Bachelor’s thesis

Effekt av ulike siktepunkt i håndballmålet på kasthastighet- og presisjon hos erfarne håndballspillere

Effects of throwing on different targets upon the performance in experienced handball players

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CONTENTS

1. SUMMARY

The purpose of this study was to investigate the effects of throwing at 4 different targets upon the throwing performance (velocity and accuracy) of experienced handball players. 13 experienced female handball players executed a throwing task where they threw as hard and accurate as they could at 4 different targets (one target in each corner of the goal) with 10 throws at each target in a randomized order (together 40 throws). The findings didn't show any significant relationship to the speed accuracy-trade off, and therefore it was not a direct connection between the velocity results and accuracy results for the different targets. However, there was found a significant difference between the average velocity and accuracy in different parts of the goal. The results showed that the average velocity is significant higher at the dominant side of the goal compared to the non-dominant side. In addition, the average accuracy was significantly higher on the bottom part of the goal compared to the upper part measured as Bivariate Variable Error.

Keywords: team handball, experienced players, throwing performance, task constraints, target, accuracy, velocity.

2. INTRODUCTION

Team handball is an Olympic team sport where two teams of seven players including the goalkeeper compete against each other. The biggest and most important task for both of the teams is to score points by throwing a handball into the goal of the other team. The team that has scored with most goals after two periods wins the game. To achieve this, handball players require high levels of physical skills for example jumping, diving, blocking, sprinting, ball control and agility (Rivilla-Garcia, Grande, Sampedro, & van den Tillaar, 2011). Last but not least, one could assume a player must have been through a lot of matches and gained a lot of experience from teamwork and a wide range of different match situations. Alertness, communication between the players and the ability to make fast decisions and to act correctly in accordance with the situation may be one of the most important skills a player can have in any team sport.

Handball is a dynamic sport, which means that everything changes from time to time. Because of all the players' decisions and actions, any team sport that includes two competing teams on a field is a dynamic process that's in a continuous alternation. Therefore, everyone has to adapt to the changes in the environments. One could also say that at any time, despite the skill or action taken in the game, everyone is always exposed to limitations, or in this context: constraints. This term comes from a theoretical model called Dynamic System Approach (DSA) which in different ways describes how motor development occurs in interaction with the environment (Sigmundsson & Haga, 2004).

2.1. The theoretical basis

Thelen and Smith was the first to introduce DSA as a theory of motor development based on probabilistic epigenesis (1994), though the foundation of DSA was made by Bernstein (1967), and further developed by Kugler, Kelso and Turvey (1982). DSA consists of multiple principles that not only describe *how* the motor development occurs, but also *why* development occurs. The terms of these principles are *degrees of freedom problem, self-organizing* and *constraints*. As a theoretical basis affiliated to this study, the main focus lies on constraints. Constraints are defined as

“boundaries or features that limit motion of the entity under consideration” (Newell, 1986). So not only do constraints function as limitations, but also as opportunities and possibilities that makes the task a lot easier. In this study the handball throw was researched. In terms of a match situation, this is the final main skill required to score a goal. In a handball throw, accuracy and velocity is absolutely vital for increasing the chance of scoring goals. The finishing throw can also be the most crucial factor for the outcome in a match: One either hits or misses the target, and one single throw can determine if the match results in a victory, a tie or a loss. The outcome of a throw can vary from time to time, depending on for example the player’s skill level and the position of the player, the opposition and the goalkeeper (Rivilla-Garcia, Grande, Sampedro, & van den Tillaar, 2011). These constraints may affect the players in a way that forces them to take an action or change the movement pattern.

Constraints are divided into three categories: Organismic constraints, environmental constraints and task constraints (Newell, 1986; Fig. 1). Each category can limit the movement task. The player’s muscle strength, endurance or skill level are examples of what the organismic constraints can be, while the environmental constraints could be the positions of the players and the goal keeper of the other team. Considering the task constraint, a player could have multiple decisions of what to do and how to take action. For example if a trainer were to tell a player to hit as hard as she could down to the left corner of the goal, it would make a task constraint for the player because she now has to act in accordance to the instruction she has received (Sigmundsson & Haga, 2004). Kugler, Kelso and Turvey (1982) meant that new movement patterns occur as a consequence of the changes in the task constraints. Furthermore, they meant that alternations of this kind could be relative permanent (structural) or temporary (functional). Structural constraints could be body mass, body height, etc., while functional constraints could be affiliated with alternations of the technique. Therefore, functional constraints must be followed by an alternation in the nerve system. By changing the functional constraint (for example by learning a new skill), one could get closer to achieve the desired result (Sigmundsson & Haga, 2004).

Van den Tillaar & Ettema (2003) showed that different types of instructions emphasizing velocity, accuracy or both caused an influence on the ball velocity for all

the subjects. The results showed that the more they focused on hitting the target, the more the velocity was reduced. This may be because the task stressed them so much that it was psychologically hard to throw the ball like they were used to. However, despite that velocity was reduced when accuracy was prioritized, accuracy did not improve either. The reason for this may be that the subjects were experienced handball players, and that they already are trained to throw accurately with relatively high speed (Tillaar & Ettema, 2003a).

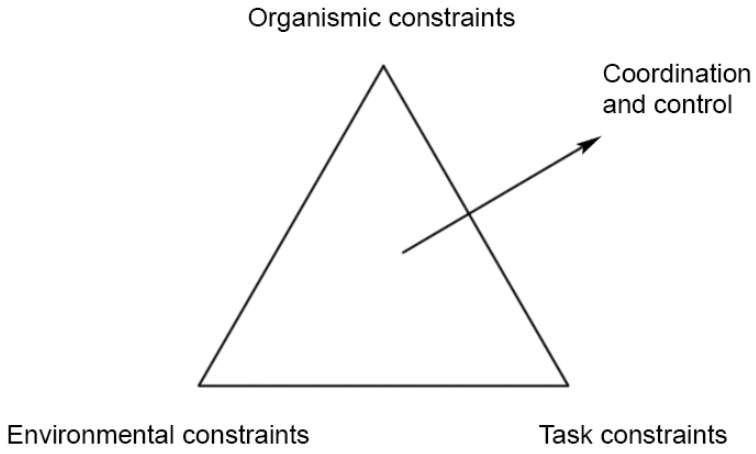

Figure 1: Classification of constraints based on their sources of origin. Redrawn from K. M. Newell, 1986. Constraints on the development of coordination.

2.2. Performance

Earlier studies (Tillaar & Ettema 2003a, 2003b, 2004, 2006, 2009) on the speed accuracy trade-off have placed the target in the middle of the goal, and this may cause a little problem with the specificity considering this is where the keeper usually stands in a match situation. The fact that one has to adapt the throw according to where the keeper stands is an inevitable part of the game, and in situations like this a player usually need to focus on hitting the corner areas. No studies have used different targets as a part of finding out how this could influence the throw. The closest example according to this study is a study of Fuglstad (2013) where he found out how penalty kick in soccer could be affected by different targets. He found out that kicking the ball to the dominant side resulted in reduced accuracy in contrast with kicking to the non-dominant side where the accuracy was significant higher. The

reason for this was that the rotation of the foot towards the dominant side was not as easy and natural as it was to rotate the foot to the non-dominant side (Fuglstad, 2013). However, none of the studies in handball investigated the effect of the different target directions upon throwing performance (accuracy and velocity). Therefore the aim of the present study was to investigate this effect. It was hypothesized that throws to the non-dominant side are faster than to the dominant side due to the possible use of the natural rotation of the body causing a longer working trajectory. In addition it can be hypothesized that when the throwing velocity is higher, the accuracy of throwing decreases. Thus, the target in which the ball velocity is the highest, the accuracy is the lowest following Fitts' law (1954).

3. METHOD

Thirteen experienced female handball players from Levanger håndballklubb participated in this study (Age 18,2 ±1,7 years, training experience 9,5 ±3,7 years, height 1,7 ±0,1 meters, body mass 68,1 ±9,6 kg). Only one of the subjects was left handed. Every subject signed a contract where they accepted that they would be tested and measured for their ball throw performance, and that the information was anonymous so it would not be used by other persons than the researcher.

3.1. Design and measurements

All tests were recorded in Trønderhallen - a sports hall next to the university college Høgskolen i Nord-Trøndelag (HiNT). The sports hall provided us with a dividing wall that was used for a simulated goal with targets set up by tape. The size of the goal was 3 meters wide and 2 meters tall, while the all the four targets were placed 0.25 meters on the inside from each corner: Target 1 in the upper dominant corner, target 2 in the bottom dominant corner, target 3 in the upper non-dominant corner and target 4 in the bottom non-dominant corner. The standing throw position was set 7 meters from the goal (Fig. 2).

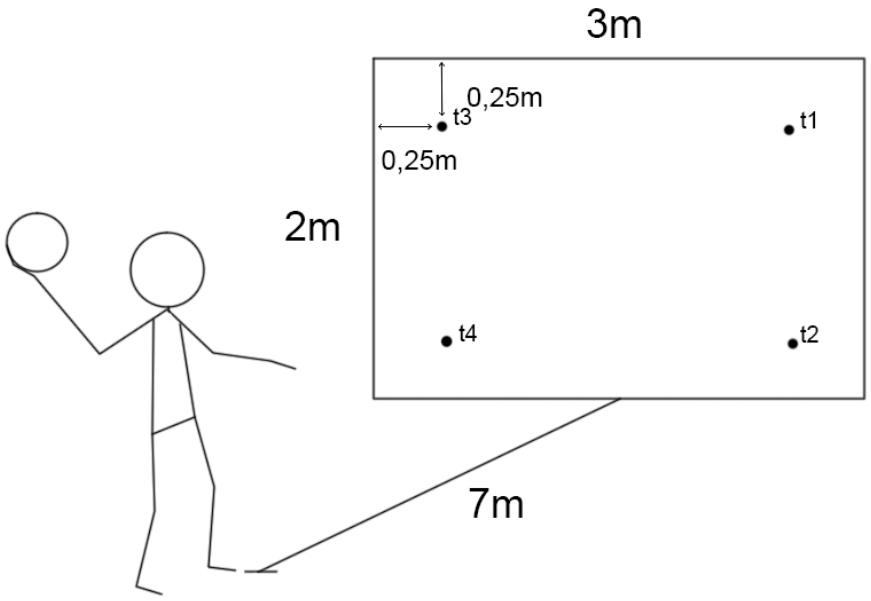

Figure 2: A simplified model of the test procedure. In this example, the targets were set up for right handed. For the left handed, the targets switched sides horizontally. That way, the targets would match the dominant and non-dominant sides for both the right handed and left handed subjects.

Maximum ball velocity and accuracy were measured with respectively radar gun (Doppler radar gun, Stalker ATS II, Applied Concepts Inc., Plano, Texas) and a video camera (Sony HDR FX 1000). The purpose of the video camera was to record the image of the goal so that the accuracy could be measured for all the subjects (the distance from the hit points to the targets).To do this, the videos of the throws were analyzed (Kinovea 0.8.15, a video analyzing program) while the image was shown on a bigger screen at HiNT. To measure the distance from the hit point to the target, transparent sheets were placed on the screen which made it possible to mark the targets and hit points with a pen. After that, the distance from the targets was measured in millimeters on the sheets and thereafter calculated to actual distances in Excel. Three different measurement parameters were used to measure the accuracy: Mean radial error (MRE), Centroid error (CE) and Bivariate variable error (BVE). As seen in figure 3, MRE is the absolute distance from the hit points (the black spots) to the centre of the target. The CE is the distance from the centrum of the average distance of the hit points (the white spot) to the target. BVE is the distance of the hit points to their own centrum (Tillaar & Ettema, 2003a).

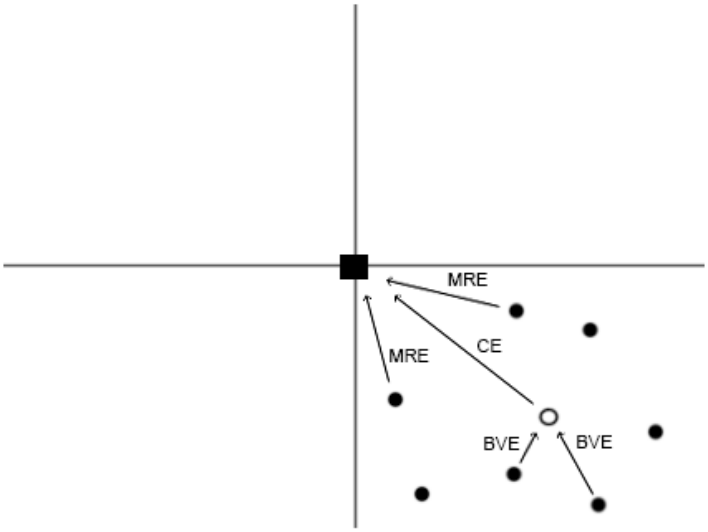

Figure 3: Model of the mean radial error (MRE), centroid error (CE) and the bivariate variable error (BVE)

3.2. Procedure

All the players did a warm-up for 10 minutes with jogging and throwing drills. After the warm-up, the players were tested for their throwing performance by performing a standing throw with a ball at 0,35 kg. In this study the subjects kept the front foot on the floor the whole time during the throw. The subjects were instructed to throw as hard as they could and try to hit 4 different targets with a total of 40 throws with 10 throws at each target. The order of the different instructions was randomized.

3.3. Statistical analysis

Windows Excel and SPSS (version 21) were used for the data analysis. In excel, the average velocity, MRE, CE and BVE was calculated for every subject, which thereafter was gathered in a file where all the subjects' standard deviation and t-tests were calculated. To assess the performances (velocity and accuracy) a One-way ANOVA with repeated measures on four levels (targets) was used in SPSS. Post hoc comparison was performed when the One-way ANOVA was significant. In addition, the data was pooled for up and down and non-dominant and dominant side in which paired t-tests was used to identify eventual differences in excel.

4. RESULT

4.1. Velocity

A significant difference was found in the average velocity between the targets. Post Hoc comparisons showed that the velocity was significant higher when throwing at target 1 compared to target 3 ($p<0.001$) and target 4 ($p=0.003$) (Fig. 4). The velocity was also significant higher when throwing at target 2 compared to target 3 ($p=0.007$). The t-tests showed no significant difference in the average velocity between the upper and the lower part of the goal. However, there was found a significant difference between the non-dominant and dominant side (Fig. 5). The velocity was significant higher on the dominant side of the goal (19.23 m/s) compared to the non-dominant side (18.64 m/s) ($p<0.001$).

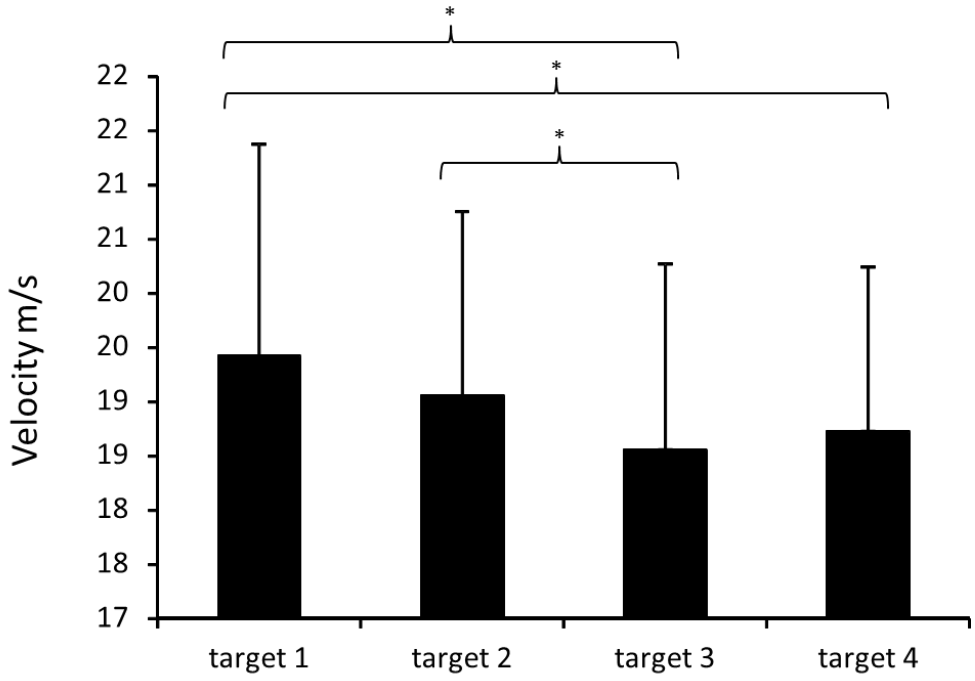

Figure 4. Average velocity from each target of the goal. * indicates a significant difference in average velocity between the targets ($p<0.05$). Target 1 = upper dominant side, target 2 = bottom dominant side, target 3 = upper non-dominant side, target 4 = bottom non-dominant side.

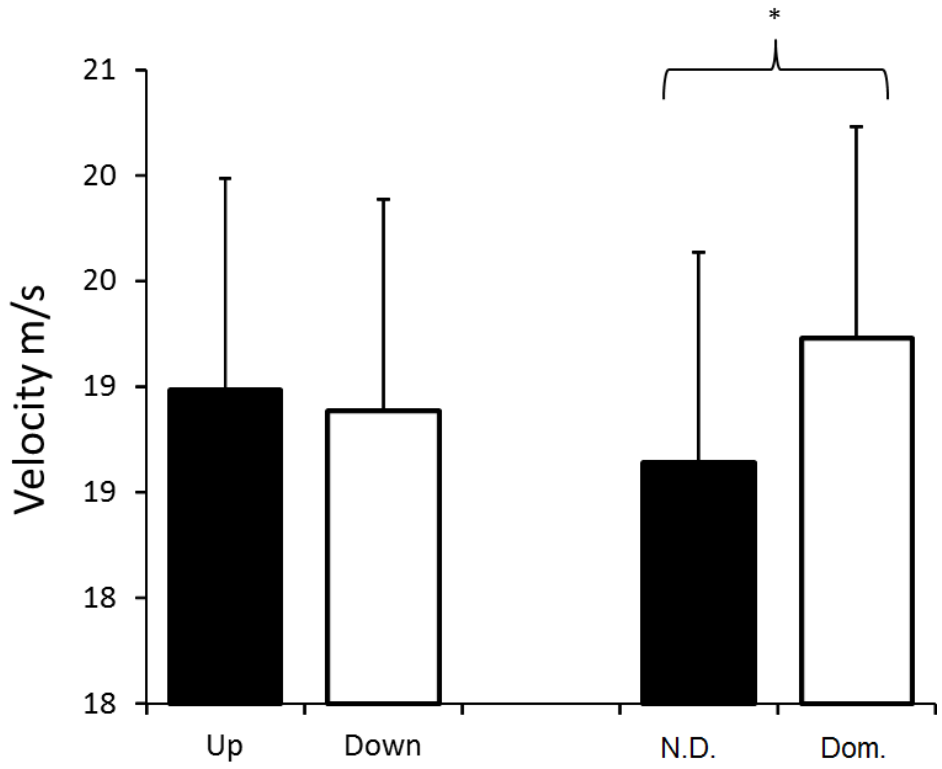

Figure 5. Average velocity from the upper and lower part of the goal and the non-dominant and dominant side of the goal. * indicates a significant difference in the average velocity between the non-dominant and dominant side ($p<0.05$).

4.2. Accuracy

No significant differences were found from the MRE measurement, although the lowest MRE came out as an average of 0.36 meters from target 2 (Fig. 6), while the highest MRE was the same for both target 1 and target 3 (0.42 m). There was found a significant difference between target 3 and 4 in CE ($p=0.022$; Fig. 7), where the lowest average CE was measured as 0.22 m (target 3) compared to the highest at 0.31 m (target 4). The measurements from BVE showed a significant difference between target 2 and 3 ($p=0.006$) and between target 3 and 4 ($p=0.002$; Fig. 8). The t-test calculations for the average accuracy in the upper and lower part of the goal and the non-dominant and dominant side of the goal didn't show any significant differences in MRE or CE. However, there was found a significant difference between the upper and lower part of the goal in BVE ($p=0.013$; Figure 9). The lowest average BVE was measured as 0.30 m at the lower part while the upper part was 0.37 m.

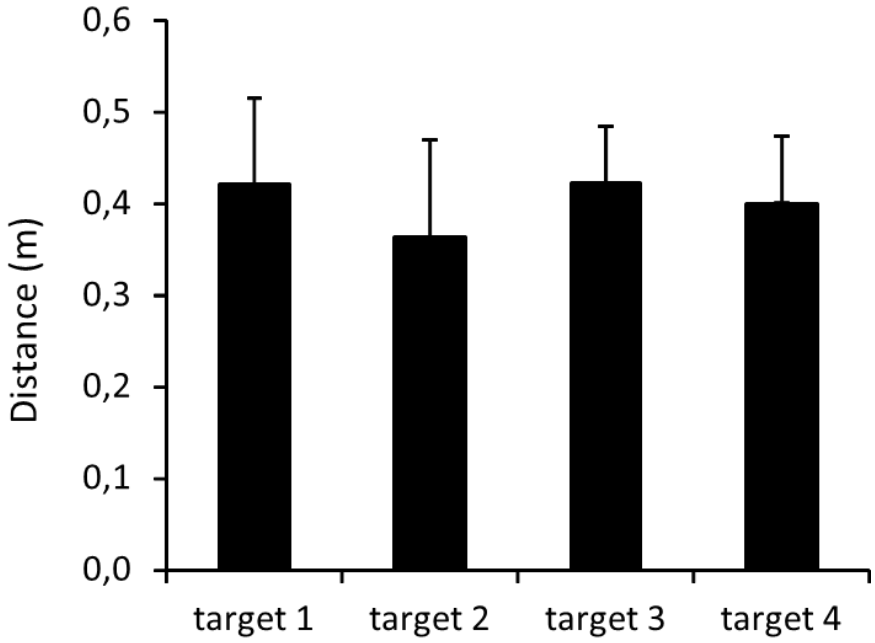

Figure 6. Mean radial error (MRE). Target 2 had the lowest MRE at 0.36 m, while target 3 and 4 had the highest at 0.42 m. Target 1 = upper dominant side, target 2 = bottom dominant side, target 3 = upper non-dominant side, target 4 = bottom non-dominant side.

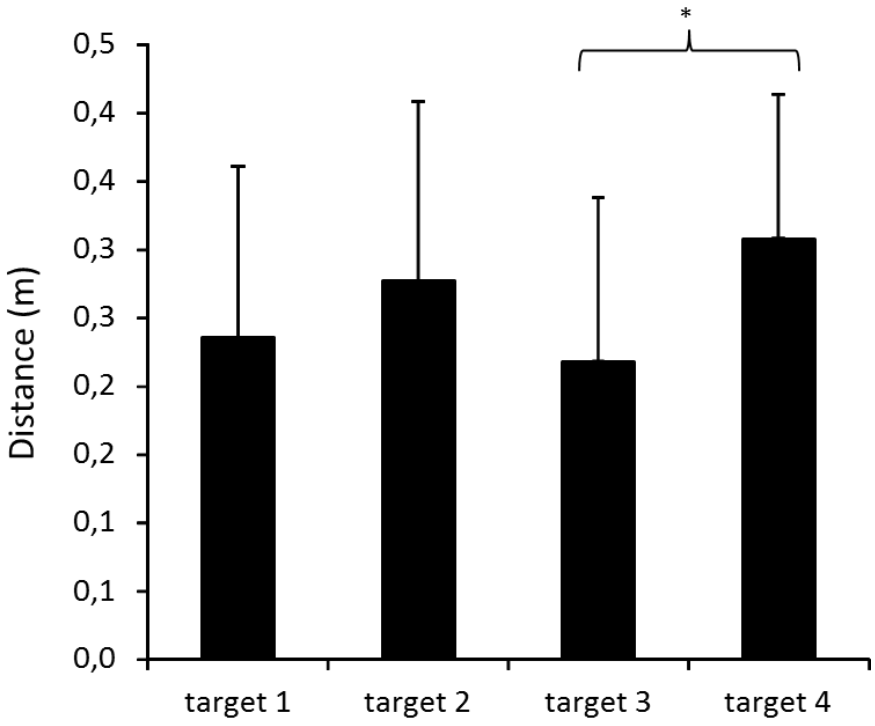

Figure 7. Centroid Error (CE). * indicates a significant difference between the targets ($p<0.05$). Target 1 = upper dominant side, target 2 = bottom dominant side, target 3 = upper non-dominant side, target 4 = bottom non-dominant side.

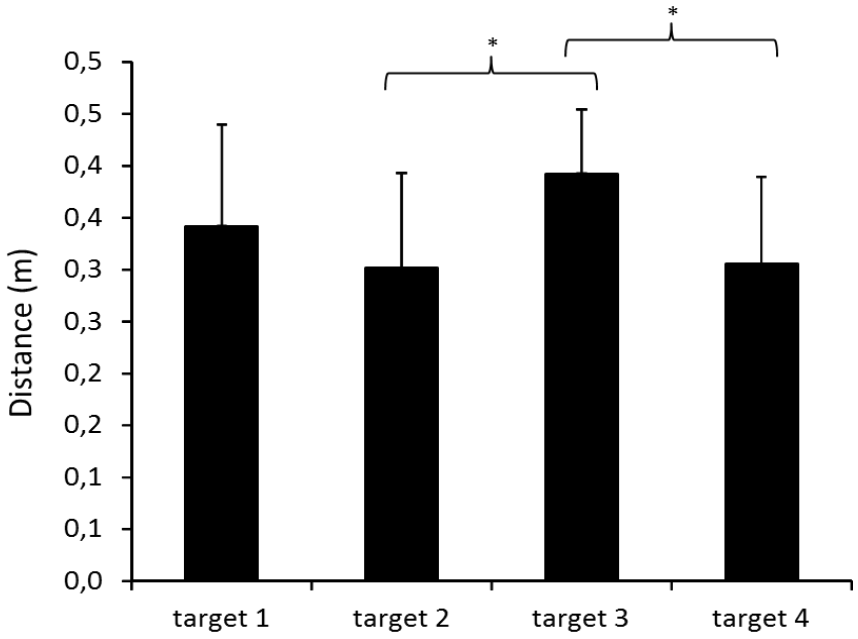

Figure 8. Bivariate error (BVE). * indicates a significant difference between the targets ($p<0.05$). Target 1 = upper dominant side, target 2 = bottom dominant side, target 3 = upper non-dominant side, target 4 = bottom non-dominant side.

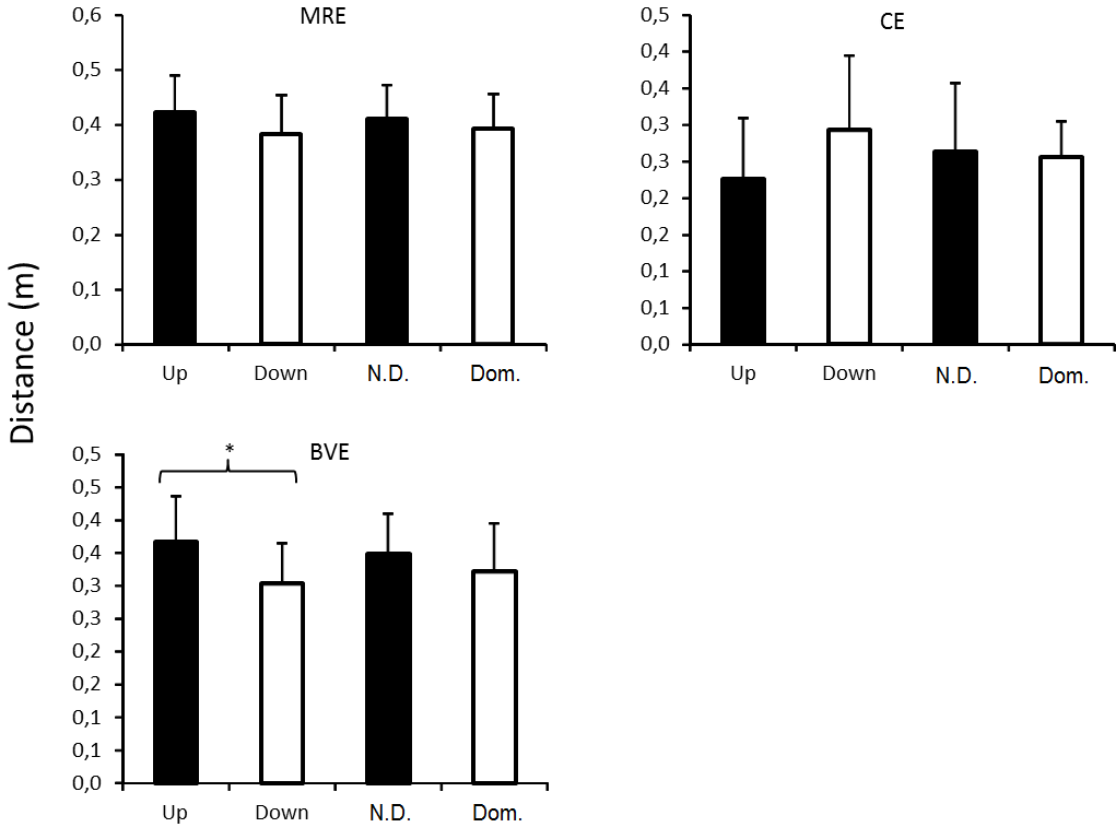

Figure 9. Direction measurements show the average accuracy in the upper and lower part of the goal and non-dominant and dominant side of the goal. * indicates a significant difference between the targets ($p<0.05$).

5. DISCUSSION

The intention of this study was to examine the effects of different targets upon the performance of experienced handball players. The main findings were that the average velocity was significant higher on the dominant side of the goal compared to the non-dominant side (Fig. 5), while the average BVE was significant lower in the lower part of the goal (Fig. 9). The One-Way ANOVA measurements on all the targets did also show some significant results, but there wasn't found any direct relationship between velocity and accuracy as the measurements varied between all of them. When that's said, these results didn't follow a speed accuracy trade-off, and thus didn't go in agreement with Fitts' law (1964) where higher accuracy is associated with lower velocity. The reason for this may be that the focus of the study was to see if there were any accuracy differences between the targets through only one instruction. Earlier studies shows that different instructions have a significant effect on the ball velocity, and confirms that when accuracy is emphasized, acceleration and velocity decreases (Tillaar & Ettema 2003a, 2003b, 2006). In those studies, a different set of instructions was given to each subject so that one could find out if the different instructions resulted in different effects. While this study didn't have any different instructions but to solely focus on accuracy and velocity through all the throws, the study was dependent on the performance of the subjects so we could see if there really was a speed accuracy trade-off in the targets themselves. Maybe one only follows a speed accuracy trade-off as long as the subject is given different tasks and he/she is aware of what to prioritize (ibid.). In this case, the subjects is more focused on throwing as hard and accurate as they can, and hence acts without thinking about alternations in their task priority which could result in changes in the movement pattern (Sigmundsson & Haga, 2004).

As mentioned above, there was found a significant difference in velocity between the non-dominant and dominant side of the goal, but it didn't show any direct relationship with the speed accuracy trade-off as the accuracy measurements was too varied (Fig. 6, 7 and 8). The reason behind the low differences between the direction measurements in the average accuracy (Fig. 9) could be that the subjects were all experienced handball players and that they have been trained to throw both fast and accurate at the same time. In addition, studies that have investigated effects of

different instructions upon the performance of handball players have shown that despite the velocity of throwing performance, there was no significant difference in accuracy (Tillaar & Ettema 2003a, 2003b, 2006). The average ball velocity may be different on the different parts of the goal, but according to this study, it doesn't necessarily mean that one could throw more or less accurate at the different directions.

There was found a lower average distance both in MRE and BVE in the lower part of the goal compared to the upper part. Only CE differ from these results where the opposite is shown (Fig. 9). This is one of the results that actually are in accordance with a speed accuracy trade-off, because where the accuracy (BVE and MRE) is the highest, the velocity is at its lowest (Fig. 5 and 9). The problem is that neither the MRE nor the velocity measurements shows a significant difference, but a possibility of a speed accuracy trade-off could be there. Since there was found a significant difference in BVE, this could mean that it's a slight bigger probability to hit the goal/target in the bottom part of the goal. Then again, it's important to take into account which of the measurements that is the most important to reckon. MRE refers to the distance to the actual target, so MRE could be of great value when it comes to measure the deviation of all the hit points. However, BVE refers to the distance to the midpoint of all the hit points, which doesn't include the actual target at all. The benefit from throwing towards the lower part of the goal could be that the deviation from the subject's own midpoint is lower, which could result in more concentrated hit points.

The results in this study could be explained by different factors in the throwing kinematics. In a study by Fuglstad (2013), as mentioned in the introduction, a relationship between accuracy and kinematics were found where the accuracy was higher on the non-dominant side of the goal because of a more natural rotation of the foot. Kinematics was initially meant to be one of the most essential parts of this study, because the motions of the throw could be investigated as a possible factor for the different accuracy and velocity results at each target. In addition to the video recording, all tests were recorded by a 3D motion capture system (Qualisys Track Manager) that provided with data of the kinematics of every throw from all the subjects. The necessary data is received, but due to all the errors within the data, the time was too short to correct all the information.

Overall, no relationship was found between accuracy and velocity, which proves the opposite of the hypothesis for this study. On the other hand, although it wasn't significant, a positive correlation could be indicated for the average velocity and the average MRE and BVE between the upper and lower part of the goal. The average accuracy was significant better at the lower part of the goal, while the average velocity was at its highest at the dominant side of the goal. This is also the opposite of that which was initially hypothesized, so maybe it isn't necessarily the possible longer rotation of the body that creates the highest velocity. The hypothesis about the longer working trajectory causing a higher velocity was brought up mainly because of the earlier studies. Van den Tillaar and Ettema (2004, 2007) have reported that the rotation of the hip, the elbow extension and the internal rotation of the shoulder showed a significant relationship with the throwing performance. Therefore, one could assume that the velocity was higher on the non-dominant side due to a longer rotation of the body. The fact that the result in this study proved to be the opposite of the study of Fuglstad (2013) may not be that surprising since this study has investigated the performance of another team sport where the most important movements are based on the upper extremity. Nevertheless, the reason for the differences in the velocity between the non-dominant and dominant side could be due to different movement patterns. Besides, Kugler, Kelso and Turvey (1982) meant that new movement patterns occur as a result of the changes in the task constraints. Since functional constraints results in alternations in the nerve system, another movement pattern may occur to solve the task.

As mentioned in the introduction, handball is a dynamic sport where the players continuously have to adapt to the environment. Therefore, it's important to look at the specificity of this study. Because of how the method procedure was set up, this study could only apply for penalty throws. The outcome of one single throw all depends on factors such as the position of the player, the opposition and the goalkeeper. Therefore, these results can't be linked up to any situation that occurs within the game. As a consequence of this study, the fact that one could throw faster at the dominant side of the goal compared to the non-dominant side may be a thought that could occur among handball players when deciding which side of the goal that they should throw at in a penalty throw.

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