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Throwing velocity in water polo elite competition: Analysis of associated variables

LAURA GARCÍA-CERVANTES[1], ENCARNACIÓN RUIZ-LARA[2], FRANCISCO MANUEL ARGUDO ITURRIAGA[1], PABLO JOSÉ BORGES-HERNÁNDEZ[1]

[1]*Department of Physical Education, Sport and Human Movement, Autonomous University of Madrid, Spain*
[2]*Department of Physical Activity and Sport Sciences, Universidad Católica San Antonio Murcia, Spain*

ABSTRACT

Throwing velocity is a relevant variable in water polo performance. Few studies have investigated the throw's speed during an official competition or real game situation in high level competition. All throws performed in 27th European Championship in 2006 (Belgrade, Serbia) and 12th World Championships in 2007 (Melbourne, Australia) were analyzed in the present study. The total sample was composed of 5,691 throws (2,474 in female category). The study was developed with an observational design. A digital video camera, a radar and Polo Análisis Directo v1.0 software were used to record data. The reliability between the observers was verified using the kappa agreement index, ensuring that in all cases this value was greater than .85. The average maximum speed of throws in female water polo was 13.88 m/s (±2.44 m/s) and 16.94 m/s (±3.38 m/s) in male. The variables distance and game situation showed a combined ability to predict 19% of speed differences in female water polo throws and 33% in male. **Key words:** TRAINING, TACTICAL ANALYSIS, THROW, MATCH, SPORTS PERFORMANCE.

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Corresponding author. *Department of Physical Education, Sport and Human Movement, Autonomous University of Madrid, Spain.* http://orcid.org/0000-0002-0767-8768
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INTRODUCTION

Water polo is a cooperation-opposition sport which combines actions of high intensity and short duration with periods of low intensity. These actions include constant throws, jumps, blocks, sprints, catches and passes, requiring fast, strong players who have the diverse technical and tactical skills that water polo demands (Smith, 1998; Tan, Polglaze & Dawson, 2009; Van der Wende, 2005).

Several authors have highlighted that of all the actions that impact water polo performance, throws are one of the most decisive technical skills in terms of the outcome of a match (Marques, et al., 2012; McCluskey, Lynskey, Leung, Woodhouse, Briffa & Hopper, 2010; Smith, 1998; Stevens, Brown, Coburn & Spiering, 2010; Van der Wende, 2005). More specifically, it is accuracy and throw velocity that have the greatest impact on the final result, assuming that a faster throw decreases reaction time and makes it more difficult for defenders and goalkeeper to intercept, increasing the likelihood of a goal (McCluskey, et al., 2010; Sinclair, Fewtrell, Taylor, Bottoms, Atkins & Hobbs, 2014; Vila, Ferragut, Argudo, Abraldes, Rodríguez & Alacid, 2009). For this reason, research in water polo has analyzed technical skills from various different perspectives, including effect of training programs on the throwing velocity (Van der Tillaar, 2004), throwing goal effectiveness (Argudo, Alonso, García & Ruiz, 2007; Argudo, Ruiz & Abraldes, 2010; Enomoto, et al., 2003; Sarmento & Magalhaes, 1991), anthropometric and biomechanical parameters (Alcaraz, Abraldes, Ferragut, Rodríguez, Argudo & Vila, 2011; Aleksandrovic, Naumovski, Radovanovic, Georgiev & Popovski, 2007; Ferragut, Vila, Abraldes, Argudo, Rodríguez & Alcaraz, 2011; Melchiorri, Padua, Padulo, D'Ottavio, Campagna & Bonifazi, 2011; Stirn & Strojnik, 2006; Tan, Polglaze, Dawson & Cox, 2009; Vila, et al., 2009), throwing velocity from different field playing positions and micro-situations (Abraldes, Ferragut, Rodríguez, Alcaraz & Vila, 2011; Alcaraz at al., 2011; Alcaraz, Abraldes, Ferragut, Vila, Rodríguez & Argudo, 2012; Ferragut, Abraldes, Vila, Rodríguez, Argudo & Fernandes, 2011; Stevens, et al., 2010).

However, very little of this research was carried out based on throws which took place in official Championships in real game situations (Abraldes, et al., 2011; Alcaraz, et al., 2011; Alcaraz, et al., 2012), where there are other factors that can have an impact (there are differences between throw speed in training and/or competition), as well as the presence of opponents, the micro-situation in which the throw is performed (even, counterattack, power play and penalty), the angle or position of the throw and the distance from the goal at which the throw was made.

It is important to study the throw speed of elite water polo players during real game, considering the throws of men and women separately, because in both competitions perceive differences between the sexes (García, Argudo & Alonso, 2012) and in type, speed and number of throwing (Argudo, Ruiz-Barquín & Borges, 2016).

This study therefore had two objectives: (i) to examine whether there are differences between men's and women's water polo in terms of the maximum velocity of throw at goal and of the various percentages of throw based on a range of categories: distance from which the throw was made, throw position and play micro-situation in which the throw was performed; and (ii) compare throw velocity based on the above variables, differentiating between sexes. Research for both objectives was carried out in a high-performance water polo competition.

METHODS

This was an observational study (Anguera, 2003) that analyzed all throws performed in a total of 160 games were filmed, 68 in the women's category (20 from the 27th European Championship in 2006 (Belgrade, Serbia) and 48 from the 12th World Championships in 2007 (Melbourne, Australia), and 92 in the men's category (44 from the European Championship and 48 from the World Championships).

Participants

The total sample comprised 5,691 throws, which were further divided into two subsamples. A women's category with 2,474 throws, of which 30.5% corresponded to the European Championship (*n*=754) and the 69.5% to the World Championships (*n*=1720), and a men's category with 3,217 throws, of which 35.6% corresponded to the European Championship (*n*=1146) and 64.4% to the World Championships (*n*=2071). As it is public event and its participants are of legal age, as well as having been authorized by the different committees and agencies, did not proceed to request the approval of the ethical committee.

Procedures

In each game, all throws were recorded and their speed was measured live. A digital video camera (JVC, GZ-MG50E, Japan) was used to record the throws, located in an standardized elevated position above the centre and in line with the mid-point of the pool. A radar (StalkerPro Inc., Plano, TX, USA) with a data collection frequency of 33 Hz, located 10 metres behind each goal and parallel to the lines of the playing field (goal, 2 metres, 5 metres and midfield) was used to record the speed of the ball (Figure 1). Subsequently, various observers who were not involved in this research and who had previously received training in observational categorisation analyzed all throws using the software *Polo Análisis Directo v1.0* (Argudo, Alonso & Fuentes, 2005). The reliability of the observers was verified using the kappa agreement index, ensuring than in all cases this value was greater than .85.

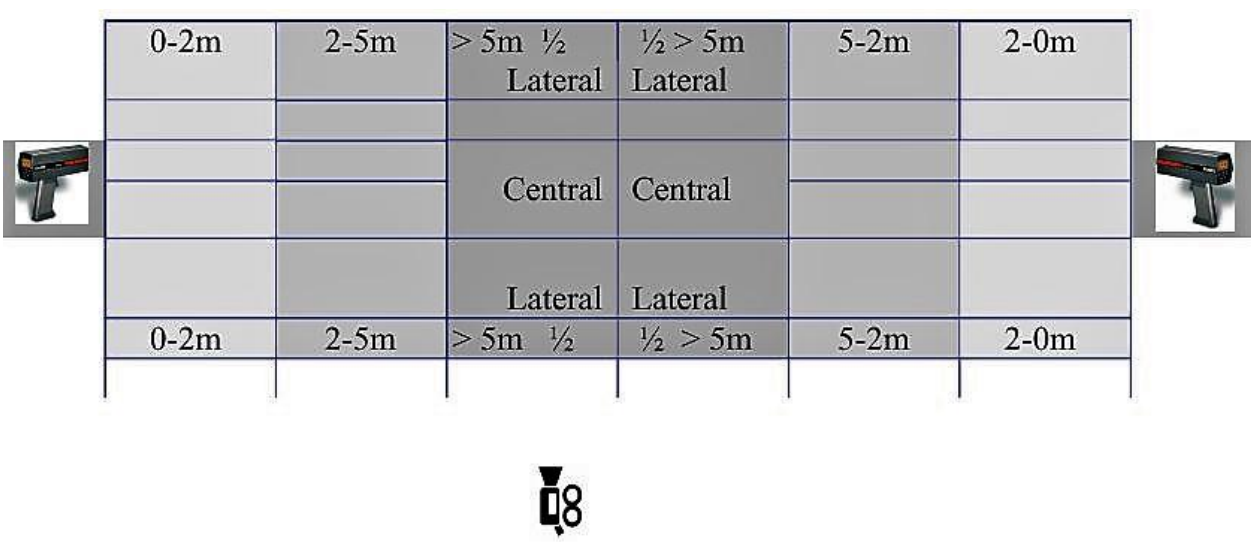

Figure 1. Video camera and radar located and playing field division

This research analyzed four variables: (1) The micro-situation when the throw was taken, divided into three categories: (a) numerical equality between the two teams (even); (b) transition from one goal area to the other which produces a temporary man-up situation (counterattack); (c) numerical inequality between the two teams due to temporary expulsion (20") of a player (power play). (2) Throw position with respect to the centre of the goal area being attacked, comprising two categories: (a) throw taken from the centre; (b) throw taken from one or other side. (3) Distance from which the throw was taken; three categories were established, measured from the goal-line of the goal being attacked: (a) throws from under 2 metres; (b) throws from between 2 and 5 metres; (c) throws from over 5 meters. (4) Maximum throw speed (ranged from 8.33 to 27.78 m/s).

Data analyses

The differences between throws in female and male water polo were analyzed using the T-test for independent samples for the speed variable and the Chi-square test for the other variables, where the direction of the differences was identified through standardized residuals corrected ($Z_{corrected}$). To compare throw speed based on the associated variables and analyse possible interaction effects, factorial variance analysis was undertaken, identifying the differences between the groups using Tukey's multiple comparison test. To measure effect size, Cramér´s V (V) for the Chi-square test and their interpretation was based on the following criteria: .10 small effect, .30 medium effect, .50 high effect (Cohen, 1988). On the other hand, we used an analysis of one-way ANOVA variance for the other statistical tests used. In this case, effect sizes (EZ) were calculated using the square eta (η2) statistic and their interpretation was based on the following criterion: .01 small effect, .06 medium effect, .14 high effect (Cohen, 1988). Analyses were undertaken using the IBM SPSS Statistics 20 software program. A confidence level of 95% was established (p<.05).

RESULTS

Table 1 shows that the average maximum throw velocity in women's water polo was 13.88 m/s (±2.44 m/s), whilst in men's water polo it stood at 16.94 m/s (±3.38 m/s), which is a statistically significant difference (t=-40.70, df=5689, p<.001, η^2=.22). A significant statically association was observed between men's and women's water polo in the percentage of throws taken from the different position. Both women and men threw most often from the sides, though the percentages differed (χ^2=4.73, df=1, p=.03, V=.03). However, there was no statistically significant difference in throwing velocity observed between women's and men's water polo and the percentages registered in terms of the throw distance variable (χ^2=.17, df=1, p=.67) or the micro-situation variable (χ^2=4.3, df=2, p=.11).

Table 1. Comparison between male and female water polo

		n	%	Female	Male	P	η2
Throws average velocity (m/s)		5691	100	13.88±2.44	16.94±3.38	<.001	.22
				% (Z Corrected)		X²	V
Distance	≤5 m	2278	40	40.3 (.4)	39.8 (-.4)	.67	—
	> 5 m	3413	60	59.7 (-.4)	60.2 (.4)		
Angle	Central	1679	29.5	31 (2.2)	28.3(-2.2)	.030	.029
	Lateral	4012	70.5	69 (-2.2)	71.7 (2.2)		
Playing micro-situation	Equality	3207	56.4	57.8 (2)	55.2 (- 2)	.11	—
	Transition	848	14.9	14.1 (-1.5)	15.5 (1.5)		
	Inequality	1636	28.7	28.1 (- 1)	29.3 (1)		

η^2: eta square; V: Cramér´s V; Z: corrected standardized residuals

Throwing velocities in high-level water polo competitions varied depending on the distance, throw position and play micro-situation, both in men's and women's water polo (Table 2). Regarding the women's water polo throws, statically significant differences in velocity were found between throws taken from a distance of five metres or less (12.65 m/s ± 2.36 m/s) and those taken from over five metres (14.71 m/s ± 2.1 m/s) (F=338.2, df=1, *p*=.001, η^2=.12), with no interaction effect from other variables (micro-situation, throw position and distance) (*p*>.05). Also, there were no significant differences in relation to the play micro-situation (F=6.6, df=2, *p*=.001, η^2=.005); the Tukey post hoc analysis identified differences between throws taken in equal or unequal micro-situations (13.89 m/s, both categories) and counterattack throws (13.46 m/s ± 2.56 m/s). This difference with relation to the micro-situation varied according to the distance from which the throw was taken, with virtually no significance (F=5.6, df=2, *p*=.004; η^2=.005). However, there was no difference between throwing speed from the centre (13.74 m/s ± 2.39 m/s) and from the side (14.19 m/s ± 2.47 m/s) (F=1.5, df=1, *p*=.209).

Table 2. Throwing velocity (m/s)

Variable	*Levels*	Female	Male
Distance	≤5 m	12.65±2.36	14.86±3.03
	> 5 m	14.71±2.1	18.71± 2.69
Throw angle	Central	13.74±2.39	17.05±3.36
	Lateral	14.19±2.47	17.49±3.47
Playing micro-situation	Equality	13.98±2.42	17.65±3.33
	Transition	13.46±2.56	16.31± 3.25
	Inequality	13.9±2.36	16.74± 3.44

With regard to the male category, there were significant differences in velocity between the throws taken from a distance of five metres or less (14.86 m/s ± 3.03 m/s) and those taken from over five metres (18.71 m/s ± 2.69 m/s) (F=1006.7, df=1, *p*<.001; η^2=.23). There were also significant differences based on the micro-situation (F=4.4, df=2, *p*=.012; η^2=.003). The Tukey post hoc analysis identified differences between all pairs of measures. That is, between throws in counterattack (16.31m/s ± 3.25 m/s), in power play situations (16.74 m/s ± 3.44 m/s) and in even situations (17.65 m/s ± 3.33 m/s). These differences in relation to distance and micro-situation varied and modulated significantly (*p*<.05) depending on other variables (*throw position*), albeit with a limited magnitude (η^2<.005). However, there were no differences according to throw position, namely between the velocity of throws from the centre (17.05 m/s ± 3.36 m/s) and those taken from the side (17.49 m/s ± 3.47 m/s) (F=3.2, df=1, *p*=.072).

Table 3. General linear model

	Female				Male			
	F	*df*	*p*	*η2*	*F*	*df*	*p*	η^2
Corrected model	53368	11	< .001	.193	143.3	11	< .001	.330
Intersection	52874057	1	< .001	.956	64875.8	1	< .001	.953
Angle	1580	1	.209	—	3.2	1	.072	—
Distance	338250	1	< .001	.121	1006.7	1	< .001	.239
Playing micro-situation	6653	2	.001	.005	4.4	2	.012	.003
Angle * distance	1159	1	.282	—	14.9	1	< .001	.005
Angle * micro-situation	5628	2	.004	.005	3.4	2	.033	.002
Distance * micro-situation	1435	2	.238	—	4.5	2	.011	.003
Angle * distance * micro-situation	.950	2	.387	—	5.3	2	.005	.003

R-squared for female = .19; R-squared for male = .33; df: degrees of freedom; η2: eta square

For both, female and male category, the previous model was statistically significant and was able to explain 19% (F=53.3, gl=11, p<.001, R^2/η^2=.19) and 33% of the dispersion in the velocity variable (F=143.3, gl=11, p<.001, R^2/η^2=.33), respectively (Table 3).

DISCUSSION

The present study analyses all throws performed in the 27th European Championship in 2006 (Belgrade, Serbia) and 12th World Championships in 2007 (Melbourne, Australia) with the purpose of studying their velocity in relation to distance, angle, and the micro-situation in which they took place.

Our results showed that the maximum throwing velocity for women is approximately 3.05 m/s slower than for men (13.88 vs. 16.94 m/s). These results are similar to those found by other authors who have analyzed throws in real game situations (Abraldes, et al., 2011; Alcaraz, et al., 2011; Alcaraz, et al., 2012). Inequalities in throwing velocity between men and women stem from the differences in body composition and strength levels between the two sexes (Lozovina & Pavicic, 2004; Tsekouras, et al., 2005; Vila, Ferragut, Abraldes, Rodríguez & Argudo, 2010).

Both women and men threw more from the side than from the centre, although the percentage of women throwing from the centre was slightly higher than the percentage of men (31% vs. 28%), whilst men threw from the side more often than women (72% vs. 69%). These results can be justified based on the usual behaviour of attackers in water polo arc or semicircle, where wingers are positioned closer to the goal for throwing.

With regard to play micro-situations (even, counterattack and power play), the percentages of throws by men and women are statistically equal. However, higher velocities were recorded in micro-situations of equality in both sex categories (8,42 m/s for women and 17,65 m/s for men), suggesting that in these micro-situations players have more time to prepare throws and these are therefore faster (Alcaraz, et al., 2012).

Taking into account the statistically significant differences found and the fact that their effect size or magnitude is not null, there is evidence that in both categories the throws that reach the highest maximum velocities are those which are thrown from a greater distance (>5m). In this respect, other authors have found significant differences in throwing velocities between throws made from over 5 metres compared with those thrown from less than 5 metres (Abraldes, et al., 2011; Alcaraz, et al., 2012). Conversely, a study by Alcaraz et al. (2011) among female water polo players did not find significant differences in the maximum and average velocities for throws made inside and outside the area of 5 metres, although the throws from the greatest distances showed higher velocities. The differences in throw speed in relation to distance from the goal could be attributed to the fact that the closer the attacker is, the more defensive pressure there is and the less time there is to make the throw (Abraldes, et al., 2011). In addition, throws made from a greater distance have time to reach maximum speed and require greater power to effectively reach the goal. Distance is therefore an essential variable when interpreting throwing velocity (as this is where differences in magnitude or effect size are found).

LIMITATIONS AND FUTURE RESEARCH

One of the limitations of this study reside in not being considered the field playing position, practices (Van den Tillaar & Marques, 2013) and physiological characteristics of the shooter, as well as the score of the match as a modulating variable of the velocity and throwing area for goal throws (Oliveira, Gómez & Sampaio, 2012). On the other hand, another limitation has been accept the absence of inter individual differences in technical skills, competitive experience and expertise of both championships athletes in the design of the research and in the associated statistical analyses.

CONCLUSIONS

In conclusion, the distance and micro-situation variables showed a capacity to predict 19% of velocity differences between throws in women's water polo and 33% in men's water polo. Future studies should therefore combine analysis of the velocity and the efficacy of throws (goal/failure) based on the variables discussed above (distance, micro-situation and throw position). As well as consider the goalkeeping effectiveness (Tedesqui & Young, 2017), or if sports experience, accuracy and speed do not affect the scorer efficacy (Southard, 2014). On the other hand, it should be considered the influence of fatigue and recovery (Jones, West, Crewther, Cook & Kilduff, 2015; Oliver, Lloyd & Whitney, 2015) in the throw speed and performance.

PRACTICAL APPLICATIONS

This research opens new lines in the tactical understanding of this sport. In this sense, knowing the throwing patterns and throw speeds offers coaches valuable information in order to improve and implement specific game training systems, such as specific work for goalkeeper's reaction time and improve player's throw speed and technical execution.

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This work is part of a longitudinal study, which aims to compare how the regulatory changes made during the last few years affect the game, so it is intended to compare these results with those obtained at the XVII World Water Polo Championship to be held in July 2017. The Author(s) declare(s) that there is no conflict of interest.

REFERENCES

1. Abraldes, A., Ferragut, C., Rodríguez, N., Alcaraz, P. E. & Vila, M. H. (2011). Throwing velocity in elite water polo from different areas of the swimming pool. Portuguese J Sport Sci, 11(Suppl. 2), 41-44.
2. Alcaraz, P. E., Abraldes, A., Ferragut, C., Rodríguez, N., Argudo, F. M. & Vila, M. H. (2011). Throwing velocities, anthropometric characteristics, and efficacy indices of women's European water polo subchampions. J Strength Cond Res, 25, 3051-3058. https://doi.org/10.1519/JSC.0b013e318212e20f
3. Alcaraz, P. E., Abraldes, A., Ferragut, C., Vila, H., Rodríguez, N., & Argudo, F. M. (2012). Relationship between characteristics of water polo players and efficacy indices. J Strength Cond Res, 26, 1852-1857. https://doi.org/10.1519/JSC.0b013e318237ea4f
4. Aleksandrovic, M., Naumovski, A., Radovanovic, D., Georgiev, G., & Popovski, D. (2007). The influence of basic motor abilities and anthropometric measures on the specific motor skills of talented water polo players. Facta Universitatis Series Physical Education and Sport, 5, 65-74.
5. Anguera, M.T. (2003). Observational methods (general). En R. Fernández Ballesteros (Ed.). Encyclopedia of Psychological Assessment, 2, pp. 632-637. London: Sage.

6. Argudo, F. M., Alonso, J. I., & Fuentes, F. (2005). Computerized registration for tactical quantitative evaluation in water polo. Polo partido v1.0. In: Proceedings of the 5th International Symposium Computer Science in Sport. Croatia.
7. Argudo, F. M., Alonso, J. I., García, P., & Ruiz, E. (2007). Influence of the efficacy values in counterattack and defensive adjustment on the condition of winner and loser in male and female water polo. Int J Perform Anal Sport, 7(2), 81-91. https://doi.org/10.1080/24748668.2007.11868398
8. Argudo, F. M., Ruiz, E., & Abraldes, A. (2010). Influencia de los valores de eficacia sobre la condición de ganador o perdedor en un mundial de Waterpolo [Influence of efficacy values on the status of winner or loser in a water polo World Championship]. Retos. Nuevas tendencias en Educación Física, Deporte y Recreación, 17, 21-24.
9. Argudo, F. M., Ruiz-Barquín, R., & Borges, P. (2016). The Effects of Modifying the Distance of the Penalty Shot in Water Polo. J Hum Kinetics, 54(1), 127-133. https://doi.org/10.1515/hukin-2016-0041
10. Cohen, J. (1988). Statistical power analysis for the behavioural sciences. Hillsdale, NJ: Erlbaum.
11. Enomoto, I., Suga, M., Takahashi, M., Komori, T., Minami, T., Fujimoto, H., Saito, M., Suzuki, S., & Takahashi, J. (2003). A notational match analysis of the 2001 women's water polo world championships. In: Proceeding of Biomechanics and Medicine in Swimming IX, Saint-Etienne, University of Saint Etienne. Ed: Chatard, J.C., 487-492.
12. Ferragut, C., Abraldes, J. A., Vila, H., Rodríguez, N., Argudo, F. M., & Fernandes, R. J. (2011). Anthropometry and throwing velocity in elite water polo by specific playing positions. J Hum Kinetics, 27, 31-44. https://doi.org/10.2478/v10078-011-0003-3
13. Ferragut, C., Vila, H., Abraldes, J. A., Argudo, F. M., Rodríguez, N., & Alcaraz, P. E. (2011). Relationship among maximal grip, throwing velocity and anthropometric parameters in elite water polo players. J Sports Med and Phys Fit, 51, 26-32.
14. García-Marín, P., Argudo, F. M., & Alonso, J. I. (2012). Waterpolo: sistemas tácticos de juego en desigualdad numérica temporal simple con posesión [water polo: game tactical systems in numerical simple inequality with possession]. Revista Movimiento Humano, 3, 45-59.
15. Jones, M. R., West, D. J., Crewther, B. T., Cook, C. J., & Kilduff, L. P. (2015). Quantifying positional and temporal movement patterns in professional rugby union using global positioning system, Eur J Sport Sci, 15(6). https://doi.org/10.1080/17461391.2015.1010106
16. Lozovina, V., & Pavicic, L. (2004). Anthropometric changes in elite male water polo players: survey in 1980 and 1995. Croatian Med J, 45(2), 202-205.
17. Marques, M. C., Liberal, S. M., Costa, A. M., Van den Tillaar, R., Sánchez-Medina, L., Martins, J. C., & Marinho, D. A. (2012). Effects of Two Different Training Programs with Same Workload on Throwing Velocity by Experienced Water Polo Players. Percept motor skills, 115(3), 895-902. https://doi.org/10.2466/25.23.PMS.115.6.895-902
18. McCluskey L., Lynskey S., Leung C. K., Woodhouse D., Briffa K., & Hopper D. (2010). Throwing velocity and jump height in female water polo players: performance predictors. J Sci Med Sport, 13, 236-240. https://doi.org/10.1016/j.jsams.2009.02.008
19. Melchiorri, G., Padua, E., Padulo, J., D'Ottavio S, Campagna, S., & Bonifazi, M. (2011). Throwing velocity and kinematics in elite male water polo players. J Sports Med Phys Fit, 51(4), 541-546.
20. Oliveira, T., Gómez, M., & Sampaio, J. (2012). Effects of game location, period, and quality of opposition in elite handball performances. Percept motor skills, 114(3), 783-794. https://doi.org/10.2466/30.06.PMS.114.3.783-794
21. Oliver, J. L., Lloyd, R. S., & Whitney, A. (2015). Monitoring of in-season neuromuscular and perceptual fatigue in youth rugby players, Eur J Sport Sci, 15(6), 514-522. https://doi.org/10.1080/17461391.2015.1063700

22. Sarmento, J., & Magalhaes, L. (1991). Determinaçao de coeficientes para a valorizaçao da observaçao do ataque em pólo aquático [Coefficients of determination for the evaluation of the observation in attack in water polo]. Nataçao, 13, 7-8.
23. Sinclair, J., Fewtrell, D., Taylor, P. J., Bottoms, L., Atkins, S., & Hobbs, S. J. (2014) Three-dimensional kinematic correlates of ball velocity during maximal instep soccer kicking in males. Eur J Sport Sci, 14(8). https://doi.org/10.1080/17461391.2014.908956
24. Smith, H. K. (1998). Applied physiology of water polo. Sports Medicine, 26(5), 317-334. https://doi.org/10.2165/00007256-199826050-00003
25. Southard, D. L. (2014). Changes in kicking pattern: Effect of experience, speed, accuracy, and effective striking mass. Res Q exercise Sport, 85(1), 107-116. https://doi.org/10.1080/02701367.2013.829383
26. Stevens, H. B., Brown, L. E., Coburn, J. W., & Spiering, B. A. (2010). Effect of swim sprints on throwing accuracy and velocity in female collegiate water polo players. J Strength Cond Res, 24(5), 1195-1198. https://doi.org/10.1519/JSC.0b013e3181d82d3b
27. Stirn I., & Strojnik V. (2006). Throwing with different kinetic chains. In Vilas-Boas, J. P., Alves, F., and Marques, A. (Eds.), Biomechanics and Medicine in Swimming X. Portuguese J Sport Sci (pp 98-100). Porto.
28. Tan, F. H., Polglaze, T., & Dawson, B. (2009). Activity profiles and physical demands of elite women's water polo match play. J Sports Sci, 27, 1095-1104. https://doi.org/10.1080/02640410903207416
29. Tan, F. H., Polglaze, T., Dawson, B., & Cox, G. (2009). Anthropometric and fitness characteristics of elite Australian female water polo players. J Strength Cond Res, 23, 1530-1536. https://doi.org/10.1519/JSC.0b013e3181a39261
30. Tedesqui, R. A., & Young, B. W. (2017). Associations Between Self-Control, Practice, and Skill Level in Sport Expertise Development. Res Q exercise Sport, 88(1), 108-113. https://doi.org/10.1080/02701367.2016.1267836
31. Tsekouras, Y. E., Kavouras, S. A., Campagna, A., Kotsis, Y. P., Syntosi, S. S., Papazoglou, K., & Sidossis, L. S. (2005). The anthropometrical and physiological characteristics of elite water polo players. Eur J Applied Phys, 95, 35-41. https://doi.org/10.1007/s00421-005-1388-2
32. Van den Tillaar, R. (2004). Effect of different training programs on the velocity of overarm throwing: a brief review. J Strength Cond Res, 18(2), 388-396. https://doi.org/10.1519/00124278-200405000-00033
33. Van den Tillaar, R., & Marques, M. C. (2013). Effect of specific versus variable practice upon overhead throwing speed in children. Percept motor skills, 116(3), 872-884. https://doi.org/10.2466/10.30.PMS.116.3.872-884
34. Van der Wende, K. (2005). The effects of game-specific task constraints on the outcome of the water polo shot. (Thesis doctoral). Auckland University of Technology, New Zeland.
35. Vila, H., Ferragut, C., Argudo, F. M., Abraldes, J. A., Rodríguez, N., & Alacid, F. (2009). Relationship between anthropometric parameters and throwing velocity in water polo players. J Human Sport Exercise, 4(1), 57-68. https://doi.org/10.4100/jhse.2009.41.07
36. Vila, H., Ferragut, C., Abraldes, J. A., Rodríguez, N., & Argudo, F. M. (2010). Anthropometric characteristics of elite players in water polo. Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte, 10, 652-663.