

Research article

Influence of opposition on ball velocity in the handball jump throw

Jesús Rivilla-García¹✉, Ignacio Grande¹, Javier Sampedro¹ and Roland van den Tillaar^{2,3}

¹ Department of Sports, Faculty of Physical Activity and Sport Sciences, Polytechnic University of Madrid, Spain

² Research Centre for Sport, Health and Human Development, Vila Real, Portugal

³ Department of Teacher Education and Sports of Sogn and Fjordane University College, Norway

Abstract

The purpose of the present study was to investigate the influence of different degrees of opposition on ball velocity in the jump throw in elite, amateur and adolescent team handball players. Thus, one hundred and nineteen elite, amateur and under 18 team handball players performed jump throws under three different conditions: 1) without opposition, 2) with the opposition of the goalkeeper and 3) with the opposition of the goalkeeper and a defensive player. The degree of opposition was found to have a negative effect on ball velocity in all three groups ($p < 0.001$). Furthermore, the level of competition had a positive effect on ball velocity ($p < 0.001$). However, no interaction was found between the level of competition and the degree of opposition on ball velocity ($p = 0.178$). The findings of this study indicate that an increase of external stimuli probably influences throwing kinematics and thereby maximal ball velocity. However, experience does not seem to be a factor that can reduce the influence of these external stimuli.

Key words: Team handball, jump throw, ball velocity, defence.

Introduction

Team handball is an Olympic team sport in which two teams of seven players each (six outfield players and a goalkeeper) try to score points by throwing a handball into the goal of the other team. The team that scores most goals after two periods wins. To achieve this, team handball players require high levels of physical skills that include jumping, diving, blocking, sprinting, ball control and agility. One of the most important skills for success in team handball is throwing ability (Gorostiaga et al., 2005). Perhaps for this reason many studies have analyzed throwing technique (Fradet et al., 2004; Gorostiaga et al., 2005; Granados et al., 2007; Jöris et al., 1985; Pori et al., 2005; Šibila et al., 2003; van den Tillaar and Ettema, 2004; 2007; Wagner et al., 2008).

The success of throwing is influenced by its accuracy (Bayios and Boudoulas, 1998; van den Tillaar and Ettema, 2003a; 2004; 2007) and ball velocity (Bayios et al., 2001; Gorostiaga et al. 2005; Marques et al. 2007; Šibila et al., 2003; Wagner et al., 2010a).

Several studies have indicated that ball velocity was determined by throwing technique, the timing of the consecutive actions of body segments, and upper and lower-extremity muscle strength and power (Jöris et al., 1985; van den Tillaar and Ettema, 2007; Van Muijen et al. 1991). However, team handball players use different throwing techniques when defensive players are involved

(Wagner et al., 2010a) and select the direction of the ball according to the movements of the goalkeeper.

In team handball the most used throw at the goal is the jump throw made from 9 m from the goal (Wagner et al., 2008). An opponent is often between the thrower and the goal, which could influence the kinematics and the throwing velocity of the attacker. Furthermore, the goalkeeper has to be surprised by the throw. Therefore, different degrees of opposition could influence throwing velocity. However, most studies are performed without any opposition (e.g. Fradet et al., 2004; Wagner et al., 2008; van den Tillaar and Ettema, 2003a; 2007), which could influence maximal throwing velocity. Only Gutiérrez et al. (2006) studied the influence of opposition on the team handball jump throw. They found no differences in maximal ball velocity between jump throws with and without opposition in experienced team handball players. These findings indicate that when accuracy was more important (to overcome a defence player and a goalkeeper) the throwing execution was not influenced and thereby escaped the velocity-accuracy trade-off. This velocity-accuracy trade-off suggests that when focusing on accuracy velocity would decrease (Fitts, 1954). According to van den Tillaar and Ettema (2003b) an explanation for this finding could lie in the specific subject group. The subjects in the study by Gutiérrez et al. (2006) were highly experienced team handball players who were not influenced by opposition in their execution of throwing during a jump throw. However, is this also the case when less experienced players perform the same jump throw or when the degree of opposition is varied?

Therefore the aim of this study was to investigate the influence of different degrees of opposition on ball velocity in the jump throw in elite, amateur and adolescent team handball players. It was hypothesized that the increase in the degree of opposition would result in a decrease of maximal throwing velocity since accuracy in throwing becomes more important when a player has to overcome a defence player and a goalkeeper compared to only surprising a goalkeeper. Furthermore, it was hypothesized that high level players would decrease throwing velocity less when the degree of opposition increased compared to less experienced players, since elite players have more knowledge about the different situations than novice players. Experts not only know what to do in a wide variety of situations, but they also know how and when to apply this knowledge and they are able to reproduce it in the appropriate situations (Singer and Janelle, 1999).

Table 1. Means (\pm SD) of anthropometrics in the three groups together with the effect size and observed power.

Level	n	Age (yr)	Height (m)	Weight (kg)	Experience (yr)
Elite	36	26.9 (3.4)	1.90 (7.8)	90.3 (5.6)	18.7 (4.6)
Amateur	30	24.0 (2.2)	1.86 (7.2)	88.2 (6.9)	14.9 (2.9)
Under 18	53	17.2 (1.3)	1.81 (5.0)	82.9 (3.4)	8.8 (1.4)
p		<.001	<.001	<.001	<.001
η^2		.783	.265	.292	.668
Statistical power		1.0	1.0	1.0	1.0

All differences among groups were significant at the p<0.05 level

Methods

Participants

One hundred and nineteen team handball players from nine handball teams who were classified into three groups according to their competitive level: elite, amateur and under 18, participated in this study. The elite group consisted of two teams who played in the highest Spanish team handball division. The amateur group also consisted of two teams from the senior category (over 18) who played in the second Spanish team handball division. While the under 18 group was made up of three teams still in their training phase (of under 18 years of age) who played in the regional youth division. The characteristics of each group are presented in Table 1. Before performing the tests, all the players, and the parents or guardians in the case of the participants under 18, were fully informed about the procedure to be followed as well as the potential risks, and signed a consent form to participate in the study. The procedure was in accordance with the approval of the local ethics committee and followed current ethical standards in sports and exercise research.

Procedure

The maximal ball velocity of the participants was evaluated performing the jump throw in three different situations: a) without any opposition: shooting at goal without the presence of the goalkeeper or a defensive player; b) with the opposition of only the goalkeeper and c) with the opposition of the goalkeeper and a defensive player.

The test was conducted after at least 24 hours of active rest and at least 48 hours after a competition. After a general warm-up, which included running, low intensity exercises and flexibility, a standard 10 minute specific warm-up was performed consisting of various specific moves, and acceleration and deceleration runs similar to the steps taken prior to a throw. This was followed by specific mobility exercises for the shoulder and throws with balls of different mass and varied jumps of progressive specificity and intensity. The specific warm-up ended with actions similar to the tests. The participants were then informed about the protocol for each test, and each player practiced several times before each test situation to familiarize himself with the action.

The instructions which were common to all three tests were: jump as high as possible and throw the ball as fast as possible with the intention of scoring a goal, using one hand and the correct throwing technique for a jump throw at goal. Take a maximum of three steps prior to the throw and throw from behind the free throw line, 9 m from the goal. All subjects were permitted to use resin on their hands thus simulating real playing actions. The test

conditions were designed with the purpose of simulating real play.

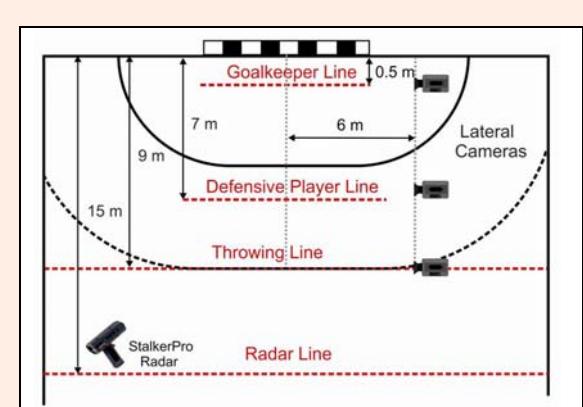


Figure 1. Experimental set up.

All subjects had to perform a jump throw from 9 m from the goal under three different conditions (Figure 1): 1) without opposition where the throws were made without the presence of the goalkeeper or a defensive player; 2) with the opposition of the goalkeeper in which the throws were made in the presence of the goalkeeper, located on a line 0.5m from the goal and allowed only to make movements in the frontal plane with his hands or feet to try to intercept the ball; with an observer monitoring his action in each sequence of throws using a slow motion camera placed laterally to the goalkeeper and the trainers supervising performance to ensure that the players used the correct technique; and the last test condition was 3) where throws were made with opposition provided by the goalkeeper under the same conditions as in the previous situation, and a defensive player. The defensive player was situated on the 7 m line trying to intercept the ball with his hands and arms, was not allowed to move past the line and was told that if he tried to block the ball with a jump he was only allowed to jump vertically. An observer monitored his performance at all times. The accuracy criterion was the same in all the tests: throws should be accurate and aimed at the areas furthest from the goalkeeper, giving priority to the corners.

These experimental situation and conditions: a jump throw from a distance of 9 m with and without opposition from the goalkeeper and a defensive player were taken from the competition itself, and were representative of a real game situation (Gutiérrez et al., 2006).

Each participant carried out two rounds of throws. In the first round the order was with increasing degree of opposition (from without opposition to opposition with the goalkeeper and a defensive player). In the second

round the reverse order was followed to guarantee that any possible differences were not due to the order of the tests or the fatigue caused by the accumulation of throws. This was confirmed in the subsequent data analysis. In each round the participant carried out jump throws until two recordings were made in each test, making four after performing two rounds. The two highest ball velocities for each test were used for further analysis.

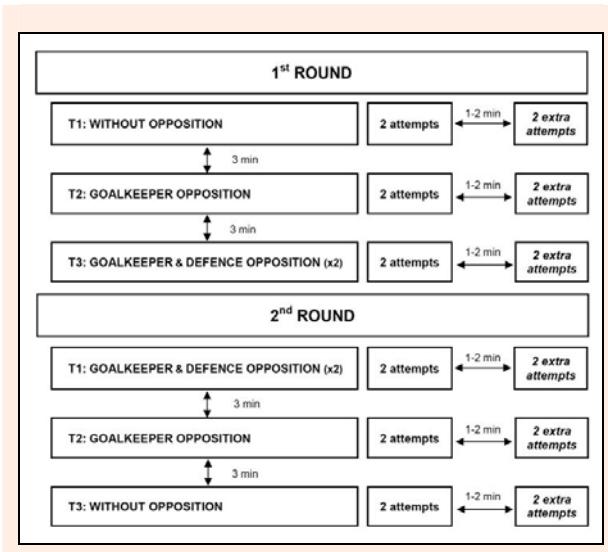


Figure 2. Protocol of the experiment.

The procedure followed in each series was as follows: each subject carried out a series of two throws with a pause of 10-15 seconds between them; if it was necessary to perform more throws because two results had not been recorded, the player carried out a second series of throws with a rest of 1-2 minutes between the series. The maximum number of series of throws allowed was two. A minimum of 3 minutes was given between tests to guarantee sufficient recovery for the player. (Figure 2) No player performed more than 15 throws in total, thus avoiding fatigue from the accumulation of explosive actions. In order to motivate the players they were informed of their ball velocity immediately after each attempt (Gorostiaga et al., 2005; Granados et al., 2007). The test lasted approximately 1h 30 min including the warm-up and the cool down.

Measurements

The tests were carried out on a team handball court in an indoor hall, with an official regulation ball weighing 480 g and with a circumference of 58 cm. Ball velocity was measured by radar (StalkerPro, Applied Concepts, Inc, Plano, USA), with a recording frequency of 100 Hz and with a sensitivity of $0.045 \text{ m} \cdot \text{s}^{-1}$, and the system was situ-

ated 15 m in front of the goal. To monitor the movements of the goalkeeper and defensive player a video camera was located laterally to both at a distance of 6m from the centre of the goal (Figure 1).

Statistical analysis

Means and standard deviations were presented for the each test for each group. A one-way ANOVA with repeated measures was used to analyze differences in ball velocity for each round of throws and in the anthropometrics, age and training experience between the groups.

To compare the effect of opposition and level of competition, a mixed design 3 (opposition: without, with only goalkeeper, and with goalkeeper and defence player: repeated measures) x 3 (group: elite, amateur, adolescent) analysis of variance (ANOVA) was used with the Bonferroni post-hoc test. The statistical calculations were performed using the SPSS 14.0 program. The effect size and statistical power are presented in Tables 1 and 2. The effect size was evaluated with η^2_p (Eta partial squared) where $0.01 < \eta^2 < 0.06$ constitutes a small effect, $0.06 < \eta^2 < 0.14$ a medium effect and a large effect when $\eta^2 > 0.14$ (Cohen, 1988). The intraclass correlation (ICC) and the coefficient of variation (CV) were calculated to ensure reliability; and were respectively 0.99 and 3.2% in the test without opposition, 0.98 and 3.8% in the test with the opposition of the goalkeeper and 0.96 and 4.7% in the test with the opposition of the goalkeeper and a defence player. The level of significance was set at $p \leq 0.05$.

Results

Significant differences in age, training experience, height and body mass were found among the three groups i.e. the elite group was the oldest, tallest and had the most experience, followed by the amateur group and the under 18 group (Table 1). No significant differences were found in ball velocity between the first and second round ($p > 0.05$). Therefore the best result of both rounds was used for further analysis.

A main effect of degree of opposition was found (Table 2). In general, ball velocity without opposition was 3.9% faster than throwing velocity with the opposition of the goalkeeper and 8.6% faster than the throwing velocity with the opposition of the goalkeeper and a defensive player (Figure 3, Table 2). Also the level of competition had an effect on ball velocity i.e. the elite group had the highest velocity, followed by the amateur groups and the lowest velocity was observed in the under 18 group (Figure 3, Table 2). However, no interaction was found between the levels of competition and the effect of opposition on ball velocity in the three different situations (Table 2).

Table 2. Statistical analysis of the effect of opposition and level of competition on ball velocity in elite, amateur and under 18 handball players.

Parameter	Effect of opposition		Effect of level of competition		Interaction degree of opposition x level of competition				
	p	η^2	Statistical Power	p	η^2	Statistical Power	p	η^2	Statistical Power
Ball velocity	<.001	.556	1.000	<.001	.490	1.000	.178	.027	.487

Effect is based on the ANOVA's main effect of opposition, level of competition and effect between groups on degree of opposition x level of competition interaction.

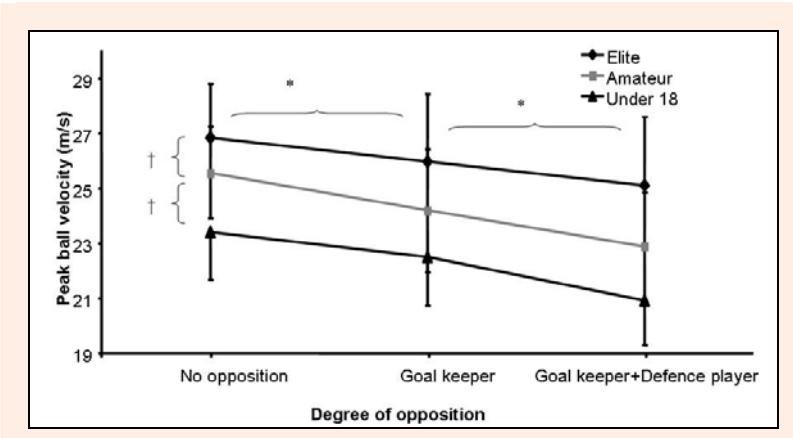


Figure 3. Means (\pm SD) throwing velocity in the three test situations: without opposition, with opposition of the goalkeeper and with opposition of the goal keeper and defence player in elite, amateur and under 18 team handball players. * Significant differences in ball velocity ($p < 0.05$): between these two degrees of opposition. † Significant differences in ball velocity ($p < 0.05$): between these two levels of competition.

Discussion

In this study the influence of different degrees of opposition on ball velocity in the jump throw was examined in elite, amateur and adolescent players in team handball. It was found that the degree of opposition had a negative effect on ball velocity in all groups, and that the level of competition had a positive effect on ball velocity. However, no interaction was found between the level of competition and the degree of opposition on ball velocity.

The decreased throwing velocity with increasing degree of opposition is in line with the findings of Van der Wende (2005) and Vila et al. (2009) who found significant differences in water polo between ball velocity with and without the opposition of the goalkeeper. In contrast, the results obtained by Gutiérrez et al. (2006) in team handball did not reveal differences between jump throw ball velocity with and without opposition, although kinematic differences were evident in the actions prior to the throw. Possible reasons for this discrepancy with the current study could be due to the level of team handball players (sub-elite) and the low number of participants ($n = 11$).

There was no interaction effect found from the level of competition and degree of opposition indicating that the degree of opposition had the same influence on all three groups in spite of their different experience in throwing. It was perhaps to be expected that the elite players would not be affected by the degree of opposition as found by Gutiérrez et al (2006). However, they only compared throwing velocity with the opposition of a defence player and goalkeeper and not when there was only a goalkeeper.

The findings of the decreased throwing velocity with increasing degrees of opposition can be partly explained by the accuracy-velocity trade-off. It is generally accepted that a trade-off (guided information processing) exists between the accuracy and velocity at which a task is performed. The basis of this assumption lies in the work of Fitts (1954). In team handball van den Tillaar and Ettema (2003a; 2003b; 2006) showed that when accuracy is more important, throwing velocity

decreases which was also the case in our study. The presence of a goalkeeper and defence player increases the number of visual stimuli that have to be processed. According to Desimone and Duncan (1995) in situations with multiple stimuli there is rivalry among them at the cognitive level to achieve the order in which they are processed and used to control behaviour. Subjectively, giving attention to one target leaves less available for others (Desimone and Duncan, 1995). In the case of throwing with opposition, visual stimuli related to accuracy could be prioritized reflecting on a decrease in attention to achieve maximum throwing velocity (Fitts, 1954). These increases in the number of visual stimuli to be processed can result in an adaptation of the throwing movement to the movements of the goalkeeper (and defensive player), e.g. to throw beside the block you have to change your throwing technique (change the movement of the trunk and throwing arm). Probably adjusting the throw to the opposition of the goalkeeper and defensive player may change the throwing kinematic pattern and could consequently change throwing velocity (Wagner et al., 2010b). A few studies have investigated whether the inclusion of opposition causes changes in the technical execution of different sports skills. Gutiérrez et al (2006) only found differences in the time of the run prior to the throw when opposition was involved, i.e. the time was shorter in the situation where there was opposition from a defence player compared to only opposition from a goalkeeper. No other kinematic differences were found in that study, indicating that the execution of the task was the same with and without opposition. Párraga et al. (2002) observed that the time of execution and accuracy did not differ with the position of the goalkeeper. However, both studies conducted 3D kinematic analysis at a frequency of only 50Hz, which probably could not detect eventual differences in kinematics at this level of execution. In other studies on the jump throw (Wagner et al. 2010a) a higher capturing resolution was used for identifying differences in throwing technique. A limitation of the current study is that we only measured ball velocity and no kinematic variables. Detailed 3D kinematic analysis of throwing with different degrees of

opposition should be conducted to get a better understanding of changes in the execution of the throw under these conditions.

Conclusion

The degree of opposition had a negative effect upon ball velocity in elite, amateur and adolescent team handball players in the jump throw, indicating that an increase of external stimuli probably influences throwing kinematics and thereby maximal ball velocity. This influence of the degree of opposition upon throwing velocity was similar for all three groups, which indicates that experience does not seem to be a factor that can reduce the influence of these external stimuli. Detailed 3D kinematic analysis of throwing with these different degrees of opposition should be conducted to get a better understanding of changes in the execution of the throw under these conditions.

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Key points

- The degree of opposition had a negative effect upon ball throwing velocity in elite, amateur and adolescent handball players in the jump throw.
- It indicated that an increase of external stimuli influences the execution of throwing.
- Experience does not seem to be a factor that can reduce the influence of these external stimuli.

AUTHORS BIOGRAPHY



Jesús RIVILLA-GARCIA

Employment

Sports Department. Faculty of Physical Activity and Sport Sciences, Polytechnic University of Madrid.

Degree

PhD

Research interests

Physical conditioning, focusing on team sports, and high performance.

E-mail: jesus.rivilla@upm.es

Ignacio GRANDE

Employment

Sports Department. Faculty of Physical Activity and Sport

Sciences, Polytechnic University of Madrid.

Degree

PhD

Research interests

Physical conditioning, focusing on individual sports.

E-mail: ignacio.grande@upm.es

Javier SAMPEDRO**Employment**

Sports Department. Faculty of Physical Activity and Sport Sciences, Polytechnic University of Madrid.

Degree

PhD

Research interests

Analysis performance sport team and recreation.

E-mail: javier.sampedro@upm.es

Roland VAN DEN TILLAAR**Employment**

Reasearcher of the Research Centre for Sport, Health and Human Development, Vila Real, Portugal and at Department of Teacher Education and Sports of Sogn and Fjordane University College, Norway.

Degree

PhD

Research interests

Coordination and mechanics of fast discrete complex movements (throwing) sprint training, biomechanics and physiology of strength training, whole-body vibration training.

E-mail: roland.tillaar@svt.ntnu.no

✉ Jesús Rivilla-García

Department of Sports, Faculty of Physical Activity and Sport Sciences, Polytechnic University of Madrid, Spain