

## THROWING VELOCITY IN ELITE WATER POLO FROM DIFFERENT AREAS OF THE SWIMMING POOL

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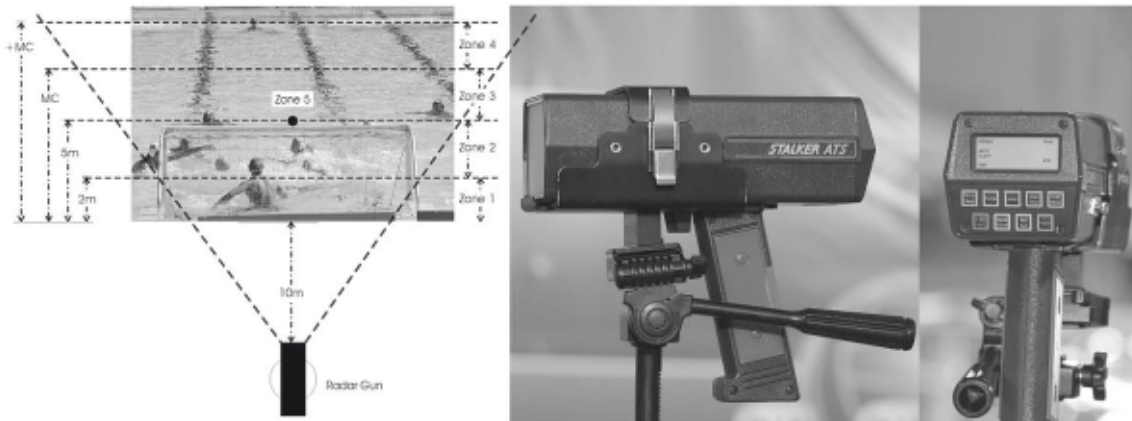
The aim of this study is threefold: 1) To identify the throwing velocity during a match; 2) to identify possible differences in throwing velocities between male and female players; 3) to determine shot velocity from different zones of the court during real competition. We analyzed the water polo world championship. In order to evaluate the precise strength production, a radar gun was used. A one-way analysis of variance was applied (ANOVA) to study differences among playing areas. In addition, a t-Test for repeated measures was employed to compare different groups. This study identifies three major zones of goal shot. We identified the highest throwing velocity zones and the zones with highest shot number. In addition, the results show that the penalty shot is the fastest shot.

**KEY WORDS:** radar, shot, zone play, competition game.

**INTRODUCTION:** Water polo is a team sporadic sport comprising both high and low intensity efforts, such as swimming, jumping in the vertical plane and receiving and passing of the ball. It is also a contact sport. Players must face their opponents, through blocking, contacting and pushing. From the several abilities that influence water polo performance, the throwing seems to be one of the most decisive (Smith, 1998; Van der Wende, 2005). Shooting is a technical skill, which is a frequent occurrence in a water polo match. The skill, which is most frequent, is overhead throwing. Ninety percent of throwing during water-polo games is overhead throwing (Bloomfield, Blanksby, Ackland, & Allison, 1990). The goal of this overhead throwing pattern is to achieve high endpoint velocity. The speed in which the ball in the throwing movement has a decisive effect on the final result, since the faster and fitter the movement is; the more difficult it is for the defenders and goalkeeper to make its interception (Joris, van Muyen, van Ingen Schenau, & Kemper, 1985). Water Polo shot has been analyzed from different points of view. Some papers examine shot efficacy values (Argudo, Ruiz, & Alonso, 2009; Argudo, Alonso, García, & Ruiz, 2007), Biomechanics and penalty shot (Elliott & Armour, 1988) and water polo throwing velocity (Van den Tillaar, 2004; Vila et al., 2009). However, there are no researches that analyze throwing velocity and its efficacy in water polo competitions. The aim of this study was to: 1) Identify the throwing velocity in water polo players during a match and 2) to identify possible differences in throwing velocities between male and female water polo players during a real competition 3) to determine shot velocity from different zones of the court during real competition.

**METHODS:** We analyzed all the shots carried out in the water polo world championship. 2355 throws in women's world championship and 2488 throws in the men's championship. We analyzed the maximum velocity and performance area during the competition. In order to evaluate the specific explosive strength production in water polo players, a radar gun (StalkerPro Inc., Plano), with 100Hz frequency of record and with a sensibility  $0.045\text{m}\cdot\text{s}^{-1}$  was used. The radar was placed 10m behind the goal post and aligned with the penalty line (Figure 1). The radar only registers maximum velocities above  $11.6\text{m}\cdot\text{s}^{-1}$  for males and  $9.44\text{m}\cdot\text{s}^{-1}$  for females, in order to differentiate the velocity of the ball from the players' upper body limbs velocities. It is usually recommended that the throwing velocities registered by radar should be done from a frontal plane. Nevertheless, a recent study has validated the radar versus a photogrammetric method with a high-speed video camera from different zones of the pool (player  $\theta = 20^\circ$  from the radar gun) with Intraclass correlation coefficient (ICC) of 0.96 and Coefficient of variation (CV) of 3.67% (Ferragut, Alcaraz, Vila, Abrales, &

Rodríguez, 2010). Individual maximum throwing velocities were classified by different zones (Figure 1): zone 1 was defined by the area between the goal and 2m from the goal; zone 2 was defined by the area between the 2m and 5m from the goal; zone 3 was defined by the area between the 5m and the ½ pool line; zone 4 was defined as the region farthest from the ½ pool line; and zone 5 was defined by the penalty shot (5m).



**Figure 1: A Schematic representation of the radar position and the different pool zones established with a model radar gun.**

Standard statistical methods were used for the calculation of the mean and standard deviations. A one-way analysis of variance (ANOVA), and a Tukey post hoc test was used to study differences among playing areas. The normality (Shapiro-wilk test), sphericity (Mauchly Test) and homocedasticity (verified in accordance with sphericity result) of all distributions were verified before the means were compared. A t-Test for repeated measures was used to compare different groups. Statistical significance was established at 95%.

**RESULTS:** Table 1 shows the number of throws and percentage values in different areas in the women's and men's water polo championship.

**Table 1**  
**Number and percentage values of throws in different areas studied.**

Championship	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Women	52 2,21%	953 40,47%	1199 50,91%	59 2,51%	92 3,91%
Men	53 2,13%	909 36,54%	1361 54,70%	65 2,61%	100 4,02%
Total	105 2,17%	1862 38,45%	2560 52,86%	124 2,56%	192 3,96%

Table 2 presents the mean throwing velocity in different areas. The results shows differences for almost all situations studied. There is a higher throwing velocity in men than in women. We see three main groups: 1) zones 1 and 2, which have lower velocity, 2) zones 3 and 4, where the throwing velocity is greater than in the first areas and finally 3) zone 5 the penalty shot area, which is the location that has the highest velocity.

**Table 2**  
**Throwing velocity ( $m \cdot s^{-1}$ ) ( $\bar{x} \pm sd$ ) in different areas.**

Championship	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Women	11.54 $\pm 1.96^{* \delta \beta \phi}$	11.71 $\pm 2.98^{* \delta \beta \phi}$	14.34 $\pm 2.15^{* \ddagger \phi}$	14.65 $\pm 1.98^{* \ddagger \phi}$	15.91 $\pm 1.45^{* \ddagger \delta \beta}$
Men	14.27 $\pm 3.86^{* \delta \beta \phi}$	14.00 $\pm 3.07^{* \delta \beta \phi}$	18.49 $\pm 2.89^{\ddagger \phi}$	18.58 $\pm 3.24^{\ddagger \phi}$	20.29 $\pm 1.44^{\ddagger \delta \beta}$
Total	12.93 $\pm 3.35^{* \delta \beta \phi}$	12.95 $\pm 2.85^{* \delta \beta \phi}$	16.62 $\pm 3.30^{\ddagger \phi}$	16.70 $\pm 23.35^{\ddagger \phi}$	18.21 $\pm 2.62^{\ddagger \delta \beta}$

\*Statistical differences ( $p \leq 0.001$ ) between groups.

Differences ( $p \leq 0.001$ ) between zones:  $\ddagger$ different from zone 1;  $\ddagger$ different from zone 2;  $\delta$ different from zone 3;  $\beta$ different from zone 4;  $\phi$ different from zone 5.

**DISCUSSION:** The results show higher incidence areas in the shot. These percentages can be explained through the combination of two different factors, which are as follows: The distance from the player to the goal and the distance from the thrower to the defense. When the thrower is closer to the goal, more defense players are nearer to the thrower, because the thrower is in a good position in order to score a goal. Contrarily when the distance from the thrower to the goal is greater, the defense pressure is lower. In these kinds of throws the flight time of the ball is greater, so the goalkeeper has a lot more time to block it. Zones 2 and 3 have the highest shooting percentages in competition (Table 1). In addition, a 3.96% of the throws in the match take place within the penalty zone (The best position in order to achieve a goal).

Throwing velocities are higher in men than in women. These data are consistent with other studies in water polo (Platanou & Botonis, 2010; Van den Tillaar, 2004; Vila et al., 2009), and are based on body composition and strength ratios between sexes (Lozovina & Pavicic, 2004; Tsekouras et al., 2005; Vila, Ferragut, Abraldes, Rodríguez, & Argudo, 2010).

The throwing velocity shows us three areas of implementation. Zone A (zone 1 and zone 2), Zone B (zone 3 and 4) and Zone C (zone 5). The fastest throws are those made from zone C (Penalty shot). The difference in throwing velocity between zone C and zone B in the game is due to: one the presence of opponents and the second the time available for throwing. These factors determine slower velocities values registered in zone B. The differences registered in the throwing velocity between zone A and B, can be explained in the same way. When the player throws from zone A, the defense pressure is bigger and it is more difficult to throw the ball. Tactical efficacy studies (Argudo, Ruiz, & Alonso, 2009; Argudo, Alonso, García, & Ruiz, 2007; Lupo, Tessitore, Minganti, & Capranica, 2010) showed the success index in goal throwing, but these indexes are not related with throwing velocity. More studies are necessary in order to establish the importance of throwing velocities and its effectiveness in real competition.

**CONCLUSION:** The throwing velocity of men was higher than that of women in all the zones analyzed. This study also identifies three major zones of goal shot. We identified the highest throwing velocity zones and the zones with the highest shot number. It would be interesting for future studies to observe the correlation between throwing velocity and throwing efficacy. Higher speed values can help in order to achieve goals, but there are other factors that may determine their effectiveness.

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