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The relationship between effectiveness and throwing velocity in a handball match

--Manuscript Draft--

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Response to Reviewers:	1. In the figures should use "throwing velocity" and "% effectiveness"; It have been changed 2.What references determined the inclusion criteria? The inclusion criteria were carried out by experts in handball. We were looking for players that throws at a high velocity, with different levels of effectiveness and played enough time to be significant, in order to study only the best throwers of the championship. In order to clarify this issues, we have included this sentence "The inclusion criteria were carried out by experts in handball". 3.Why include only goals scored in throwing velocity analysis? We only include goals scored because we wanted to study only the success throws, and to study the relationship between player´s match effectiveness and their successful throwing velocity 4.Doesn't that compromise the Pearson's correlation? Pearson correlation is not compromised for several reasons, they are two quantitative and ratio measurement scale variable and the assumption of normality has been met. with the KS test (Kolmogorov-Smirnov). They are also inclusion criteria of this study To assess any other situation that affects throwing velocity, it would lead us to another study and to have to design and use other variables. We know that these studies are necessary, including more variables, and in this line, we continue to move forward. 5.The references below may contribute to the manuscript: 1.https://doi.org/10.14198/jhse.2017.12.Proc3.12 2. Bayios, I., & Boudolos, K. (1998). Accuracy and throwing velocity in handball. In H. J. Riehle & M. M. Vieten (Eds.), 16 International Symposium on Biomechanics in Sports (Vol. 1). Konstanz: International Society of Biomechanics in Sports. Retrieved from https://ojs.ub.uni-konstanz.de/cpa/article/view/1593/1496 The references have been included

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Running head: Effectiveness and throwing velocity in handball

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THE RELATIONSHIP BETWEEN EFFECTIVENESS AND THROWING VELOCITY IN A HANDBALL MATCH

ABSTRACT

The relationship between throwing velocity and performance is an important question in handball, but has received little research attention in competitive scenarios. The aim of the present study was to analyse the relationship between throwing velocity and player effectiveness during a match. We analysed the throws of 69 players, recording the ball velocity of 1007 goal-scoring shots. Based on their effectiveness, the players were divided into three groups: Group 1 (G1): 40% to 49.9% effectiveness; Group 2 (G2), 50% to 59.9% effectiveness; and Group 3 (G3) ≥ 60% effectiveness. No significant differences were observed between G1 and G2, but G3 presented significantly lower velocities (21.14 ± 4.97 vs 23.40 ± 6.19, $p<0.001$; and vs 22.41 ± 7.19, $p<0.05$) than G1 and G2, respectively. We also found an inverse relationship between effectiveness and throwing velocity ($r=-0.48$; $p< 0.001$), whereby faster throws reduced players' effectiveness in competitive scenarios. All previous studies on throwing in handball have been conducted in non-competitive contexts; however, contrary to the results obtained in training contexts, we found an inverse relationship between effectiveness and high throwing velocity in competitive scenarios.

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INTRODUCTION

Handball is an Olympic team sport characterised by rapid transitions between offensive and defensive action during the match with the objective of scoring a goal. To score goals, the offensive players (6 players and one goalkeeper) attempt to create spaces that place one of their number in an optimal position to score a goal.

Studies have examined various aspects of handball players in order to identify the factors that influence performance, including physiology (Wagner, Fuchs, & von Duvillard, 2018), morphology (Vila et al., 2012) and psychology (Kristiansen and Stensrud, 2017). However, the problem with these studies is that they shed little light on competitive play and even less on the factors that determine performance. Handball is a complex, multifactorial sport in which players do not act alone but in coordination with other members of the team, whose actions are in part determined by the behaviour of their opponents (Milanović, Vuleta, & Ohnjec, 2018).

Many researchers have attempted to determine and classify the technical-tactical movement patterns used during a handball match (Ferrari, Valente dos Santos, & Simões Vaz, 2014; van den Tillaar and Ettema, 2006; Volossovitch, 2005; D. Vuleta, Milanović, & Sertić, 1999), identifying 134 such patterns typical of handball that are easily recognisable during a match. Players must therefore be able to adapt to these changing situations and implement a high number of technical actions and movements, an aspect that distinguishes elite from novice players (Garcia, Sabido, Barbado, & Moreno, 2013). The most important of these numerous actions are those that entail handling the ball (passing between team members and throwing the ball at the goal) (Dinko Vuleta, Sporiš, Talović, & Jelešković, 2010). Throwing velocity has been identified as the most important offensive action (Granados, Izquierdo, Ibanez, Ruesta, & Gorostiaga, 2008)

and a significant factor in handball performance (Wagner, Pfusterschmied, von Duvillard, & Muller, 2011, 2012).

To date, most studies on throwing velocity in handball have been conducted from the perspective of biomechanics (van den Tillaar and Cabri, 2012; Wagner, et al., 2011) or have focused on differences between the sexes (Gromeier, Koester, & Schack, 2017; Serrien, Clijsen, Blondeel, Goossens, & Baeyens, 2015) or levels of the game (Ferragut, Vila, Abraldes, & Manchado, 2018); however, all have analysed this aspect under controlled conditions in non-competitive contexts.

Nevertheless, rare is the occasion in handball when a player can attempt to score a goal in an undefended goal area. Hence, some studies (Rivilla-Garcia, Grande, Sampedro, & van den Tillaar, 2011; Vila, et al., 2012) have analysed throwing velocity in the presence of a goalkeeper, finding that this alone reduced throwing velocities. These results indicate that defensive action forces players to adjust their movement during execution of the throw. Therefore, the best players are those who present a high capacity to adapt to changes in the game in order to achieve better performance (Wagner, et al., 2012).

Velocity is one of the factors that influence performance in handball, but throwing velocity alone is insufficient to score goals; rather, it must be accompanied by throwing accuracy (Bayios and Boudolos, 1998; van den Tillaar and Ettema, 2006).

All of the above-mentioned studies were conducted under controlled conditions in training contexts, whereas handball is characterised by interaction between the goalkeeper, a team member and the opponent, and this influences the throw. It is well known that there is a need within the world of sport to elucidate what happens during competitive play from both a technical and a research perspective (Ribeiro et al., 2019).

To this end, studies have monitored different parameters of play to analyse and objectively quantify team performance levels during matches in relation to match results (Murray et al., 2016).

Continuing in this line, Zapardiel Cortés et al, 2017a) analysed the velocity and accuracy of handball players from several teams during matches, and concluded that throwing velocity and effectiveness are both closely related to the type of opposition presented by the opponent before throwing the ball towards the goal. These authors (Zapardiel Cortes et al, 2017b) also report that during a match, the best teams obtain higher throwing velocity in central position, but they did not find differences in relation to effectiveness

These data and analyses underscore the importance of making a qualitative and quantitative leap in the analysis of real-life competitive play in order to adapt training to the specific match performance of each team, where players must identify and use the relevant available information from the competitive context. Therefore, the dual aim of this study was: (a) to evidence some of the limitations of previous research on throwing velocity in handball; and (b) to determine the relationship between competitive throwing velocity and player effectiveness.

MATERIAL AND METHODS

Sample

The study sample consisted of the best players —in terms of throwing effectiveness— in teams competing in the 23rd World Men's Handball Championship. Of these, we identified those players who achieved the highest throwing velocities and best percentages of effectiveness (goal). The inclusion criteria were carried out by experts in handball: presenting a percentage of effectiveness over 40%, having executed more

than 20 throws and achieving velocities higher than 18.11 $m.sec^{-1}$. We analysed the throws of 69 players, recording the ball velocity of 1007 goal-scoring shots.

Variables

The variables analysed were as follows:

1. Completion

We recorded throws that scored a goal. According to the International Handball Federation rules (IHF, 2016**)** "*Rule 9:1 A goal is scored when the entire ball has completely crossed the goal line, provided that no violation of the rules has been committed by the thrower, a teammate or a team official before or during the throw*".

2. Percentage of effectiveness

The percentage of effectiveness was calculated according to the formula below:

Effectiveness = (number of goals * 100) /number of throws.

Based on their effectiveness, the players were divided into three groups:

Group 1 (G1), comprising players with a percentage of effectiveness between 40% and 49.9%;

Group 2 (G2), comprising players with a percentage of effectiveness between 50% and 59.9%;

Group 3 (G1), comprising players with a percentage of effectiveness equal to or more than 60%.

3. Throwing velocity

Throwing velocity during matches was recorded using a radar gun (StalkerPro Inc., Plano, TX, USA) with a 100 Hz sampling frequency and 0.045 $m.s^{-1}$ sensitivity. This

was positioned 3 m behind the goal in a perpendicular direction to the player, at a height of 1.20 m. Two observers carried out this task, one of them recording throwing velocity and the other recording the player executing the throw. The mean velocity each player achieved when scoring a goal was subsequently analysed.

Statistical analysis

Standard statistical methods were used to calculate the mean and standard deviation of throwing velocity ($m.s^{-1}$). All data are expressed as mean ± standard error. The Kolmogorov-Smirnov, Lilliefors and Levene tests were used to determine normal distribution and homogeneity of the data. For a comparison of means, we conducted an analysis of variance (ANOVA) to determine whether there were any differences between the three levels of effectiveness (G1, G2 and G3). When an analysis of variance was significant, comparisons between pairs were conducted using Tukey's HDS test.

Pearson's correlation coefficient was calculated to determine the relationship between throwing velocity and percentage of effectiveness. Statistical significance was set at 5% ($p<0.05$). All statistical analyses were performed using SPSS version 24.

Effect sizes ($\eta 2$) were calculated to assess the practical significance of the differences, and were interpreted as small ($\eta 2 \geq .01$), medium ($\eta 2 \geq .06$) and large ($\eta 2 \geq .14$) (Cohen, 1992).

RESULTS

We found differences between the players' mean throwing velocities ($p<0.001$, $\eta 2=0.20$). An analysis of players' throwing velocities according to their effectiveness

group did not reveal differences between G1 and G2, but G3 presented significantly lower velocities (21.14 ± 4.97 vs 23.40 ± 6.19, $p<0.001$; and vs 22.41 ± 7.19, $p<0.05$) than G1 and G2, respectively (Figure 1).

[INSERT FIGURE 1]

An analysis of the relationship between mean throwing velocity and percentage of effectiveness for each player indicated an inverse relationship ($r=-0.48$; $p< 0.001$), whereby higher throwing velocities were accompanied by reduced effectiveness (Figure 2).

[INSERT FIGURE 2]

DISCUSSION

The main finding of our study was the existence of an inverse relationship between throwing velocity and effectiveness in real-life competitive scenarios. Our data showed that the most effective players did not use their maximum throwing velocity when scoring a goal.

These results indicate that when players in a match throw the ball at higher velocities, their percentage of effectiveness is between 40%and 50%, whereas those who maintain slightly lower mean velocities during a match present percentages of effectiveness of over 60%. These data are consistent with those reported by (Indermill and Husak, 1984) in baseball and (Etnyre, 1998) in darts, who both suggested that in line with Fitts' Law (Fitts, 1954), the higher the velocity of a throw, the lower its accuracy. However, in the case of handball, it has been reported that ball velocity is one of the major determinants of performance (Fradet et al., 2004; van den Tillaar and Ettema, 2004,

2007), which is inconsistent with results of our study, where high velocity appeared to diminish performance.

The relationship between velocity and accuracy in handball has been studied by several researchers (Bayios and Boudolos, 1998; Garcia, et al., 2013; Nuno et al., 2016; van den Tillaar and Ettema, 2003a, 2003b), but the results obtained in these studies are again inconsistent with those reported here. In a study of elite handball players who were asked to execute accurate, high velocity throws (van den Tillaar and Ettema, 2003b), accuracy was not reduced when the ball was thrown at the highest velocity, but neither was it improved when the ball was thrown at significantly lower velocities. The authors concluded that the inverse relationship previously reported between velocity and accuracy was not applicable to this kind of complex movement. Similar results to those observed with elite subjects were obtained in a subsequent study using a sample of inexperienced handball players (van den Tillaar and Ettema, 2003a), indicating that elite and novice players alike employ the same general pattern of throwing coordination. These authors also claimed that the elite players had optimised their throwing technique to overcome the possible existence of a trade-off between velocity and accuracy, whereas the novice players had not, and therefore might present some level of trade-off between velocity and accuracy. According to these authors, handball players are capable of maintaining high velocities close to the maximum (80–90%) without impairing accuracy.

However, the results obtained in the present study do not confirm the conclusions reached in previous studies. One explanation for these differences might be that movements executed during training (closed movement pattern) are not representative of the complex coordinated movement patterns characteristic of competitive scenarios in many sporting activities (Davids, Button, & Bennett, 2008), including handball. All of the above-mentioned studies were conducted in training contexts rather than in

competitive scenarios, where maximum demand is placed on players' decision-making, perceptual and anticipatory capacities and their attentional resources are divided.

In the present study, the maximum velocities recorded for the international players assessed were associated with percentages of effectiveness of around 40% (G1). This suggests that it is throwing skill (variable and adaptive) rather than the conditional element (maximum velocity) that is truly important. Consequently, it would be useful to identify the range within which players combine effectiveness and velocity (which could be termed "effective velocity") and subsequently, via training, to improve this effective velocity in competitive play.

A comparison of the velocities recorded in competitive scenarios and those recorded in other studies with elite handball players which used training to improve throwing velocity (conditional element) (Cherif, Chtourou, Souissi, Aouidet, & Chamari, 2016; Hermassi et al., 2017; Iacono, Eliakim, & Meckel, 2015; Spieszny and Zubik, 2018; Wagner, et al., 2018) (Table 1) indicates that the latter situations failed to replicate the usual professional handball training programmes; therefore, the maximum velocity values obtained were far from the mean effective velocities recorded in competitive scenarios. This suggests that there is a significant gap between competitive performance and throwing velocity training programmes and loads. To the best of our knowledge, no study has reported an increase in throwing velocity that resulted in increased velocity during matches, yet the goal of training in team sports is to improve performance as reflected in the match results.

[INSERT TABLE 1]

In conclusion, our results suggest that:

Most studies on handball throwing velocity have been conducted in training contexts using throwing situations that are very different to those characteristic of competitive scenarios. Further studies are required to analyse players' throwing and effectiveness in competitive scenarios and determine whether training programmes aimed at improving velocity generate improvements in throwing and effectiveness in real-life matches.

There is an inverse relationship between effectiveness and high throwing velocity in competitive scenarios, contrary to the results obtained in studies conducted in training contexts.

PRACTICAL APPLICATIONS

The present results indicate the need to train for high velocities (effective velocity), but not maximum velocities, since the player's effectiveness will be impaired.

It is necessary to maintain a high percentage of effectiveness in the throws executed during training, but under conditions that replicate as closely as possible those of competitive scenarios. Consequently, coaches must devise situations (visual, auditory and kinaesthetic) that stimulate players' capacity to perceive movement, anticipate and make decisions, and design and implement tasks that include multiple degrees of freedom within a dynamic context, since variable, random practice helps increase learning and improve skill transfer in the medium and long term.

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Nevertheless, rare is the occasion in handball when a player can attempt to score a goal in an undefended goal area. Hence, some studies (Rivilla-Garcia, Grande, Sampedro, & van den Tillaar, 2011; Vila, et al., 2012) have analysed throwing velocity in the presence of a goalkeeper, finding that this alone reduced throwing velocities. These results indicate that defensive action forces players to adjust their movement during execution of the throw. Therefore, the best players are those who present a high capacity to adapt to changes in the game in order to achieve better performance (Wagner, et al., 2012).

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All of the above-mentioned studies were conducted under controlled conditions in training contexts, whereas handball is characterised by interaction between the goalkeeper, a team member and the opponent, and this influences the throw. It is well known that there is a need within the world of sport to elucidate what happens during competitive play from both a technical and a research perspective (Ribeiro et al., 2019).

To this end, studies have monitored different parameters of play to analyse and objectively quantify team performance levels during matches in relation to match results (Murray et al., 2016).

Continuing in this line, Zapardiel Cortés et al, 2017a) analysed the velocity and accuracy of handball players from several teams during matches, and concluded that throwing velocity and effectiveness are both closely related to the type of opposition presented by the opponent before throwing the ball towards the goal. These authors (Zapardiel Cortes et al, 2017b) also report that during a match, the best teams obtain higher throwing velocity in central position, but they did not find differences in relation to effectiveness

These data and analyses underscore the importance of making a qualitative and quantitative leap in the analysis of real-life competitive play in order to adapt training to the specific match performance of each team, where players must identify and use the relevant available information from the competitive context. Therefore, the dual aim of this study was: (a) to evidence some of the limitations of previous research on throwing velocity in handball; and (b) to determine the relationship between competitive throwing velocity and player effectiveness.

MATERIAL AND METHODS

Sample

The study sample consisted of the best players —in terms of throwing effectiveness— in teams competing in the 23rd World Men's Handball Championship. Of these, we identified those players who achieved the highest throwing velocities and best percentages of effectiveness (goal). The inclusion criteria were carried out by experts in handball: presenting a percentage of effectiveness over 40%, having executed more

than 20 throws and achieving velocities higher than 18.11 $m.sec^{-1}$. We analysed the throws of 69 players, recording the ball velocity of 1007 goal-scoring shots.

Variables

The variables analysed were as follows:

1. Completion

We recorded throws that scored a goal. According to the International Handball Federation rules (IHF, 2016**)** "*Rule 9:1 A goal is scored when the entire ball has completely crossed the goal line, provided that no violation of the rules has been committed by the thrower, a teammate or a team official before or during the throw*".

2. Percentage of effectiveness

The percentage of effectiveness was calculated according to the formula below:

Effectiveness = (number of goals * 100) /number of throws.

Based on their effectiveness, the players were divided into three groups:

Group 1 (G1), comprising players with a percentage of effectiveness between 40% and 49.9%;

Group 2 (G2), comprising players with a percentage of effectiveness between 50% and 59.9%;

Group 3 (G1), comprising players with a percentage of effectiveness equal to or more than 60%.

3. Throwing velocity

Throwing velocity during matches was recorded using a radar gun (StalkerPro Inc., Plano, TX, USA) with a 100 Hz sampling frequency and 0.045 $m.s^{-1}$ sensitivity. This

was positioned 3 m behind the goal in a perpendicular direction to the player, at a height of 1.20 m. Two observers carried out this task, one of them recording throwing velocity and the other recording the player executing the throw. The mean velocity each player achieved when scoring a goal was subsequently analysed.

Statistical analysis

Standard statistical methods were used to calculate the mean and standard deviation of throwing velocity ($m.s^{-1}$). All data are expressed as mean ± standard error. The Kolmogorov-Smirnov, Lilliefors and Levene tests were used to determine normal distribution and homogeneity of the data. For a comparison of means, we conducted an analysis of variance (ANOVA) to determine whether there were any differences between the three levels of effectiveness (G1, G2 and G3). When an analysis of variance was significant, comparisons between pairs were conducted using Tukey's HDS test.

Pearson's correlation coefficient was calculated to determine the relationship between throwing velocity and percentage of effectiveness. Statistical significance was set at 5% ($p<0.05$). All statistical analyses were performed using SPSS version 24.

Effect sizes ($\eta 2$) were calculated to assess the practical significance of the differences, and were interpreted as small ($\eta 2 \geq .01$), medium ($\eta 2 \geq .06$) and large ($\eta 2 \geq .14$) (Cohen, 1992).

RESULTS

We found differences between the players' mean throwing velocities ($p<0.001$, $\eta 2=0.20$). An analysis of players' throwing velocities according to their effectiveness

group did not reveal differences between G1 and G2, but G3 presented significantly lower velocities (21.14 ± 4.97 vs 23.40 ± 6.19, $p<0.001$; and vs 22.41 ± 7.19, $p<0.05$) than G1 and G2, respectively (Figure 1).

[INSERT FIGURE 1]

An analysis of the relationship between mean throwing velocity and percentage of effectiveness for each player indicated an inverse relationship ($r=-0.48$; $p< 0.001$), whereby higher throwing velocities were accompanied by reduced effectiveness (Figure 2).

[INSERT FIGURE 2]

DISCUSSION

The main finding of our study was the existence of an inverse relationship between throwing velocity and effectiveness in real-life competitive scenarios. Our data showed that the most effective players did not use their maximum throwing velocity when scoring a goal.

These results indicate that when players in a match throw the ball at higher velocities, their percentage of effectiveness is between 40%and 50%, whereas those who maintain slightly lower mean velocities during a match present percentages of effectiveness of over 60%. These data are consistent with those reported by (Indermill and Husak, 1984) in baseball and (Etnyre, 1998) in darts, who both suggested that in line with Fitts' Law (Fitts, 1954), the higher the velocity of a throw, the lower its accuracy. However, in the case of handball, it has been reported that ball velocity is one of the major determinants of performance (Fradet et al., 2004; van den Tillaar and Ettema, 2004,

2007), which is inconsistent with results of our study, where high velocity appeared to diminish performance.

The relationship between velocity and accuracy in handball has been studied by several researchers (Bayios and Boudolos, 1998; Garcia, et al., 2013; Nuno et al., 2016; van den Tillaar and Ettema, 2003a, 2003b), but the results obtained in these studies are again inconsistent with those reported here. In a study of elite handball players who were asked to execute accurate, high velocity throws (van den Tillaar and Ettema, 2003b), accuracy was not reduced when the ball was thrown at the highest velocity, but neither was it improved when the ball was thrown at significantly lower velocities. The authors concluded that the inverse relationship previously reported between velocity and accuracy was not applicable to this kind of complex movement. Similar results to those observed with elite subjects were obtained in a subsequent study using a sample of inexperienced handball players (van den Tillaar and Ettema, 2003a), indicating that elite and novice players alike employ the same general pattern of throwing coordination. These authors also claimed that the elite players had optimised their throwing technique to overcome the possible existence of a trade-off between velocity and accuracy, whereas the novice players had not, and therefore might present some level of trade-off between velocity and accuracy. According to these authors, handball players are capable of maintaining high velocities close to the maximum (80–90%) without impairing accuracy.

However, the results obtained in the present study do not confirm the conclusions reached in previous studies. One explanation for these differences might be that movements executed during training (closed movement pattern) are not representative of the complex coordinated movement patterns characteristic of competitive scenarios in many sporting activities (Davids, Button, & Bennett, 2008), including handball. All of the above-mentioned studies were conducted in training contexts rather than in

competitive scenarios, where maximum demand is placed on players' decision-making, perceptual and anticipatory capacities and their attentional resources are divided.

In the present study, the maximum velocities recorded for the international players assessed were associated with percentages of effectiveness of around 40% (G1). This suggests that it is throwing skill (variable and adaptive) rather than the conditional element (maximum velocity) that is truly important. Consequently, it would be useful to identify the range within which players combine effectiveness and velocity (which could be termed "effective velocity") and subsequently, via training, to improve this effective velocity in competitive play.

A comparison of the velocities recorded in competitive scenarios and those recorded in other studies with elite handball players which used training to improve throwing velocity (conditional element) (Cherif, Chtourou, Souissi, Aouidet, & Chamari, 2016; Hermassi et al., 2017; Iacono, Eliakim, & Meckel, 2015; Spieszny and Zubik, 2018; Wagner, et al., 2018) (Table 1) indicates that the latter situations failed to replicate the usual professional handball training programmes; therefore, the maximum velocity values obtained were far from the mean effective velocities recorded in competitive scenarios. This suggests that there is a significant gap between competitive performance and throwing velocity training programmes and loads. To the best of our knowledge, no study has reported an increase in throwing velocity that resulted in increased velocity during matches, yet the goal of training in team sports is to improve performance as reflected in the match results.

[INSERT TABLE 1]

In conclusion, our results suggest that:

Most studies on handball throwing velocity have been conducted in training contexts using throwing situations that are very different to those characteristic of competitive scenarios. Further studies are required to analyse players' throwing and effectiveness in competitive scenarios and determine whether training programmes aimed at improving velocity generate improvements in throwing and effectiveness in real-life matches.

There is an inverse relationship between effectiveness and high throwing velocity in competitive scenarios, contrary to the results obtained in studies conducted in training contexts.

PRACTICAL APPLICATIONS

The present results indicate the need to train for high velocities (effective velocity), but not maximum velocities, since the player's effectiveness will be impaired.

It is necessary to maintain a high percentage of effectiveness in the throws executed during training, but under conditions that replicate as closely as possible those of competitive scenarios. Consequently, coaches must devise situations (visual, auditory and kinaesthetic) that stimulate players' capacity to perceive movement, anticipate and make decisions, and design and implement tasks that include multiple degrees of freedom within a dynamic context, since variable, random practice helps increase learning and improve skill transfer in the medium and long term.

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Table

Table 1. Mean and standard deviation values ($\bar{x} \pm sd$) corresponding to throwing velocity in professional handball players.

Authors	**n**	**Level**	**Maximal throwing velocity ($m*s^{-1}$)s**
Hermassi, et al 2017	22	Top level male	Jump Throw = 29.2 ± 3.5 3-Step running = 31.0 ± 2.3
Spieszny and Zubik, 2018	28	Professional male	Standing throw = 24.3
Iacono, Ardigo et al, 2015	18	Elite handball male	Standing throw = 24.50 ± 0.77 Jump Throw = 27.10 ± 1.05
Wagner, Fuchs and Duvillard, 2018	36	Elite handball male	25.7 ± 1.5
Cherif, et al, 2016	22	Elite handball male	Jump Throw = 26.9 ± 2.0

Figure 1

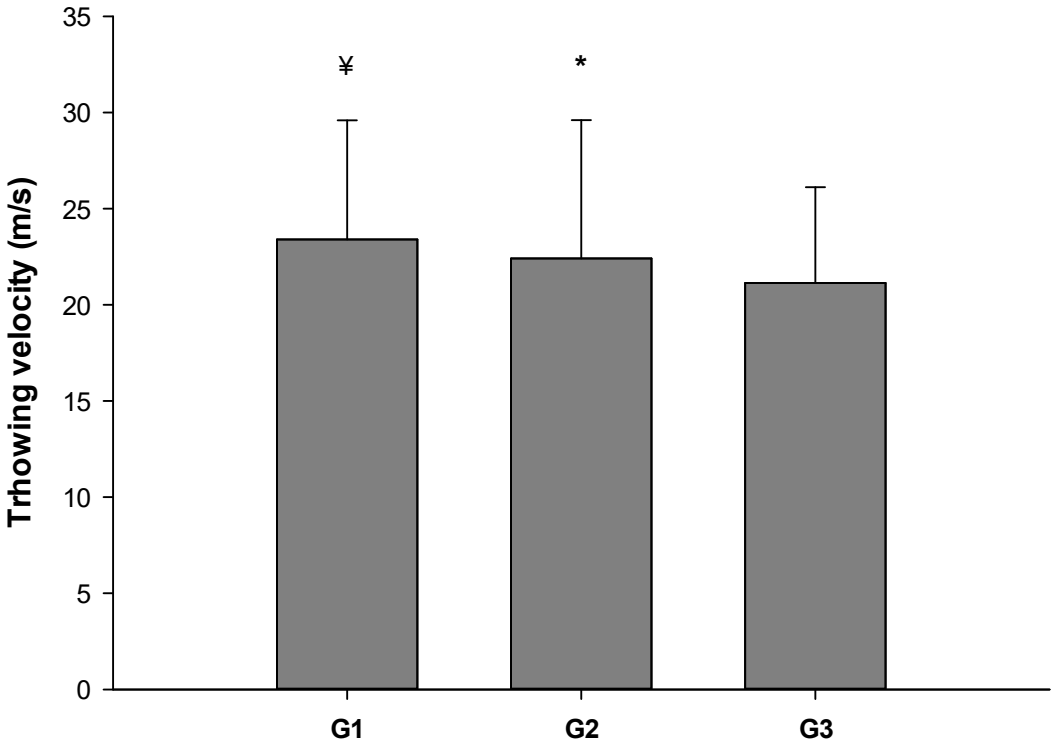

Figure 1. Mean and standard deviation values ($\bar{x} \pm sd$) corresponding to throwing velocity by groups of effectiveness. ¥ Statistical differences with G3 p>0.001, * Statistical differences with G3 p>0.05

Figure 2

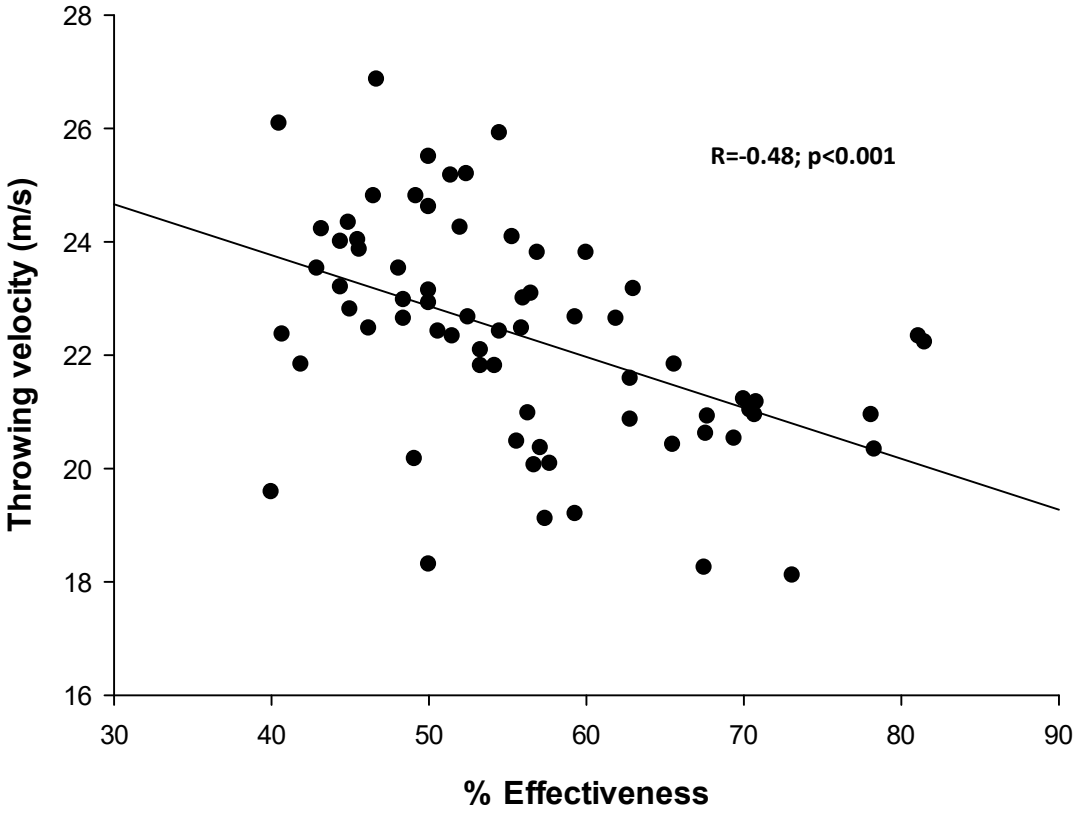

Figure 2. Correlation between Throwing velocity and Effectiveness