

## Speed-accuracy trade-off in 7-meter throw in handball with real constraints: goalkeeper and the level of expertise

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### Abstract

Speed and accuracy are two of the determining factors in sports that involve launching a mobile object towards a target. This paper analyzes how speed and accuracy in a 7-meter throw in handball are affected, taking into account the player's experience, the opposition of a goalkeeper and with maximum accuracy being an aim. 24 players, divided according to their experience, participated in the study ( $N=14$ , cadet;  $N=10$  juniors). The accuracy of 24 throws was recorded by filming them in 2D and subsequent digitization. The ball speed was recorded by mobile radar.

The cadet players achieve more accuracy in the absence of a goalkeeper ( $p=.005$ ) and the throws are faster when a goalkeeper is present ( $p=.001$ ). In relation to the juniors, there are no differences between the two conditions. Between-groups, juniors achieve faster throws than cadets when no goalkeeper is present ( $p=.001$ ). The level of competitiveness determines both accuracy and throwing speed, with and without opposition. The presence of a goalkeeper has a positive effect on throwing speed among cadet players.

**Key words:** speed, accuracy, cadet, junior, performance

### Introduction

The relationship between velocity and accuracy when throwing or hitting an object determines the performance of several technical actions in relation to the following sports: baseball, handball, cricket, soccer, tennis, and volleyball. From this standpoint, there is scientific literature which attempts to place a higher value on the importance of velocity and accuracy in handball (Jöris et al., 1985; Bayios et al., 2001; Rivilla et al., 2011; Gorostiaga et al., 2005). These studies have different objectives and designs, beginning with the study between velocity and accuracy and how varying one of these aspects can influence the other (Van den Tillaar and Ettema, 2006). There are many variables that could have an influence on these two factors, among them are: the level of experience (Van den Tillaar and Ettema, 2003a,b;) the type of instruction provided (Wagner and Muller, 2008; García et al., 2013) the use of different training methods of the technical gesture, (Fleck, 1992) or combinations of one of any of those variables (Granados et al., 2008).

Related to handball, the efficacy of the throw depends on a high percentage of the speed of the ball being thrown, as well as the accuracy of the ball being launched at the goal in relation to the goalkeeper's position (Van den Tillaar and Ettema, 2004a; Van den Tillaar and Ettema, 2007). Some researchers suggest that the speed of the ball being thrown is one of the most important factors (Gorostiaga et al., 2005; Marqués et al., 2007). In fact, they emphasize that the faster the ball goes, the less time the defenders and goalkeeper will have to block it.

Thus, several authors state that the success rate of throwing in handball is conditioned by accuracy (Indermill and Husak, 1984; Van Muijen et al., 1991; Wagner and Muller, 2008; Wagner et al., 2010) and the speed of the ball (Bayios et al., 2001; Gorostiaga et al., 2005; Rivilla and Sampedro-Molinonuevo, 2010; Rivilla et al., 2010). Accordingly, it seems reasonable to think that the faster and more accurate the throw is, the less chance there is of the goalkeeper and defenders blocking it.

The findings of different studies show that juniors reach higher levels of accuracy according to throwing values between 75% and the 85% of the maximum velocity (Van Muijen et al., 1991). However, some studies have failed to find that an increase in throwing speed implies a significant decrease in accuracy (García et al., 2013; Van den Tillaar and Ettema, 2003a). The decrease of the throwing velocity does not imply an increase of the

efficacy in accuracy among handball players of a high level. These studies found that the type of instruction given to the players (juniors) influenced their throwing speed, but not their accuracy, thus an increase or decrease in speed did not necessarily imply an increase or decrease in their throwing accuracy.

In most of the previously mentioned studies, the experimental situation consisted of throwing or hitting objects (balls) toward a bullseye, points of reference, and surface of contact or specific objective to be impacted. These methods are in accordance with reality in regards to many technical sport gestures: throwing in handball, serving in volleyball, kicking in soccer, hitting in baseball or cricket, or anywhere where the defenders and/or the goalkeeper's actions condition the speed and accuracy of these technical gestures. Thus, different degrees of defense might influence the speed and accuracy of throwing.

Recent reports show the influence that the goalkeepers' defense can have on throwing accuracy at a goal (Rivilla et al., 2010), considering individuals with low levels of experience. Other research did not come to the same conclusions among junior individuals, (Gutiérrez et al., 2004). On the other hand, a later study regarding handball in which the defender and goalkeeper's position was manipulated among three groups of individuals with different level of experience shows that an increase in the opposition in throwing greatly reduces the throw's velocity (Rivilla et al., 2001). These findings match with others based on junior participants in other sports such as the water polo (Vila et al., 2009).

Because of this, it has been found necessary to go into detail when analyzing the behaviour of both variables in situations where there is goalkeeper and/or defender opposition.

*The hypothesis of this study is* that the existence or not of actual goalkeeper opposition modifies the speed and accuracy of the handballs being thrown, thereby influencing the players' level of competition at the same time.

This study expects to provide more knowledge about the behaviour of both factors in an experimental situation which is closer to the reality of the target sport. Furthermore, it tries to improve the limitation existing in previous studies, which did not compare the performance in throwing in situations which did or did not utilize a goalkeeper. In this way, an additional value is provided to be considered by the trainers regarding the task's design using real constraints which were omitted in previous research.

## Material and Methods

### *Participants*

Twenty-four healthy male players took part in the research. They were distributed into two groups using years of experience in handball training as a criteria: the junior group included players with 8 years or more of experience at a national level ( $N=10$ ; *Mean* age= $19,9\pm 1,8$ ) and cadet group ( $N=14$ ; *Mean* age= $15,4\pm 0,8$ ) including players with 3 to 5 years' experience at a national level. None of them had deliberately trained 7-meter throws outside of the training sessions during the course of the research. All participants and their parents (in the case of minors) were informed of the characteristics of the study and had given informed consent.

### *Measures and instruments*

The independent variable was the presence or lack of a goalkeeper in 7-meter throws. The dependent variable was shot accuracy and maximum percentage of speed of the ball. The accuracy was measured by mean radial error –MRE– (Van den Tillaar and Ettema, 2003a). The MRE was considered the absolute distance measured in centimetres from the target marked on the throw goal to the site reached by the ball, that is, the vector module was comprised of each throw's spatial coordinates 'X -horizontal-' and 'Y -vertical-'. The ball speed was measured in kilometres per hour (km/h).

The 7-meter-throws were recorded with a digital video camera (Sony®DCRHC-18E) at a frequency of 50 Hz. This frequency has been used previously in other sports to measure launching and hitting accuracy (Menayo et al., 2012; Hernández-Davó et al., 2014).

The video camera was placed in front of the goal, 2 meters behind the line from which the throws were performed, and at 2.5 meters in height (Figure 1).

The MRE was obtained via a recording, in which real coordinates of the shots on the goal were digitalized and transformed. A software package written in Visual Basic 5.0<sup>®</sup>, that had been previously employed in other research was used (Menayo et al., 2012). Later, the square root of the sum of the squares was applied to the real coordinates of the handball goal was sent, delimited by the 4 points of the real reference system for every corner (left and right). Then the digitized coordinates of the throws were subtracted. To record the maximum percentage of the ball speed in each of the throws, a radar gun (Sports Radar SR3600) was used (Menayo et al., 2012; Hernández-Davó et al., 2014). The radar was placed behind the player and pointed at the target located in the goal (Figure 1). A handball ball of 54 centimeters in circumference and 350 grams in weight was used for the throws (Rasán<sup>®</sup> -IHF3 for juniors, and IHF2 for cadets-).

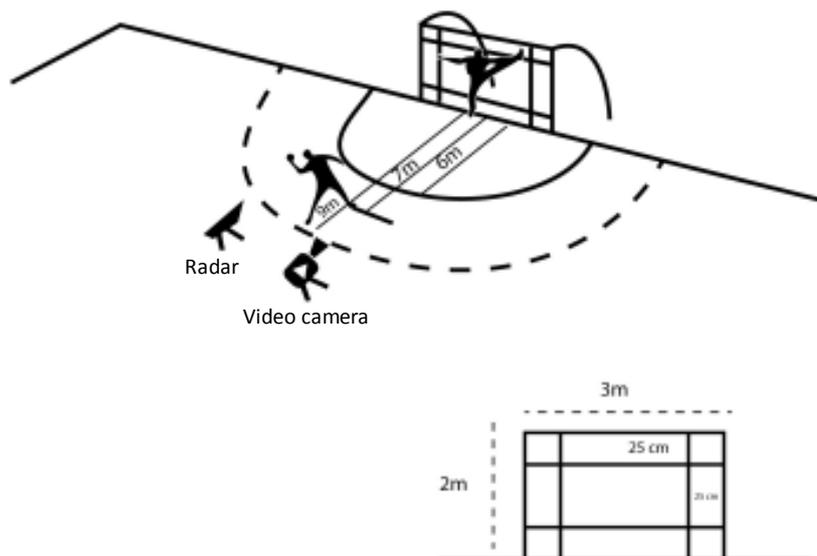


Figure 1. Experimental set-up.

*Procedures*

The maximum percentage of the ball speed after the throws was assessed. After receiving information about the task, and having implemented a standardized warm up of 12 minutes, each player throws at the goal 3 times without any precision requirement and with one-minute rest between each action. The highest speed recorded was chosen among the throws in order to determine the percentage of maximum speed. Next, the test was conducted on both groups. The target was created using two elastic bands which were located at 50 cm by 50 cm from the top and bottom corners of the goal, thus forming a cross. In this test, the player had to perform 24 valid throws –the errors were not registered–, at random into four zones of the goal, and distributed in two blocks, under the requirement: "throw as accurately as possible" (Van den Tillaar and Ettema, 2003a). The rest between the two blocks was 10 minutes.

The first block was performed with a goalkeeper and the second without a goalkeeper. The task of the goalkeeper was to stop the throws. The time between throws was 5 seconds, to guarantee that the player was able to maintain his/her attention and concentration (Tripp et al., 2004).

*Data analysis*

Statistical analysis was conducted via SPSS v.21.0 (SPSS Inc., Chicago, IL) software. The Shapiro-Wilk test confirmed the homogeneous distribution of the data. A two-sample t-test was applied within the group to analyze the differences between accuracy and ball speed with and without a goalkeeper. A mixed ANOVA test was applied to the groups to analyze the accuracy and ball speed with and without a goalkeeper. The size of the effect was calculated by Partial Eta Squared ( $\eta^2$ ). The significance level for statistical tests was  $p \leq .05$ .

**Results**

The intra-group analysis determines the existence of significant differences in percentage of maximum of ball speed ( $p=.0001$ ,  $\eta^2=.997$ ) and accuracy ( $p=.050$ ,  $\eta^2=.680$ ) on the cadet group between throws executed with and without goalkeeper. The cadet achieves more percentage of maximum of ball speed in the throws when goalkeeper is present. But, this group achieves more accuracy when goalkeeper is not present (Table 1). No differences were founded in junior group. Between group analysis, shows significant differences in percentage of maximum of ball speed only ( $p=.001$ ,  $\eta^2=.400$ ) between groups in throws without goalkeeper. The junior achieves more percentage of maximum of ball speed than cadets when goalkeeper is not present (Table 1).

Table 1. Accuracy and percentage of maximum ball speed in 7-meter handball throws.

Group	Accuracy		Ball speed	
	Without goalkeeper (cm)	With goalkeeper (cm)	Without goalkeeper (km/h)	With goalkeeper (km/h)
Cadet	39,9 ±11,6	88,7±88,1*	87,5±5,3 *	86,9±5,0
Junior	48,1± 12,0	52,6±15,3	80,2±3,9†	88,6± 4,4

\* Cadet group differences on ball speed and accuracy in throws with and without goalkeeper ( $p \leq .05$ ).

† Significant differences between groups on ball speed in throws without goalkeeper ( $p \leq .05$ ).

## Discussion

The aim of this study was analyze the influence that the goalkeeper's real opposition had on the speed and the accuracy in the throwing to goal in handball, in players with different level of experience. The results found in the percentage of speed thrown by the juniors (over their 100%), with or without goalkeeper are very similar, without identifying significant differences.

This data matches with other studies in which the junior's players throwing speed with real opposition was analyse (Gutiérrez et al., 2006), and suggests that probably the speed in the throwing cannot be influenced by the opposition when junior athletes throw. The analysis of the results determines that the junior group keeps a very balanced behaviour in the throwing speed, with or without the goalkeeper's opposition. Thus, the speed can be used for one or another situation in the same way. It is possible, that the juniors are highly adapted to throw with speed percentages close to 90% of their maximum and still modifying their degree of opposition (with or without goalkeeper), keep the frequent values for them (García et al., 2013). If now, we refer to the inexperienced individuals, the presence of the goalkeeper produces a significant decrease in the percentage of the throwing speed which is a data that matches with the findings about handball by other researchers (Rivilla et al., 2011) in which the presence of the opposition implied a decrease in the accuracy. It is important to emphasize that in that study, also found that difference with junior players in difference with our results (Rivilla et al., 2011).

In the comparison with the throwing speed in both groups about the two series, it is identified that the juniors group throws to a higher percentage of speed than the group of players in training process (being this difference meaningful if there is not a goalkeeper). The results show that the juniors throw with close values to 90% of their maximum speed in the first series without goalkeeper while, in the second series, they continue throwing to speeds close to their maximum, about the 85% of their maximum speed. These values are slightly higher to those found by other authors (Van den Tillaar and Etema, 2006), in which the group of junior players threw to the 85% of their maximum speed and the group of inexperienced to the 84% when they looked for a better accuracy. Likewise, this result would be closed to those found, in which a throwing task in cricket, all the groups (top level and sub-top level players) reach their major accuracy throwing between the 75% and the 85% of their maximum velocity (Freeston et al., 2007).

## Conclusions

As it is shown in the results, the cadet group was significantly less accurate with the goalkeeper's position than without it. On the other hand, for the junior players there were not differences in the accuracy in both throwing conditions. This data is likely to the one found in a previous study with junior players, were players with experience did not reduce their accuracy in the throwing for the effect of the opposition (Rivilla and Sampedro-Molinonuevo, 2010). This balance in the results of the junior group match with the values found in other works, in which despite of change the velocity in the throwing, the accuracy did not decrease meaningfully (Van den Tillaar and Etema, 2006; García et al., 2013). According to the found results with the cadets, it is possible that the effect on the goalkeeper troubles the activity and thus the accuracy of the throwing is lost.

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