legs

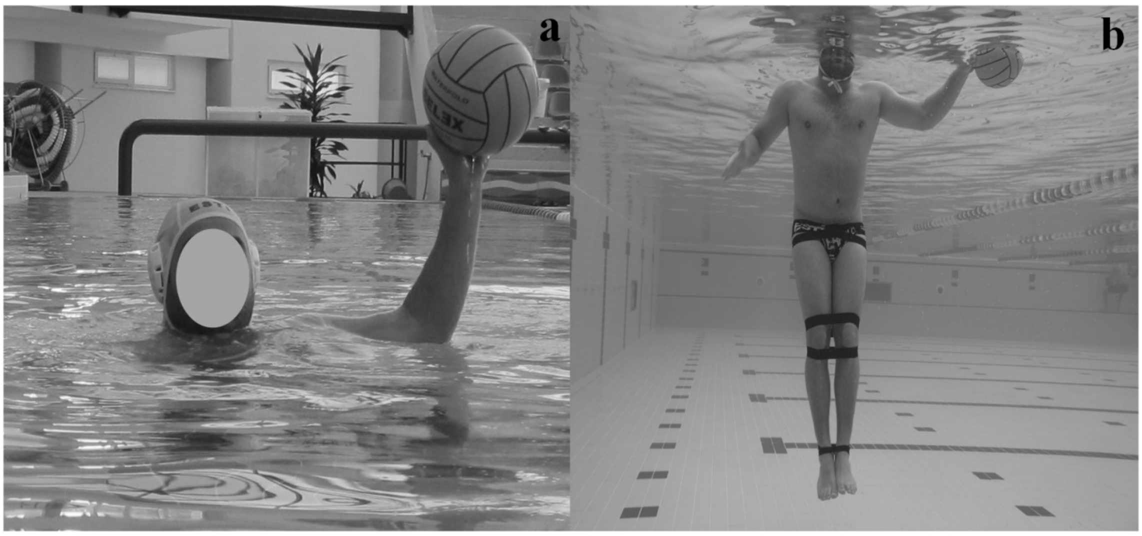

Figure 3: Without leg movement shoot, (a) trunk, (b) legs

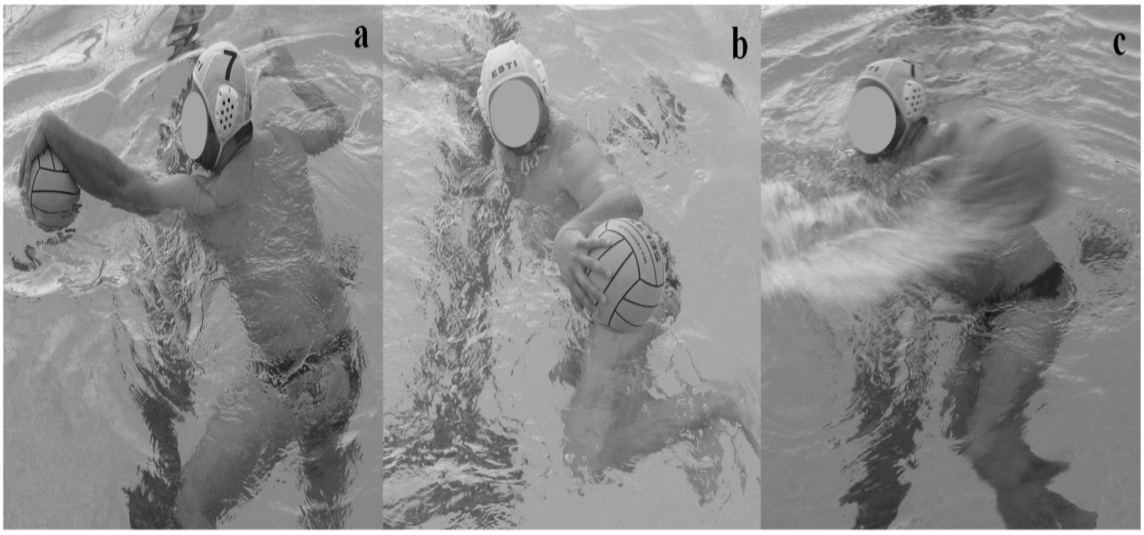

Figure 4. Back hand throw

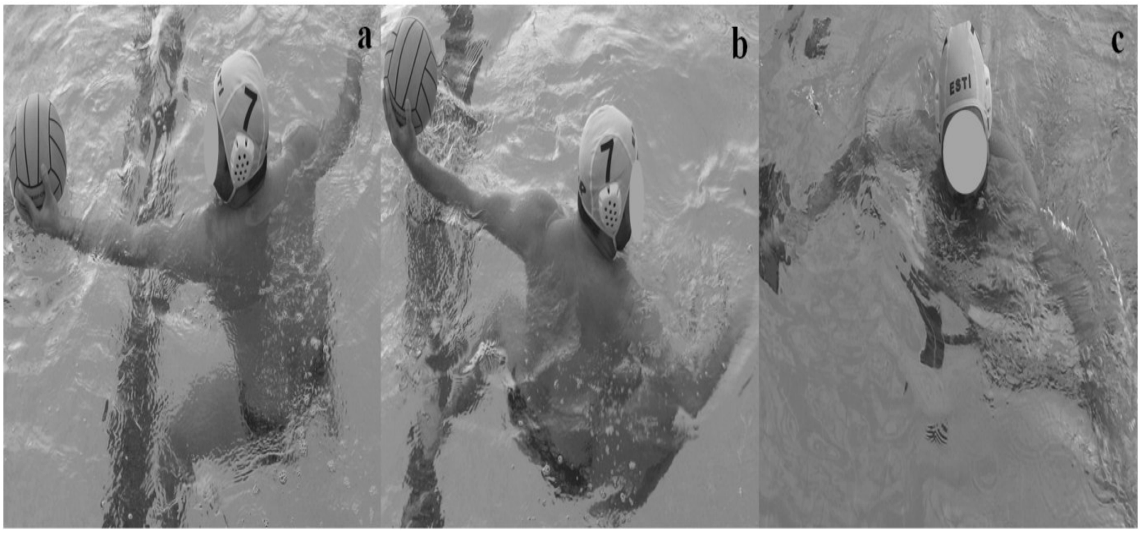

Figure 5: Sweep throw

2.4 Isokinetic Strength Measurements

Before the isokinetic test, subjects warmed-up on a cycle ergometer pedaling at a work rate of 20 watts at 50 rpm for 7-minutes. An isokinetic dynamometer (Cybex Humac Norm 770, USA) was used to measure the lower and upper extremities (hip abduction-adduction, hip flexion-extension, knee flexion-extension, shoulder flexion-extension, trunk flexion-extension) torque. The isokinetic dynamometer was calibrated at the beginning of each test day in accordance with the procedures specified by the manufacturer's manufacturer.

The tests were carried out in a standing, seatting and sitting position on the unit's special seat. After giving preliminary information about the test, the anthropometric data were input to the Cybex apparatus which was to be measured by the players, and the device was adjusted. The range of motion the addition by the computer was found by making a movement to the player. After the test measurements were taken, the test measurements made according to the protocol specified were transferred to the computer environment. Isokinetic concentric muscle strength tests were performed without gravity for specified joint movements. The measurements were completed in two days for all players. Verbal encouragement was given to the subjects during the measurement.

On the first day, isokinetic strength measurements of hip abduction/adduction, shoulder extens/flexion and hip extensions/flexion were determined. The submaximal trial (3 repetitions) and the test (5 repetitions) were performed at 60°/s angular velocity in hip abduction/adduction and hip extension/flexion isokinetic force measurements. Shoulder extension/flexion is 7 min at warm up for isokinetic force measurement. Arm ergometer (55-65 rpm) and 3 min. Followed by submaximal trial (3 repetitions) and test (5 repetitions) at 90°/s angular velocity (Brown, 2000).

On the second day, trunk extension/flexion and knee extension/flexion isokinetic strength measurements were performed. In these isokinetic strength measurements warming protocol for 7 min cycle (55-65 rpm), 1.5 min for special warming (crunch, push-up, reverse shuttle for trunk), 1.5 min stretching followed by submaximal trial at 60°/s) and test (5 repetitions) (Brown, 2000). A 30 s time interval was provided between repetitions whereas a 2 min rest period was given between angular velocity tests (Tsiokanos et al., 2002).

2.5 Statistical Analyses

For data analyses, descriptive statistics relating the players' physical characteristics, data from isokinetic strength measurements and throws taken from different positions were carried out. Shapiro-Wilk (SW) test was applied to test the fit of the data with normal distribution. The paired t-test was used for statistical evaluation of the differences between shoot types (with and without leg movements) in each shoot area. The relationships between with and without leg movements throwing velocity measurements were evaluated using Pearson Product Moment Correlation analysis. Lineer regression method is used to show the most predictive isokinetic data for each of the lower and upper extremities tests. All analysis was executed in SPSS for Windows version 17.0 and the statistical significance was set at $p < 0.05$.

3. Results

Speeds in with leg shoots; 65.94 ± 6.97 km·h^{-1} in 2nd area, 64.78 ± 6.23 km·h^{-1} in 4th area and 63.98 ± 5.12 km·h^{-1} in 3rd area. Speeds in without leg shoots; 57.00 ± 5.96 km·h^{-1} in 4th

area, 56.50 ± 6.20 km·h^{-1}in 2nd area and 54.89 ± 5.66 km·h^{-1} in 3rd area. According to Table 1, it was determined that the with leg shoots speeds were higher than the without leg shoots speeds. In addition, the region where the shoot speeds with leg and the without leg are closest to each other is the P6 area (back hand throw).

For each region, paired t test was used to measure the statistical significance of the difference between the averages of with leg and the without leg on throwing velocities. According to this; there is a significant difference between with leg and the without leg on throwing velocities in 2nd, 3rd, 4th, 6th (sweep) regions ($p<0.01$, Table 1).

Table 1: Differences and descriptive statistics on throwing velocities (km·h^{-1}) by the positions they are taken (n=18)

positions	with leg shoot	CV%	CI (95%)	without leg shoot	CV%	CI (95%)	difference	p	Cohen's d	CI (95%) d_{Cohen}
P2	65.94 ± 6.97	10.57	62 - 69	56.50 ± 6.20	10.97	53 - 60	9.44**	0.000	1.431	0.396 - 2.467
P3	63.83 ± 5.12	8.02	61 - 66	54.89 ± 5.66	10.31	52 - 58	8.94**	0.000	1.657	0.586 - 2.727
P4	64.78 ± 6.23	9.61	62 - 68	57.00 ± 5.96	10.45	54 - 60	7.78**	0.000	1.276	0.263 - 2.29
P6(BHS)	50.22 ± 11.87	23.63	44 - 56	44.11 ± 7.94	18.01	40 - 48	6.11**	0.001	0.605	-0.34 - 1.55
P6(SS)	45.94 ± 10.10	21.98	41 - 51	41.89 ± 9.63	22.98	37 - 47	4.06	0.114	0.41	-0.523 - 1.344

Isokinetic strength values in water polo players; 352.67 ± 71.3 Nm in trunk flexion and 292.22 ± 66.78 Nm in left hip extension and in right hip extension 291.83 ± 64.32 Nm, 94.56 ± 14.61 Nm in shoulder flexion, 104.56 ± 25.1 Nm in right hip abduction and 104.89 ± 24.47 Nm left hip abduction (Table 2).

Table 2: Isokinetic peak torque values (in Nm) and descriptive statistics, (n=18)

		mean ± sd	min - max	range	CV%	CI (95%)
Trunk (60°/s)	Extension	222.17 ± 37.76	172 - 283	111	16.99	203 - 240
	Flexion	352.67 ± 71.3	216 - 525	309	20.21	317 - 388
Shoulder (90°/s)	Extension	127.72 ± 37.33	81 - 198	117	29.22	109 - 146
	Flexion	94.56 ± 14.61	66 - 122	56	15.45	87 - 101
Hip (60°/s)	Right Extension	291.83 ± 64.32	179 - 400	221	22.04	259 - 323
	Right Flexion	179.94 ± 38.61	124 - 259	135	21.45	160 - 199
	Left Extension	292.22 ± 66.78	172 - 426	254	22.85	259 - 325
	Left Flexion	165.67 ± 28.91	115 - 207	95	17.45	151 - 180
	Right Abduction	104.56 ± 25.1	66 - 146	80	24.01	92 - 117
	Right Adduction	174.5 ± 54.12	100 - 266	166	31.01	147 - 201
	Left Abduction	104.89 ± 24.47	60 - 138	78	23.32	92 - 117
	Left Adduction	188.61 ± 52.87	116 - 262	146	28.03	162 - 214
Knee (60°/s)	Right Extension	229 ± 37.54	168 - 308	140	16.39	210 - 247
	Right Flexion	157.61 ± 20.90	123 - 198	75	13.26	147 - 168
	Left Extension	224.72 ± 37.93	155 - 296	141	16.87	205 - 243
	Left Flexion	150.28 ± 23.09	114 - 212	98	15.36	138 - 161

Table 3: Pearson correlation coefficients between with leg throwing velocities and isokinetic strength measurements

Positions	**TF (60°/s)**	**TE (60°/s)**	**SE (90°/s)**	**SF (90°/s)**	**RHE (60°/s)**	**LHE (60°/s)**	**RHF (60°/s)**	**LHF (60°/s)**	**RHAb (60°/s)**	**LHAb (60°/s)**	**RHAd (60°/s)**	**LHAd (60°/s)**	**RKE (60°/s)**	**LKE (60°/s)**	**RKF (60°/s)**	**LKF (60°/s)**
2	0.52*	0.23	0.56*	0.42	0.44	0.41	0.34	0.39	-0.01	0.53*	-0.28	0.15	0.61**	0.43	0.43	0.51*
3	0.53*	0.21	0.40	0.47*	0.36	0.36	0.36	0.37	0.06	0.52*	-0.33	0.25	0.50*	0.30	0.44	0.53*
4	0.47*	0.41	0.34	0.56*	0.47*	0.52*	0.52*	0.52*	0.41	0.64**	-0.12	0.32	0.52*	0.49*	0.37	0.50*
6 (back)	0.72**	0.46	0.75**	0.61**	0.59*	0.63**	0.62**	0.56*	0.41	0.61**	0.02	0.32	0.69**	0.61**	0.30	0.28
6(sweep)	0.53*	0.12	0.07	0.08	0.32	0.52*	0.35	0.16	0.26	0.28	-0.06	0.15	0.35	0.36	0.09	0.18

* $p \leq 0.05$, ** $p \leq 0.01$, TF; trunk flexion, TE; trunk extension, SE; shoulder extension, SF; shoulder flexion, RHE; right hip extension, LHE; left hip extension, RHF; right hip flexion, LHF; left hip flexion, RHAb; right hip abduction, LHAb; left hip abduction, RHAd; right hip adduction, LHAd; left hip adduction, RKE; right knee extension, LKE; left knee extension, RKF; right knee flexion, LKF; left knee flexion.

The relationships between with and without leg movements throwing velocity measurements were evaluated using Pearson Product Moment Correlation analysis. In terms of shooting positions, 2nd position when the relationship between the velocity of with leg movement shoot and isokinetic muscle strength was considered, trunk flexion (r=0.52), shoulder extension (r=0.56), left hip abduction (r=0.53), left knee flexion (r=0.51) as relevant $p<0.05$, a relationship with right knee extension (r=0,61) was found ($p<0.01$). 3rd position, a positive relationship ($p<0.05$) was recorded between trunk flexion (r=0.53), shoulder flexion (r=0.47), left hip abduction (r=0.52), right knee extension (r=0.50) and left knee flexion (r=0.53). In 4th position, between the with leg movement shoot and trunk flexion (r=0.47), shoulder flexion (r=0.56), right hip extension (r=0.47), left hip extension (r=0.52), right hip flexion (r=0.52), left hip flexion (r=0.52), right knee extension (r=0.52), left knee extension (r=0.49), left knee flexion (r=0.50) and left hip abduction (r=0.64). A positive relationship ($p<0.01$) between with leg movement (backhand) shoots thrown from 6th and trunk flexion (r=0.72), shoulder extension (r=0.75), shoulder flexion (r=0.61), left hip extension (r=0.63), right hip flexion (r=0.62), left hip abduction (r=0.61), right knee extension (r=0.69) and left knee extension (r=0.61). Also a positive relationship ($p<0.05$) between the with leg movement backhand shoots thrown in 6th position, and right hip extension (r=0.59) and left hip flexion (r=0.56). A positive relationship ($p<0.05$) was seen between the shoots thrown from part 6th position with leg movement sweep shoots and trunk flexion (r=0.53) and left hip extension (r=0.52).

Table 4: Pearson correlation coefficients between without leg throwing velocities and isokinetic strength measurements

Positions	TF (60°/s)	TE (60°/s)	SE (90°/s)	SF (90°/s)
2	0.68**	0.24	0.63**	0.49*
3	0.64**	0.31	0.49*	0.51*
4	0.68**	0.24	0.45	0.42
6 (back)	0.69**	0.41	0.87**	0.63**
6 (sweep)	0.56*	0.43	0.56*	0.46

* $p\leq0.05$, ** $p\leq0.01$, TF; trunk flexion, TE; trunk extension, SE; shoulder extension, SF; shoulder flexion

When the relationship between the velocity of without leg movement shoot and isokinetic strength is overviewed according to the positions, in 2nd position there is a relationship between without leg movement shoot and trunk flexion (r=0.68) a positive relationship was seen ($p<0.01$) and shoulder extension (r=0.63), with the shoulder flexion (r=0.49) a positive relationship was seen ($p<0.05$). In 3rd position, there is a positive relationship ($p<0.01$), was recorded in the trunk flexion (r=0.64), a positive relationship ($p<0.05$) was seen in shoulder extension ($r=0.49$) and shoulder flexion ($r=0.51$). In 4th position, a positive relationship ($p<0.01$) was found with the trunk flexion ($r=0.68$). A positive relationship ($p<0.01$) was found with the without leg movement backhand shoots that were thrown from the 6th position and trunk flexion ($r=0.69$), shoulder extension ($r=0.87$), shoulder flexion ($r=0.63$). A positive relationship ($p<0.05$) was recorded with the without leg movement sweep shoots and trunk flexion ($r=0.56$) and shoulder extension ($r=0.56$).

4. Discussion

The purpose of this study is; male water polo players to investigate the relationship between the isokinetic forces produced by the upper and lower limbs (with leg movements) and only upper limbs (without leg movements) and the velocity of the shoot measured in two different shoot protocols (with and without leg movements) in five different joint movements.

4.1 Examination of the difference between with and without leg movements velocity of the shoot

There were significant differences in throwing velocities between different throw forms taken from 2nd, 3rd, 4th, 6th positions ($p<0.05$). In 6th area, there was no significant difference between two shoot form (back and sweep). It is seen that the average of the with leg movements throwing velocity is higher (13.17%) than that of the with leg movements throwing velocity. The lower extremity fixed from the feet, knees and hips in the unbalanced shoot protocol, the body is more resistant to water resistance because it can not lift the body up. Staying in the water until the shoulder is up to the shoulder causes the whip movement in the direction of the shooting shoot to fail (trunk extensor and flexion) and this situation has a negative effect on the shooting velocities. The level of out of the water at the shoot, the vertical is the best determinant of the ball speed (Ball, 2004). In unsteady shoot form, this may have affected the speed of the ball because the lower extremities of the subjects were fixed and their bodies could not be brought to maximal height.

4.2 Investigation of the relationship between the isokinetic forces of the upper and lower extremities and the with leg movements velocity of the shoot

There was found to be statistically significant the relationship between the isokinetic forces produced by the upper and lower extremities and the the with and without leg movements velocity of the shoots taken from different regions. Platanou and Varamenti

(2011) found that the isokinetic strength of the shoulder inner rotation (IR) and the outer rotation (ER) affected the shooting velocity in the water polo in their study of 33 female water polo players. In their study, they found a positive correlation between the velocity of the muscle and the velocity of the shoot.

In one of the studies, the shooting velocity and internal - external rotation forces of the two groups of female water polo players (old-young) were examined and the power differences between the groups were examined. Older players; the superiority of the technical skills in the head-to-head shootings, the increased arm lengths, the increased strength of the shoulder's internal and external rotation indicate that the velocity of the shoot is higher than that of young players. Anthropometric features are important in shoot velocity, increased muscular performance, superior physiological and technical characteristics will increase the shooting velocity (Varamenti and Platanou, 2008). In with leg movements velocity of the shoots; trunk flexion, shoulder flexion, left hip extensor, left hip abduction, right knee extension and left knee flexion are more effective. This is because there is a significant positive correlation between the forces produced by these joint movements and the shooting velocities of at least 3 and more regions from 5 different regions shoot at.

During the shoot, the force generated by the legs (eggbag kick) in the repeated the hip and knee helps the athlete to lift his body out of the water. At this time, the body moves like a whip with the release of the torso and the force is transmitted to the arm, then the ball is shoot. A positive relationship was found with the without leg movement backhand shoots that were thrown from the 6th position and trunk flexion, shoulder extension, shoulder flexion, right-left hip extension, right-left hip flexion, left hip abduction, right-left knee extension. In the over-water and underwater evaluations of the reverse shooting action, when reaching the ball and throwing the ball, reaching the ball and throwing the ball at the moment of the shoulder extensors, again catching the ball and raising the athlete during the shooting, knee and hip thrusts and traction, in the last shoot, the trunk rotation was seen to be used more during the shoot in the rotation of the body.

It is seen that the left hip extension before the ball hand exit, and the trunk flexion in the forward movement of the body are used more frequently during the catching of the ball during the sweep shoots that were thrown from the 6th position. It is seen that shooting preparation during the shoots that were thrown from the 2nd and 3th position, the shoulder flexion when the body is pulled back together with the ball. Throwing the ball together arm from before the ball hand exit, the body flexion appears to be used more for the contribution of the lower extremity (hip and knee) movements to the vertical rise from the water. Raising or jumping in water, with appropriate anthropometric properties, increase in muscle strength are parameters that provides an increase in shoot velocity.

4.3 Investigation of the relationship between the isokinetic forces of the upper extremities and the different position without leg movements velocity of the shoot

There was found to be statistically significant the relationship between the isokinetic forces produced by the upper extremities and the without leg movements velocity of the shoots taken from different regions. In our study, there was a positive relationship seen between the velocity of without leg movement shoot and isokinetic strength is overviewed according to the positions, in all position there is a relationship between without leg movement shoot and trunk flexion (60°/s) 352.67 ± 71.30 Nm, shoulder flexion (90°/s) 127.72 ± 37.33 Nm (6th position back/sweep, 2nd and 3rd position) (Table 2). When in our study the correlation coefficients between the shoot velocities obtained from the two different shooting protocols and isokinetic strength measurements, the contribution of the isokinetic strength produced by the upper extremities to the velocity of shoot appears to be greater in the with leg movement than in the without leg movement shoot (Table 3-4). In the without leg movements velocity of the shoots; trunk flexion (2nd, 3rd, 4th and 6th back/sweep position), shoulder flexion (2nd, 3rd and 6th back) and shoulder flexion (2nd, 3rd and 6th back) was found to be more effective than in the with leg movement shoot.

In the without leg movement shoot, the athlete, who is fixed by his ankle, knee and thigh, takes all his strength from the upper extremity. In the meaning of muscle performance an athletes who have a strong body, abdomen, abdomen, back and arm muscles and with good anthropometric characteristics use the momentum of the body during the shooting.

In our study, it was determined that the contribution of the upper extremities was more than without leg shoots speeds were higher than the with leg shoots speeds. This shows us that the strength of the trunk, back and shoulder muscles as well as the lower extremity is necessary for a quick shoot. The increase in strength produced by each segment of the body provides a more effective shoot. To increase ball speed, shoulder internal and external rotation, flexion and extension, elbow supine and wrist flexion are contributing factors. The momentum created by the body in front of the shoot is very important for ball control during the shoot. Water polo players, their bodies closes like a whips and the accelerating the force transmitted to the ball makes a effective shoot.

Narici et al. (2000), was investigated the relationship between knee extension and hip flexion forces and ball striking velocity in soccer players. Peak torque values of the knee extensor muscles were 103 ± 21 Nm and peak torque values of the hip flexion muscles were 147 ± 33 Nm. In their study, it was found high correlation between these forces with maximal shooting velocity. William et al. (1999) found that the increase in strength of the shoulder abduction-adduction with shoulder external-internal rotation at 90°/s angular velocity increases torque production.

Saliba's study (2001), was conducted to determine if there is a relationship between isokinetic strength and shoot performance and leap in Austrian football players and measuring it by applying the test protocol to the knee flexion extremity at a biodex isokinetic dynamometer at 60 °/s, 240 °/s, 360 °/s angular velocity. There was no statistically relationship between maximal shoot velacity and isokinetic knee strength.
David et al. (2005) were found that increase in strength force in shoulder flexion, shoulder internal rotation, and abduction increased isokinetic strength in 40 tennis players. The isokinetic forces of the internal and external rotation of the shoulder at 60-120 °/s angular velocity were measured, while standing at the national level male handballs. There was no statistically relationship between shoulder internal and external rotation isokinetic peak torque and shooting velocity. Larry et al. (1982) were investigated the relationship between upper extremity strength and shooting velocity in 8 baseball player. They was found that a relationship between elbow and wrist extension strength and shooting velocity. Fleck et al. (1992) were found that to be stronger than internal rotators and external rotators in both dominant and non-dominant arm measurements at 90 °/s and 180 °/s angular velocity in two handball players groups. In other study, the isokinetic data measured on the baseballs that imitate the upper-arm throw similar to the goal-ball castle motion were found to be similar (Brown, 2000). Studies examining the biomechanical analysis of the shoot in the water polo (Ball, 1996; Stirn and Strojnik, 2006; Van der, 2005), the speed of shoot, the force of the muscles, the technique and the synchronization of the different segments. Kaga et al. (1986) emphasize that the elite water polo players have moved higher up the body with knee flexion-extensions to emphasize that they produce more force during the shooting, that is, they use the lower extremity more. In a biomechanical study examining the effect of the torso on the shoot, they found that the lateral flexion of the torso and trunk rotation (along with hip and shoulder rotation) contributed to the rotation of the ball around itself and to the desired direction (Van der, 2005). Leach et al. (1985) were found that the ability to use lateral trunk flexion and the increased range of motion of the shoulder joint accelerate a shoot with a good technique. In the same study, increased elbow flexion and external rotation indicated that ball speed would increase.

Ball (2005), in his biomechanical study of elite players in the waterpolo, he stated that the shooting speed reached 50-80 km/h depending on the muscular force, shoot technique, fascia length and lateral trunk flexion. In Ball (2004) analysis, he was found that 30-35% of trunk rotation, 20-30% of shoulder internal rotation and arm adduction, 20-27% of elbow extension and 8-13% of wrist flexion contributed to shoot velocity in water polo. In the water polo players, body flexion, trunk extensor, and shoulder extensions were significantly correlated with shoot speed of joint motion width measurements (Bloomfield, 1990; Tan, 2009; Triplett, 1991; McMaster, 1991).

These works show that there is a significant contribution to the shooting velocity of the upper limbs; even if the shooting forms are in with and without leg forms in the water polo. The contribution of the isokinetic strength produced by the upper extremities to the shooting velocity seems to be higher without leg movements velocity shoot than with the leg movements velocity of the shoots.

5. Conclusion

A significant difference was found between with and without leg movement in different throwing velocity shoots were recorded in different shooting positions. This difference was significant in shoots from the 2nd, 3rd, 4th, 6th (sweep) regions.

It was determined that the average of the with the leg movements velocity of the shoots was higher than with the leg movements velocity of the shoots. The isokinetic strength produced by the upper and lower limbs' relation with the velocity of with leg movement shoots. The isokinetic strength produced by the upper limbs' relation with the velocity of without leg movement shoots thrown from different parts was found. The isokinetic strength's (produced by the upper limbs) contribution to the velocity of the shoot in without leg movement shoot is higher than with leg movement shoots. The results of the study upper limbs strengths' (trunk flexion, shoulder flexion, shoulder extension) are more effective in the velocity of the shoot.

According to these results, in order to meet the conditional and physiological requirements specific to the sewing machine, the isokinetic measurements should be made during the pre-season. The results of this study; coaches will assist in the planning of strength training, taking into account the different correlations and contributions of isokinetic strength produced by the upper and lower extremities in with and without leg movement in different throwing velocity shoots.

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