

Perceptual Training Effects on Anticipation of Direct and Deceptive 7-Meter Throws in
Team Handball

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA

BY

Khaled E. Alsharji

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Michael G. Wade, PhD

May, 2014

Acknowledgements

I would like to thank those people who made this achievement possible. Firstly, I would like to thank my advisor Dr. Michael G. Wade for all of his help with this dissertation. None of this would have happened without you. I would like to thank Dr. Thomas A. Stoffregen, who provided sound advice and direction. I would also like to thank Dr. Nicholas Smeeton from the UK, who accepted my request to stand as one of my PhD committee members when we first met at the ICSEMIS 2012 conference in Glasgow, UK. Last but certainly not least, I would like to thank Dr. Nicole LaVoi: I would like to thank you for serving on my committee and for providing valuable feedback on my project. Your creative teaching style and your psychology of coaching class contributed significantly to my own development. I now have my vision, goals, and plan covered, as well as a sound life, teaching, and coaching philosophy.

I want to especially thank my family. My parents have always supported me through every aspect of my life. I can't thank them enough for all they have done for me over the 34 years of my life. It was hard to be away from you for the last 6 years. However, I hope this achievement makes you proud.

A special thank you to my wife for all of her sacrifices on this journey. Also I would like to thank my four children, Mariam, Shikha, and Sulaiman, for being everything good in this journey. Thank you, too, to my fourth kid, Abdulwahaab, who was born in Kuwait while I worked on statistical analysis in the US.

Abstract

This research investigated the effects of video-based perceptual training on the performance of handball goalkeepers when anticipating the directions of both direct and deceptive 7-meter throws (i.e., penalty throws). Forty two Kuwaiti handball goalkeepers voluntarily participated in this study and were randomly assigned to 3 matched-ability groups based on their pre-test performance: participants in the perceptual training group received video-based perceptual training over 7 consecutive days; participants in the placebo training group received video-based regular training; and participants in the control group received no training. The primary findings demonstrated that video-based perceptual training significantly improved anticipatory performances from pre- to post-test under both throwing conditions (i.e., direct and deceptive). Although perceptual training significantly improved anticipation of direct and deceptive throws, anticipation of deceptive throws showed less improvement. The current findings support the first research hypothesis that perceptual training group would improve their anticipation under both throwing conditions more than placebo training and control groups. The findings also support the second research hypothesis that anticipation of deceptive 7-m throws would show less improvement compared to anticipation of direct throws. In conclusion, this study confirms the importance of perceptual training for anticipation skills in sport and adds to the literature that perceptual training can also improve anticipation of deceptive actions. In addition, this study confirms that deception in handball is a challenging task that goalkeepers can minimize, but cannot eliminate, its effect by enhancing their perceptual skills.

Table of Contents

List of Tables.....	v
List of Figures.....	vi
Chapter 1 : Introduction.....	1
<i>Purpose of the Study.....</i>	<i>6</i>
<i>Significance of the Study.....</i>	<i>6</i>
<i>Research Questions and Hypotheses.....</i>	<i>7</i>
Chapter 2 : Review of The Literature	9
<i>Introduction to Expertise.....</i>	<i>9</i>
<i>Team Handball.....</i>	<i>30</i>
<i>Deception & Detection of Deception.....</i>	<i>35</i>
<i>Can Expertise Be Developed?.....</i>	<i>51</i>
<i>Summary.....</i>	<i>58</i>
Chapter 3 : Methodology	60
<i>Introduction.....</i>	<i>60</i>
Study I.....	61
<i>Introduction.....</i>	<i>61</i>
<i>Method.....</i>	<i>62</i>
<i>Results.....</i>	<i>63</i>
<i>Discussion and Implications for Study III.....</i>	<i>64</i>
Study II.....	66
<i>Introduction.....</i>	<i>66</i>
<i>Method.....</i>	<i>67</i>

<i>Results</i>	72
<i>Discussion and Implications for Study III</i>	74
<i>Study III</i>	77
<i>Method</i>	77
Chapter 4 : Results	84
<i>The Effect of Perceptual Training on Anticipation</i>	86
<i>The Size of Improvement</i>	88
<i>The Size of the Difference Before and After Perceptual Training</i>	89
<i>Summary of the Results</i>	90
Chapter 5 : Discussion and Conclusion	92
<i>The Effect of Perceptual Training</i>	92
<i>Reasons for Performance Improvement</i>	94
<i>Portable Perceptual Training Devices</i>	99
<i>Limitations</i>	100
<i>Practical Implications</i>	102
<i>Conclusion</i>	106
References	108

List of Tables

Table 1	61
Table 2	84

List of Figures

<i>Figure 1</i>	63
<i>Figure 2</i>	64
<i>Figure 3</i>	68
<i>Figure 4</i>	71
<i>Figure 5</i>	73
<i>Figure 6</i>	81
<i>Figure 7</i>	86
<i>Figure 8</i>	87
<i>Figure 9</i>	87
<i>Figure 10</i>	88
<i>Figure 11</i>	90
<i>Figure 12</i>	93
<i>Figure 13</i>	94
<i>Figure 14</i>	105

Chapter 1 : Introduction

Team handball is a complex, fast-based, Olympic contact sport played professionally in Europe and at an amateur level in 174 countries worldwide. It consists of intense, intermittent activities, such as running, sprinting, jumping, and full-body actions, such as throwing, hitting, blocking, deceiving, and pushing, and fast and precise individual and team defense and attack tactics. Due to core changes in the rules of the game over the last few decades, modern handball is now a much tougher, faster, and more complex and powerful game. Thus, to succeed in the game, handball field players and goalkeepers are required to achieve the proper level of physiological, psychological, and perceptual ability determined by their playing positions (e.g., wing, back, playmaker, or goalkeeper).

In handball, an old saying goes, “If you want to have a good handball team, get a good goalkeeper.” Today, the role of the handball goalkeeper is a vital one. As the last line of defense, a skilled handball goalkeeper can enable his team to achieve victory. In addition, as the first line of offense, a proficient goalkeeper can significantly contribute to a championship goal by, for instance, initiating a long, accurate, and direct pass to a running wing.

Recently, research has indicated that in each handball game there is an average of 3.68 penalty throws (Foretić, Uljević, & Prižmić, 2010). Due to the relatively short distance (i.e., 4-7 m) between the goalkeeper and a thrower, and due to the velocity of a handball throw, which reaches $26.2 \text{ m}\cdot\text{s}^{-1}$ (Fradet et al., 2004) or $26.27 \text{ m}\cdot\text{s}^{-1}$ (Bayios,

Georgiadis, & Boudoulos, 1998), the best goalkeepers can hope to save only about 50% of the penalties thrown toward the goal. Due to these difficulties, to stop 7-m throws (penalty shots), an expert goalkeeper must exhibit a high level of expertise accrued through years of sport-specific practice. The literature on sport expertise indicates that an important component of superiority in competitive situations such as goalkeeping is the use of perceptual-cognitive skills to determine the other player's intention to execute an action. Hence, anticipation of the opponent's next action has become a hallmark of expert performance in general, and in handball in particular.

Handball goalkeepers experience a difficult time deciding whether to track the ball after its release from a thrower's hand or to anticipate the direction of the ball before the releasing point. Based on the suggestions of the scientific research (Abernethy & Russell, 1987; Farrow, Abernethy, & Jackson, 2005; Müller, Abernethy, Eid, McBean, & Rose, 2010), however, a proficient goalkeeper must demonstrate a superior ability to detect advance visual information arising from a thrower's postural orientation and to employ efficient visual search (Savelsbergh, van der Kamp, Williams, & Ward, 2005; Savelsbergh, Williams, van der Kamp, & Ward, 2002; Williams, Ward, Knowles, & Smeeton, 2002) to anticipate the ball direction.

Although there is an agreement about the correlation between anticipatory performance and superiority in sport competition (e.g. Abernethy, 1990; Abernethy & Zawi, 2007; Farrow & Abernethy, 2003; Müller, Abernethy, & Farrow, 2006; Savelsbergh et al., 2002; Savelsbergh et al., 2005), there is as yet only a vague view about anticipation's efficiency in the case of deception. Most of the previous research,

which considers a variety of sport situations, has not considered the possible effects of deceptive actions on the accuracy of anticipation. With the exception of two studies that address the direct effect of deception on anticipation in tennis and soccer, respectively (Rowe, Horswill, Kronvall-Parkinson, Poulter, and McKenna, 2009; Smeeton & Williams, 2012), most empirical studies have investigated the ability of athletes to detect deceptive movements with respect to their experience levels (e.g., Cañal-Bruland & Schmidt, 2009; Cañal-Bruland, van der Kamp, & van Kesteren, 2010; Jackson, Warren, & Abernethy, 2006; Sebanz & Shiffrar, 2009). The results revealed from Rowe et al., (2009) and Smeeton and Williams (2012) indicate that a deceptive shot and deceptive kick significantly reduce response accuracy in anticipating the ball directions in tennis and soccer and that while deceptive movements affected both experts and novices, novices were more affected.

The findings from these two studies reveal that the use of deception in sport, as well as the perception of deception, is an important skill that might give athletes advantages over their opponents. Given that deceptive actions are common skills in the field of team handball, the findings from the previous studies suggest a need to further investigate the direct effect of deceptive actions on the ability of team handball goalkeepers to anticipate throw directions, rather than on their ability to detect only deceptive movements.

The goalkeeper-thrower interaction in handball is unique and challenging for both goalkeepers and throwers. A thrower usually tries to minimize the potential dynamical information that can be used by the goalkeeper to anticipate the action (i.e., the ball's

direction). To minimize the communication of important visual information, the thrower executes deceptive hand movements that mask the real throw by indicating an intention to throw the ball to a different location. The most common type of deception in handball occurs when a player, while executing a 7-m throw, initiates deceptive or fake throws by rapidly moving the throwing arm forward, stopping the forward movement to move the ball backwards, and then initiating the real shot within a time frame of 3 s. The movement makes it challenging for a goalkeeper to utilize advance cues and effectively search for important kinematic information from a thrower's body to accurately anticipate a throw direction.

The exceptional perceptual skills of skilled athletes in different types of sport have served as a starting point for numerous experiments seeking an empirical base for training programs (Hagemann, Strauss, & Cañal-Bruland, 2006). In contrast to the general commercial vision training programs that provide no measurable benefits (Abernethy & Wood, 2001), there is broad empirical evidence that perceptual-cognitive skills can be trained for specific sports (Williams, Ward, & Chapman, 2003; Williams, Ward, Smeeton, & Allen, 2004). In fact, perceptual training programs have been developed and applied frequently in racket and ball games, such as tennis, soccer, and hockey (Williams et al., 2004; Smeeton, Williams, Hodges, & Ward, 2005; Williams et al., 2003).

There are encouraging findings supporting the notion that anticipation in sport is a perceptual-cognitive skill that can be improved via perceptual training. Researchers have examined the possible influence of sport-specific perceptual training on anticipation

using different instructional techniques (e.g., explicit vs. implicit learning), and using different methods for orienting visual attention toward relevant information (e.g., highlighting, coloring, or occluding particular body parts). From an ecological point of view, reduced usefulness training (Jacobs, Runeson, and Michaels, 2001; and Smeeton, Huys, and Jacobs, 2013) was found to be good alternative training method to enhance perceptual learning. This method aims to stimulate observers to detect more useful informational variables as used by experts, than the variables initially used by novice perceivers. The majority of perceptual training studies have employed a video-based simulation (Starkes & Lindley, 1994) as a training tool for enhancing the ability of anticipation. The video clips have been displayed via either a life-size screen or a regular notebook. The response type has been recorded as either physical or verbal response. When training perceptual skills for anticipatory performance, there has been no significant difference found between the use of perception-action or perception-only training, (Williams et al., 2004); similarly, there has been no significant difference found between the use of a life-size screen or a small screen (Spittle, Kremer, & Hamilton, 2010).

In sum, the perceptual training-related research has shown that anticipation is a skill that can be improved through appropriate instruction regardless of whether the learner must physically respond to the action or merely make a perceptual judgment and whether the video-simulation is displayed via large or small screen. There therefore remains considerable opportunity for exploring innovative methods and techniques to facilitate the acquisition of anticipation skills in regular sport situations. In addition, there

is considerable opportunity to explore methods and techniques for developing anticipation skills in deceptive situations. Indeed, little research exists to address developing and improving anticipation in the specific situations in which deception often occurs.

Purpose of the Study

The purpose of this study was to add to the previous sport expertise literature by investigating the effects of video-based perceptual training on the performance of handball goalkeepers when anticipating the directions of both direct and deceptive 7-meter throws (i.e., penalty throws).

Significance of the Study

Research has not yet determined how team handball goalkeepers best anticipate ball direction in deceptive or non-deceptive situations, nor has it determined how to best structure handball-specific perceptual training programs to enhance anticipation skills. The present research sought to address this gap. Handball coaches are concerned with teaching goalkeepers how to read opponents' (handball throwers') actions in deceptive and direct throwing situations in order to gain an advantage over opponents. Coaches are looking for practical, affordable, effective, simple, and enjoyable perceptual training programs that could be used to supplement the usual training routines. Although coaches often focus on developing technical, physical, and psychological skills, they tend to neglect perceptual-cognitive skills. Technical, physical, psychological, and perceptual training programs should not be seen as mutually exclusive, but as a combination of programs that can potentially enhance sport performance. In general, if coaches seek

superiority in the performance of their athletes, they must apply an extensive and effective amount of practice, either deliberate practice (Ericsson, Krampe, & Tesch-Römer, 1993) or deliberate play activities (Berry, Abernethy, & Côté, 2008). To reach an appropriate amount of effective practice hours, however, coaches cannot only coach their athletes on the field; they must also encourage off-field training. In the same way that some athletes invest time in extra technical and physical training, they must also practice some perceptual-cognitive activities to enhance their performance. The present research suggests that deploying effective video-based perceptual-cognitive activities presented via a portable device such as an iPad may further help athletes to achieve sport excellency.

This study supplies research to investigate the effects of a handball-specific video-based perceptual training program on the handball goalkeepers' ability to anticipate the directions of both direct and deceptive 7-m throws.

Research Questions and Hypotheses

To address the research problem of ascertaining if the anticipation of deceptive and direct 7-m throws can be learned and improved through sport-specific perceptual training programs, one research question guided this study:

RQ1: Does perceptual training improve goalkeepers' anticipatory performance for both direct and deceptive 7-m handball throws?

Based on this research question, two hypotheses were developed:

H₁: Differences will be present in the performance between group receiving perceptual training and groups receiving no perceptual.

H₂: Anticipation of deceptive throws will differ from performance of direct throws.

Two pilot studies (Study I and Study II) were conducted to streamline and support the main study (Study III) that tested these two hypotheses and addressed the research question. Both pilot studies were conducted to strengthen the design of the handball-specific anticipation test and the perceptual training. Therefore a full description of the pilot studies plus the design and methodology of the main study are described in Chapter 3. The results of the main study are discussed in Chapter 4, and the discussion and overall conclusions are provided in Chapter 5.

Chapter 2 : Review of The Literature

Introduction to Expertise

Expertise refers to the mechanisms underlying the superior achievement of an individual who has acquired special skill in, or knowledge of, a particular subject through professional training and practical experience (Ericsson, Charness, Feltovich, & Hoffman, 2006). The term expert is used to describe highly experienced professionals such as medical doctors, accountants, teachers, and scientists, but it has been expanded to include any individual who has attained superior performance by instruction and extended practice (Ericsson et al., 2006).

The nature of expertise has been studied according to two general approaches: the first investigates expertise by studying people defined as exceptional with the goal of understanding how they perform in their domain of expertise; the second approach studies expert performers compared to novices. Regarding the latter, contrastive, method, Ericsson et al. (2006), indicated that the definition of expertise in this sense is more relative because the more knowledgeable group is considered “expert” and the less knowledgeable group “novice.” Therefore, the term “novice” is used in a generic sense, in that it can refer to a range of nonexperts, from the naïve to journeymen (Ericsson et al., 2006). The purpose of studying relative expertise is not simply to describe and identify the ways in which experts excel. Instead, the essential goal of studying expert-novice differences is to understand how experts became that way so that novices can learn to become more skilled and knowledgeable and achieve higher levels of performance.

One of the most fascinating questions within the domain of sport science has been whether scientists can differentiate abilities or traits between athletes and non-athletes, or between experts and novices (Kioumourtzoglou, Kourtessis, Michalopoulou, & Derri, 1998). For many years, maturation or capacity limitations were thought to be the exclusive attributers for the differences between experts and novices. However, since the early 1970s, a considerable amount of the research has strongly implied that the importance of maturity and capacity has been overestimated (Kioumourtzoglou et al., 1998).

To identify and evaluate the components that were thought to contribute to skilled performance, or expertise, a pioneering work by de Groot (1965) (as cited in Chase & Simon, 1973) examined the differences between skilled and less skilled performers. De Groot (1965) proposed that some aspects of memory (i.e., short-term memory) are critical to superiority in chess. To test the hypothesis, a group of chess players of varying skill levels were asked to study the position of chess pieces for a period of five seconds, and then they were asked to recall a chess position. The findings of this experiment showed that chess grandmasters were more accurate in the recall of the position of chess pieces. There were two possible conclusions to be drawn from the superior performance of good players on a five-seconds recall task. First, as indicated by de Groot (1965), the grandmaster chess players may have better memory capacity and ability in general. Second, the perceptual abilities of chess players (experts) may help them to be better at encoding information specific to their skill domain and rapidly encode and retrieve specific available information. According to Ericsson et al (2006), encoding refers to

“how information is transferred into a form that can be stored in memory,” whereas retrieval refers to “the way information in memory is accessed in order to respond to the task at hand.”

Based on de Groot’s classic work (1965), Chase and Simon (1973) developed a study to determine which conclusion was the controlling factor for expertise or expert performance (i.e., the subject’s memory or the nature of the stimulus and the individual’s perception). Unlike de Groot’s (1965) investigation, Chase and Simon asked individuals, including but not limited to novice and expert chess players, to recall randomly arranged chess pieces on the board. In this task, when the chess pieces were randomized, all of the chess players, regardless of their level of expertise, performed about equally. Thus, Chase and Simon concluded that the superior performance of the grandmasters on the chess positions was likely due to advanced task-specific knowledge and to rapid and efficient encoding and retrieval of available information (Chase & Simon, 1973).

Since the publication of this research, the paradigm of task recall introduced in de Groot (1956) and Chase and Simon (1973) has consisted of demonstrating an interaction between skill level and stimulus information. A large body of research has been interested in identifying attributes that distinguish experts from novices, skilled from less skilled individuals, in their specific domain (e.g., transportation, music, education, medicine, nursing, and particularly sports).

In non-sport related domains, for instance, it has been found that compared to novices, expert automobile drivers were more accurate in their ability to perceive dangerous events (Champan & Underwood, 1998). Stokes, Kemper, and Kite (1997)

found that experienced pilots outperformed novice pilots in a situation-recognition task. Similarly, expert pilots were better at integrating conflicting information than less-experienced pilots when flying a Frasca 142 flight simulator; they recognized deteriorating weather conditions faster than less experienced pilots (Wiegmann, Goh, & O'Hare, 2002). In music, the eye movement of experts performed a simple music-reading task more accurately and rapidly than novices (Waters & Underwood, 1998). The roles of pattern recognition and prediction in sight-singing performance were examined and the findings revealed that skilled sight-singers were superior compared with less-skilled singers (Fine, Berry, & Rosner, 2006). The preceding studies were examples of the research in which expertise and expert performance were examined in non-sport related domains. In the following section, sport-related studies interested in expertise and expert performance are discussed.

Expertise in Sport Domains

The ability to encode and retrieve task-specific information, which has been proven to be a controlling factor for superior performance (Chase & Simon, 1973), is assumed to be an important component of expert performance in sport (Williams, Davids, & Williams, 1999). These two abilities have been examined extensively in sport literature through the contrastive approach to studying expertise. Over the last two decades, sport scientists focused most of their attention on identifying differences between skilled athletes and less skilled athletes, or novices, in many sport domains (e.g., tennis, cricket, badminton, soccer, hockey, basketball, and volleyball). According to Williams et al. (1999), the interested sport scientists in the area of sport expertise have been addressing a

collection of investigative questions such as: Do experts encode and retrieve game-structured information more efficiently than novices? Are skilled sport performers able to detect and locate objects within the visual field faster and more accurately than less skilled performers? Are expert athletes able to make better use of contextual information in anticipating future actions? Are expert players able to make effective use of situational probabilities within the anticipation process? Do skilled athletes make faster and more accurate decisions? How do performers make decisions in sport? And based on the results for previous questions, the final and the most important question is how do these skills emerge as a function of practice or experience?

Thus, the qualities of expert performers in many sport-related domains, the appropriate techniques by which these qualities can be acquired, and the perceptual complications associated with these qualities will be covered extensively in the following literature.

Recall task and pattern recognition. It has been suggested that recall and recognition are the two most commonly used approaches to examine the ability of coding-retrieving information (Williams et al., 1999). Basketball and volleyball (Allard, Graham, & Paarsalu, 1980; Allard & Starkes, 1980) were among the first open team sports in which sport scientists explored and investigated the role of perceptual abilities in differentiating between experts and novices. For example, Allard et al., (1980) showed that expert basketball players significantly recalled more game situations than novices, but only regarding structured game situations. Participants were asked to view slides that illustrated basketball games; one half of the slides contained structured game information

(e.g., an offensive play in progress), and the other half of the slides showed unstructured game situations (e.g., a turnover or rebound). Additionally, expert basketball players were superior to novices in recognition tasks for both structured and unstructured game situations. The researchers concluded that the superiority in experts' performance was due to their ability to rapidly encode information at a deeper level than non-experts.

However, when Allard and Starkes (1980) examined differences between volleyball experts and novices, no differences were found in pattern detection between structured and non-structured situations. Yet, expert volleyball players were significantly faster in responding than non-experts. Researchers attributed these differences to skill and knowledge of the game rather than a simple difference in athletic ability. Proceeding from these findings from both studies, researchers concluded that it was possible that experts in various sports developed different perceptual strategies using their domain-specific knowledge according to the speed and complexity of the game. Since this research was conducted, the expert's ability to recall and recognize structured information has since been demonstrated in American football (Garland & Barry 1990, 1991), field hockey (Starkes, 1987), and snooker (Abernethy, Neal, & Koning 1994).

Responding to Allard and Starkes' (1980) volleyball study, Borgeaud and Abernethy (1987) provided two possible explanations for the lack of anticipated differences between expert and novice volleyball players in both structured and unstructured patterns. The researchers first suggested that structure might not be a relevant cue in the game sequences presented. Second, they suggested that the loss of information in time, direction, and movement, due to the use of static representation of

game situations (i.e., slides), might have influenced the experts' performance. Therefore, Borgeaud and Abernethy conducted a volleyball study in which subjects viewed both structured and unstructured dynamic sequences of volleyball game situations presented on videotape, instead of static sequences presented in slides. The researchers found that players were more accurate than non-players for the structured situations, while this difference was not apparent for the unstructured situations. However, the researchers indicated that this difference was due to the novices' increased error from the structured to the unstructured situations rather than due to experts' reduction in error in recalling structured situations. They stressed the point that superior skill and sport-specific knowledge in cognitive performance was apparent in volleyball just as it was in other sports, for example, basketball (Borgeaud & Abernethy, 1987).

In soccer, another team sport, the recall paradigm was used to examine expert soccer defenders' perceptual and cognitive superiority over novices (Williams, Davids, Burwitz, & Williams, 1993). The recall errors were smaller for expert players than novices on the structured trials; while in unstructured conditions, no differences were observed between groups. Further, the recognition paradigm confirmed that expert soccer defenders were also faster and more accurate than novices in recognizing the sequence of viewed actions (Williams & Davids, 1998).

Williams, Hodges, North, and Barton (2006), also investigating the differences among soccer experts and non-experts, tested the relative importance of superficial display features (e.g., positions and/or movements of players) for recognizing sequences of play. They asked skilled and less skilled soccer players to complete a recognition test

where sequences of play were presented via film and point-light display. In the point-light condition, the positions and movements of players were highlighted as colored dots against a black background, with the field of play represented by white lines. Superficial features such as the color of players' uniforms, postural cues, or the condition of the playing surface and other environmental effects were removed. Findings showed that more expert players were less accurate in their responses to the point-light display but *not* less accurate than the nonexpert players. Skilled players were found to be able to recognize patterns of play based upon structural relations and the higher order predicates they convey (e.g., the tactical and strategic significance of these relations between players), while less skilled players depended almost exclusively on more superficial structural features (Williams et al., 2006).

In another type of sport, tennis, a comparison between skilled tennis players and novices in their use of visual information of an opponent's movement pattern to anticipate and respond revealed that skilled players were significantly more accurate than novices with live and video displays, but not with point-light displays. Additionally, expert performers were significantly faster when they returned balls hit by a live opponent than when they returned balls projected from a cloaked ball machine. The researchers concluded that expert tennis players were able to use movement-pattern information to determine shot selection and then use that information to significantly reduce their response delay times (Shim, Carlton, Chow, & Chae, 2005).

The previous studies that examined the recall and recognition of patterns suggest that these two perceptual abilities are important predictors of a variety of skills, including

the skills of anticipation, in both team and individual sports. Although less is known about using pattern recognition in handball, it appears that experts in every sport share similarities in better recognizing the pattern of the play than novices. Thus, expert handball field players or goalkeepers must rely on these perceptual skills when making decisions about future actions of their opponents, or even about their teammates. For example, an expert goalkeeper may accurately and quickly read the pattern of the play and pass the ball to one of his/her teammates to score a fast-break; or an expert goalkeeper may determine to which direction a thrower will throw the ball based on the pattern of the defensive line and based on the pattern of the thrower's movement.

Situational probabilities. Researchers have proposed that as a pattern of action unfolds, experts use knowledge stored in their long-term memory to establish accurate expectations of likely events and demonstrate an enhanced ability to extract contextual information from the action's display (Lavallee, Kremer, Moran, & Williams, 2004). Subsequently, in addition to their ability to extract meaningful contextual information from the pattern of actions provided in each particular domain, experts, compared with novices, have more accurate expectations of the events most likely to occur.

As cited in Lavallee et al. (2004), Alain and colleagues carried out the initial work in the area of situational probabilities. Alain and Sarrazin (1980) examined the extent to which players in various racket sports made use of situational probabilities to anticipate the shots available to their opponents. They filmed rallies of badminton, squash, and tennis players in match situations, replayed the films to the players, and then asked the players to assign subjective probabilities to the occurrence of the different serves

executed by their opponents. It appeared that players' initial anticipatory movements were guided by their expectations, with subsequent corrective or confirmatory movements made on the basis of current information

Expert baseball and soccer athletes also showed superiority in using previous expectation, or situational probabilities, to determine forthcoming actions of their opponents. In baseball batting, it has been reported that experts are superior to less skilled players in using information from scenarios of pitch counts to anticipate the next type of pitch when anticipation is measured from a video-simulation temporal occlusion of a pitcher's action (Paull & Glencross, 1997). In addition, elite and sub-elite soccer players (Ward & Williams, 2003) were asked to assign probability values to the best passing options available to a player in possession of the ball. The researchers asked the players to immediately highlight the likely passing recipients (where the player should pass) when film sequences were paused the moment the ball was being passed. Findings showed the elite players were better than the sub-elite players at identifying those who were in the best position to receive the ball. Elite players were also more accurate in assigning an appropriate probability to players in threatening and non-threatening positions, as determined by a panel of expert coaches (Ward & Williams, 2003). Elite players, in contrast to sub-elite players, appeared to be certainly putting their expectations to more effective use, and to be more effectively using their contextual information.

In handball, goalkeepers can build their decisions based on previous information (e.g., pre-match scouting). For instance, coaches often provide their athletes with statistics about the probabilities of their opponents' actions based on previous games.

They sometimes inform their goalkeepers that a player “A” throws to the right if he/she is coming from the left side, and vice versa. Thus, based on previous contextual information, handball goalkeepers can enhance their abilities to determine the probabilities of their opponents’ actions.

Advance visual cues utilization. Advance cue utilization is one of those perceptual-cognitive skills that differentiate experts from novices in sport. It refers to an athlete’s ability to make accurate predictions based on contextual information available early in an opponent’s action sequence (Abernethy, 19987; Williams & Ford, 2008). In handball, utilizing visual cues in advance enables a defender to predict an opponent’s next action, and enables a goalkeeper to predict a throw’s direction. The ability to make these kinds of predictions upon partial or advance sources of information is what is known as perceptual anticipation.

In fastball sports (e.g., tennis, team handball, basketball, and soccer), the ability to anticipate future events based on emergent postural information from an opponent’s kinematic action is essential. Jones and Miles (1978) had a head start in research on the ability to anticipate future events when they used the temporal occlusion technique in tennis to investigate future actions. Expert, intermediate, and novice tennis players were presented with filmed images of an opponent’s serve. They were then asked to anticipate where the ball would land within the service court area and to use a pen and paper to record their response. The researchers presented each serve under three different temporal occlusion periods: Condition A: 336 msec after the impact of the ball on the racket; Condition B: 126 msec after impact; and Condition C: 42 msec before contact. Results

indicated that experts were more accurate in their anticipation than intermediate and novice tennis players. Additionally, experts scored better than chance level even at the earliest occlusion condition (i.e., Condition C: 42 msec before contact).

Anticipation of future actions was also examined even earlier. Salmela and Fiorito (1979) asked ice hockey goaltenders to observe filmed sequences of a hockey player executing a series of ice hockey shots. The film clips included the ice hockey player's approach to the puck and his preparatory actions up to the point of occlusion. Prior to the puck being struck by an attacker, there were three temporal occlusion periods (i.e., 500 msec, 333 msec, and 166 msec). While goaltenders viewed the film clips, they were required to verbalize into which of the four corners of the goal the puck would be directed. Immediately after making their judgments, goaltenders indicated their degree of response confidence on a 5-point Likert scale. The findings demonstrated that the ice hockey goaltenders were able to make effective use of available visual information prior to the puck being struck. In addition, findings, as measured by the Likert scale, supported the fact that experts are very confident in their ability to make accurate decisions in sport situations.

The previous findings, that expert tennis players and expert goaltenders were able to accurately anticipate future action earlier than novices, have led the researchers to further determine the different characteristics between experts and novices. Some researchers (e.g., Williams & Burwitz, 1993) argue that detecting and using advance sources of visual information may not necessarily be the primary reason for expert-novice differences; rather, the experts are more confident than novices in making decisions

based on less or partial visual information. That is to say, in contrast to novices, expert performers pick up the most action-related visual cues, and therefore, their responses seem to be faster and more accurate. For example, expert and novice soccer goalkeepers observed filmed sequences of five different field players as they took penalty kicks (Williams & Burwitz, 1993). The goalkeepers viewed the kickers' preparatory postures, via the kickers' running and kicking actions, up to a point of occlusion. The researchers then asked the goalkeepers to indicate to which corner of the goal the ball would be directed. The periods of occlusion were 120 and 40 msec before the field player kicked the ball, exactly at ball contact, and 40 msec after ball contact. The findings of the study showed that expert goalkeepers performed better than novices under both pre-impact viewing conditions (i.e., 120 and 40 msec occlusions). These results offered further support for the argument that experts are able to utilize visual cues faster, more accurately and with more confidence than novices.

The ability of highly skilled and low skilled cricket batsmen to utilize visual information prior to and during sections of ball flight before striking balls delivered by fast bowlers has also been examined (Müller et al., 2009). The researchers asked study participants (i.e., experts and novices) to first wear vision occlusion spectacles, and to then strike delivered balls while their vision of the bowler's delivery action and ball flight was selectively occluded. Findings showed that highly skilled batsmen were superior in utilizing information to judge short ball length before the ball was released. In addition, expert batsmen were better able to utilize ball flight information prior to and post-bounce to attain a superior number of bat-ball contacts (Müller et al., 2009).

Advance cue utilization was also examined in hockey goaltending, which is very similar to handball goalkeeping. Once a hockey puck reaches a velocity upwards of 160 km/h (Panchuk & Vickers, 2006), the functional capacity of the goaltender's visual system is exceeded and the goaltender can no longer accurately track the puck to contact using pursuit eye movements. Surprisingly, however, regardless of the limitations in pursuit tracking abilities, goaltenders in ice hockey stop an average of 90% of all shots they face (Panchuk & Vickers, 2006). Consequently, hockey goaltenders utilize some visual cues prior to, or simultaneously with, a shooter's action. Thus, goaltenders use some visual information to anticipate the direction of the puck instead of to track its flight. When temporal-occlusion was used to examine the gaze behavior of goaltenders in hockey, researchers found that goaltenders used early visual information to anticipate the direction of the shots (Panchuk & Vickers, 2006).

Similar to goaltending in hockey, to stop a handball 7-m throw (i.e., a penalty shot) that flies with a velocity of $26.2 \text{ m}\cdot\text{s}^{-1}$ (Fradet et al., 2004) or $26.27 \text{ m}\cdot\text{s}^{-1}$ (Bayios et al., 1998), a goalkeeper must exhibit a high level of motor-perceptual expertise developed through years of sport- and task-specific training. When a handball reaches this velocity, which exceeds the goalkeeper's capability of simply tracking the trajectory of the flying ball, the goalkeeper must anticipate the direction of the throw based on advance cue utilization (more information about handball will be provided in the team handball section)

Visual search behavior. Visual search behavior offers another significant approach to determining the characteristics between experts and novices and has been

used extensively to determine the information used to guide the action of experts in sports. This approach involves measuring visual search strategies through the use of eye movement registration systems (e.g., spatial occlusion via slides or video clips, crystal goggles, a head mounted eye-tracking system, or vision in-action system [VIA]). These systems record experts' and novices' eye movements while they observe specific tasks. Then, the duration of each fixation and gaze behavior are used to differentiate experts from novices. The registration of visual search behaviors, via eye-tracking system for instance, provides additional means for gaining evidence on the key visual cues from opponent's bodies that expert performers can use to anticipate event outcomes (Abernethy, Farrow, Gorman, & Mann, 2012). Research interested in expert's visual search behavior suggests that expert performers spend more time than novices fixating upon events and segments that occur earlier in the kinematic chain.

In contrast to the preceding articles, which all support the supposition that anticipatory information contained in dynamic patterns of movement is distributed across the body of an opponent (e.g., Diaz, Fajen & Phillips, 2012; Huys et al., 2009; Huys, Smeeton, Hodges, Beek, & Williams, 2008; Smeeton & Huys, 2011), Abernethy & Russell (1987) provided more direct support for the fundamental differences in the perceptual strategies (i.e., visual strategies) of expert and novice players, in the sense that in their study expert racquet players were able to extract information from a special, and not general, cue (e.g., the arm holding the racquet in badminton).

In a situation relevant to handball goalkeeping, experts' and novices' visual search strategies were investigated in soccer (Savelsbergh et al., 2002). Goalkeepers wore

an eye-head integration system (i.e., a masking technique) to find or to compute the visual point of gaze. Findings showed that as the penalty kick evolved, novice goalkeepers spent a longer time fixating on the trunk, arm, and hip regions, whereas the expert goalkeepers preferred to fixate their gaze on the kicking leg, non-kicking leg, and ball areas. Experts fixated their gaze toward the most relevant areas in the opponent's body that might contribute to the ball directions. Fixating their gaze to more than one specific body segment related to the final outcome of the action was proved later to be an important factor for protecting experts in competitive sports from being deceived by their counterparts (Jackson et al., 2006). Savelsbergh et al. (2005) later examined whether there were differences in visual search behavior within a group of expert-level goalkeepers. Goalkeepers were classified as successful or unsuccessful based on their performance on a film-based test of anticipation skill involving the soccer penalty kick. Results showed that the successful expert goalkeepers were more accurate in anticipating the height and direction of the penalty kick, waited longer before initiating response, and appeared to spend longer periods of time fixating on the non-kicking leg compared with the non-successful experts (Savelsbergh et al., 2005). Likewise, in studies from non-sport domains (e.g., Waters & Underwood, 1998; Inglis & Alcock, 2012), findings have shown that expert goalkeepers use more selective search patterns in which they look longer at fewer and more connected areas. The experts also fixate their gazes on significantly fewer areas per trial than novices.

Similarly, researchers investigated expert-novice differences in situations where participants were presented with whole soccer field situations (i.e., 11 vs. 11 situations),

micro-soccer situations (e.g., 3 vs. 3 situations), or situations such as offensive compared to defensive simulations (Vaeyens, Lenoir, Williams, Mazyn, & Philippaert, 2007; Williams & Davids, 1998). It was shown that the skill level and task-specific expertise (playing experience) were strong indicators for efficient visual search behavior employed during decision-making. While some differences have been reported in the eye movements or gaze behavior of experts and non-experts as they view images of an opposing player's movements, such differences do not appear systematically and need not necessarily accompany differences in anticipatory performance. The factor that limits expert anticipation appears to be the ability to interpret available information rather than the execution of ocular fixations on particular cues (Müller & Abernethy, 2012).

In sum, the research suggests that skilled performers, in many sport situations, demonstrate a superior ability to efficiently use and pick up advance visual information from an opponent's postural orientation prior to key events. Those perceptual abilities have been suggested to be partly due to skilled performers' greater attunement to kinematical information. In addition, the sensitivity to the kinematical information has been suggested to enable expert performers to be less susceptible to deception compared to their less skilled counterparts (note: further discussion will be provided in the deception section). The previous attributes of expertise and expert performance, especially advance cue utilization and visual search behavior, are important attributes for handball goalkeepers. Without improving those perceptual-cognitive skills, a handball goalkeeper would not be able to track a flying ball that exceeds his/her reaction ability.

Thus, the current study aimed to determine the anticipatory performance of handball goalkeepers when such perceptual-cognitive skills are improved.

Local vs. Global Information Extraction Approach. The previous section highlighted the importance of the ability to extract information arising from advance postural cues of an opponent when trying to anticipate their forthcoming actions. For instance, the previous research showed that when compared with novices, expert performers demonstrate a superior ability to pick up advance information from opponent's postural orientation prior to key event such as ball-leg contact and ball-racket contact (e.g., Abernethy & Russell, 1987; Savelsbergh et al., 2002; Williams et al., 2002). In recent years, following the pioneering work of Johansson (1973) that assumed that kinematic cues convey the information underlying biological motion perception, researchers in the field of sport science have shown that athletes can successfully anticipate when actions are presented as point-light display (see Abernethy, Gill, Parks, & Packer, 2001; Diaz et al., 2012; Shim et al., 2005; Ward, Williams, & Bennett, 2002) stick-figures (see Bourne, Bennett, Hayes, Smeeton, & Williams, 2013; Huys et al., 2008; Smeeton & Huys, 2011; Williams, Huys, Cañal-Bruland, & Hagemann, 2009). Instead of using a film-based occlusion approach (see Abernethy & Russell, 1987; Abernethy & Zawi, 2007; Farrow et al., 2005; Müller, Abernethy, & Farrow., 2006) to identify the critical cues underpinning anticipation in sport, a new approach, the principle component analysis (PCA), has recently emerged as a technique for identifying the dynamical information underpinning anticipation in sport. Huys et al. (2008), and Huys et al. (2009) were the first to apply PCA to explore the dynamical information underpinning

anticipation of tennis forehand shot directions. The findings from both studies suggest that information underpinning successful anticipation is not picked up locally (Abernethy, 1990; Abernethy & Russell, 1987; Williams et al., 2002), but rather distributed over a large part of the system that executes the action.

Accordingly, the researchers found that skilled tennis players utilize a more global or holistic approach when attempting to anticipate an opponent's intentions, whereas less skilled players rely mainly on extracting information localized around the arm-racket (Williams et al., 2009). Supporting this argument, Diaz et al. (2012) found that when anticipating the outcome of another person's soccer kick, participants (observers) were sensitive to sources of information distributed across the body of the actor. In agreement with this type of racket sports and soccer research, handball research suggests that skilled and less skilled participants employ different information extraction strategies, although information from the opponent's throwing arm is critical to anticipation for both groups (Bourne et al. 2013). Skilled handball participants were able to extract useful information from areas on display (i.e., throwing-arm, shoulder, and hip) by the penalty throwers, whereas less skilled participants are sensitive to a specific area. Confirming this argument, Wagner, Buchecker, Duvillard, and Müller (2010) indicated that the trunk flexion of the handball thrower in the initial phase of a throw is a good indicator for throw velocity.

The preceding findings may help to explain why less skilled performers are more prone to fall for the deceptive action of their opponents (see Cañal-Bruland & Schmidt, 2009; Jackson et al., 2006; Sebanz & Shiffrar, 2009). For instance, when an athlete (e.g.,

a goalkeeper) relies on a more local information extraction strategy it is likely that the opponent (e.g., a thrower) may employ some deceptive actions that minimize the athlete's (perceiver) ability to detect deception and anticipate the next action.

In sum, the preceding studies suggest that the more an athlete picks up global information from his/her opponent's body parts the more he/she is protected from being deceived, and vice versa. The notion of local vs. global information extraction strategies is in agreement with the earlier findings of the research that investigated visual search behavior in sport which suggest that expert performers use more fixations with less duration on different connected areas in opponent's body. These findings supported the methodological design of the current study in which the video-based perceptual training was aimed to enhance the handball goalkeepers' ability to globally extract important information from the thrower's body segments.

Transferring expertise across sports. In the realm of sport expertise, there is a sufficient amount of empirical research confirming the perceptual differences between expert and novices, or between highly skilled and less skilled athletes. The most pressing question, particularly for the present study, is whether these perceptual abilities are transferable or generalized across sports. Most of the primary literature agrees that talented individuals from one sport have some common skills that transfer across sports or even to other domains, even though the evidence supporting this transfer assumption is not strong (Williams & Ford, 2008).

Athletes' perceptual sensitivity may indicate perceptual learning by attunement to the appropriate informational variables available as a result of visual-motor experience in

their specific sport. For example, expert basketball, volleyball, and water polo players were found to have different perceptual skills (Kioumourtzoglou et al., 1998). There is recent evidence to suggest that perceptual skill is not only specific to the sport, but also to an athlete's position within that sport. Williams, Ward, Ward, and Smeeton (2008) showed that skilled and experienced soccer defenders demonstrated superior anticipation skill when compared to equally skilled and experienced soccer offensive players. These results suggest that the nature of each sport strongly influences the way in which athletes capture the kinematic information that is related to opponents' actions in each sport, and each position within each sport requires a particular type of perceptual abilities. There is an exceptional positive transfer between sports that have similar structures (e.g., hockey, basketball, soccer). However, the perceptual skill positively transferred across these sports was found to be pattern perception skill (Abernethy, Baker, & Côté, 2005; Smeeton, Ward, & Williams, 2004). Thus, the research on expertise indicates that each sport, and each position within each sport, requires particular kinds of perceptual abilities that do not transfer across sports.

In conclusion, the preceding review of the literature about the nature and the attributes of expertise indicate that some exceptional people are superior in performing many tasks and activities related to their fields. The nature of expertise in many domains such as sport, music, transportation, and education has much in common, and especially in the area of perceptual and cognitive abilities. In particular, expert sport performers possess an elaborate sport-specific cognitive knowledge base (e.g., situational probabilities and pattern recognition) and perceptual skills (advance cue utilization and

effective visual search behavior) that enables them to interpret events similar to those previously experienced. When compared with their more novice counterparts, experts are faster and more accurate in recognizing and recalling patterns of play from within their domain of expertise, are better at anticipating their opponents' actions based on advance visual cues, employ more effective and appropriate visual search behaviors, and are more accurate in their expectation of what is likely to happen given a particular set of circumstances (i.e., anticipation). In addition, the development of research in the area of expertise and expert performance indicates that each sport, and each position within each sport, and perhaps even each task in each position, requires specific perceptual-cognitive skills that do not transfer across sports.

Team Handball

Team handball is a complex, fast-based, Olympic contact sport that is played professionally in Europe, and at an amateur level in other countries around the world. It consists of intense, intermittent activities such as running, sprinting, and jumping, throwing, hitting, blocking, deceiving, and pushing, as well as fast and precise individual and team defending and attacking. Due to core changes in the rules of the game, modern handball over the last few decades has become a much tougher, faster, and more complex and powerful game. Thus, to succeed in the game, handball field players and goalkeepers are required to achieve an appropriate level of physiological, psychological, and perceptual ability that is determined by their playing positions (e.g., wing, back, playmaker, or goalkeeper).

As indicated in the Introduction, the role of the handball goalkeeper is a vital one. A brief investigation of the World or European Championships indicates that the top ranking teams have the best goalkeepers. Despite the classical team handball defense system (6:0) that is the core of the German and Scandinavian teams, the modern styles of defense, such as 5:1, 3:2:1, 3:3, and the creative fast styles of offense increase the possibility of direct player-goalskeeper contact and increase the chance for more 7-m throws (penalty throws). Recently, researchers calculated that in each handball game there is an average of 3.68 penalty throws (Foretić et al., 2010). The relatively short distance (4-7 m) between a goalskeeper and thrower, the great velocity, reaching $26.2\text{m}\cdot\text{s}^{-1}$ (Fradet et al., 2004) or $26.27\text{ m}\cdot\text{s}^{-1}$ (Bayios et al., 1998), of the throws, and the psycho-physiological stress on the goalskeeper saving a 7-m throw influences the course of the scores and the motivational climate of the team. Due to the game's difficulty, the best goalkeepers can only hope to save about 50 % of the penalties thrown toward the goal.

Goalskeeper characteristics. Based on the literature regarding expert performance, sport expertise is not only sport-specific but also position-specific within each sport (Williams et al., 2008). Thus, handball goalkeepers must hold specific characteristics that differentiate them from other players. Unfortunately, there is a lack of literature analyzing the qualities (physical/motor, psychological, and perceptual qualities) of team handball goalkeepers in relation to competitive proficiency. In other words, there is a lack of literature analyzing what differentiates skilled from non-skilled handball goalkeepers. Most studies only concentrate on the differences between handball players in different playing positions (Pori, Šibila, Justin, Kajtna, & Pori, 2012). As regards their

motor/physical characteristics, handball goalkeepers have been found to be slower runners compared to field players (Sporiš, Vuleta, Vuleta Jr, & Milanović, 2010), although another study found no difference between goalkeepers and others of the same character (Chaouachi et al., 2009). Some studies suggest that goalkeepers have a highly developed level of pelvis flexibility and a well-developed level of explosive strength compared to field players (as cited in Pori et al., 2012); other studies have focused on morphological traits and found goalkeepers to be taller, heavier, with longer limbs, and with a higher percentage of body fat (Hasan, Rahaman, Cable, and Reilly, 2007; Šibila & Pori, 2009). Recently, Pori et al., (2012) attempted to find if motor abilities could determine a good handball goalkeeper. Motor abilities were measured with seven motor tests, assessing the level of strength, coordination (agility), and flexibility. The authors of the study were unable to conclude that these motor abilities are correlated to the differences between skilled and less skilled handball goalkeepers. Psychological characteristics, such as aggression, anxiety, fluid intelligence, and concentration, have also been compared between skilled and less skilled handball goalkeepers (Kajtna, Vuleta, Pori, Justin, & Pori, 2012). The findings of this study suggest that skilled goalkeepers are not better than less skilled in any of the tested psychological traits.

The core findings of the literature on expertise (e.g., Abernethy & Russell, 1987; Abernethy & Zawit, 2007; Williams et al., 1999) that perceptual-cognitive attributes are the hallmarks of expertise in sport confirm the preceding handball-specific findings that physical, motor, and psychological attributes are not keys to superiority in handball goalkeeping performance. After approximately 20 years of studying expertise in sport

domains, it has been concluded that visual-cognitive strategies are a vital variable for sport performance, as they greatly influence anticipation, which is considered to be a fundamental quality in many sport domains. In line with the discussion above about the complexity and the velocity of the handball throw and the attributes of expert performance, skilled handball goalkeepers, compared with less skilled or novices, have been found to rely on advanced visual information provided by their opponent (Schorer, 2005; Schorer & Baker, 2009), to be able to identify the advance cues that indicate the side of the throw (Gutierrez-Davila, Rojas, Ortega, Campos, & Parraga, 2011), to use more efficient visual search behavior (Rivilla-García, Muñoz, Rodríguez, Almenara, & Molinuevo, 2013). In addition, studies have also found that the perceptual skills of handball goalkeepers are resistant to normal age-related declines over time (Schorer & Baker, 2009). Although there are few handball studies on this topic, the differences in perceptual-cognitive abilities found in previous handball studies coincide with the results obtained in soccer, tennis, hockey, and volleyball (see expertise in sport domains).

Based on the scientific findings related to the perceptual-cognitive skills of expert performers, practitioners in the field of handball should pay more attention to those skills in order to improve the performance of goalkeepers, and in order to select the right athletes for the goalkeeping positions. That does not mean that other attributes such as psychological and physical are not important, however, as the literature shows that perceptual-cognitive attributes explain the superior performance for expert athletes in sport.

Rules of the game: goalkeeper & 7-meter throw. In the execution of a 7-m throw in handball, there are unique rules that govern the action of the goalkeeper and the thrower. According to the recent IHF rules of the game (2010), when a 7-m throw is executed, the thrower should throw the ball within 3 s after the referee's whistle signal; within those 3 s the thrower is allowed to initiate any type of deceptive hand movements. The thrower also must take up a position behind the 7-m line, not further away than 1 m behind the line, and the goalkeeper must not cross the restraining line (the 4-m line) before the ball leaves the thrower's hand.

Mechanics of the handball throw. Throwing on a goal is the most important aspect of the handball game. Handball's 7-m throw is a complex skill involving a coordinated pattern of movements that span the entire upper body, reflecting the formation of motor synergies involving multiple upper body segments. For example, to generate a powerful 7-m throw while maintaining stability and executing deceptive actions, a thrower is required to use hips, trunk, shoulders, arms, and to some extent, wrist and fingers. For a throw (e.g., a 7-m throw) to be successful, maximum ball velocity and accuracy is required as well as the integration of an element of surprise for the defensive players and goalkeeper. Three factors have been suggested as essential factors for efficient throwing: mechanics, coordination of consecutive actions of body segments, and upper and lower extremity muscle strength and power (Marques et al., 2007). In team handball competition, 6-9% of all throws during the game are 7-m throws (Wagner et al., 2011). From a biomechanical point of view, and as in all activities that involve overarm throwing (such as baseball pitching and javelin throwing), the motions of the arm in

segments follow a specific pattern. The fastest throwing action is accomplished with a proximal-to-distal progression of the segments. In team handball throwing, the proximal-to-distal sequence has been found to be important for maximizing ball velocity and has been defined by calculating the timing of occurrence of the maximal linear velocities of the segments (Wagner, Pfusterschmied, von Duvillard, & Müller, 2012). The joint movements in a standing throw (e.g., a 7-m throw), or in a standing throw with a run-up (Wagner et al., 2012), occur in a proximal-to-distal sequence, beginning with the proximal joint movement of the pelvic rotation, trunk rotation, and trunk flexion, followed by shoulder internal rotation, elbow flexion, and wrist and finger flexion (Van der Tillar & Ettema, 2009). It has been shown that a standing throw in handball involves the internal shoulder rotation angular at ball release, and that maximal elbow extension and the timing of maximal pelvic angle are important contributors to ball velocity (Van der Tillar & Ettema, 2004/2007; Wagner & Müller, 2008).

Combining the previous studies with the studies that investigated the dynamical structure of information underpinning anticipation in sport (e.g., Bourne et al. 2013) reveals that the handball throw is a complex movement that depends on a coordination of many body segments. Therefore, and as referenced earlier, it is necessary to rely on a more global information pick up strategy, especially when anticipating an action, such as the handball throw, which is associated with deception.

Deception & Detection of Deception

Although most research addressing anticipation in sport has focused on how skilled participants use advance cues to anticipate their opponents' actions (Mann,

Williams, Ward, & Janelle, 2007), a neglected topic has been the effectiveness of the deceptive actions performed to minimize anticipatory cues from being detected by observers (Jackson et al., 2006). In competitive sports, to have an advantage over opponents, players such as a striker in soccer, a pitcher in baseball, and a 7-m thrower in team handball might try to minimize potential dynamical information used by perceivers (soccer and team handball goalkeepers, or a baseball batter) to anticipate their upcoming actions. To minimize such important visual information the actors execute some deceptive skills through which they can inhibit their real actions' intention from being realized. For example, handball players who execute 7-m throws are allowed, by rule of the game, to initiate a deceptive throw by moving the arm forward, stopping the forward movement to move the ball backwards, and then initiating the real shot within a time frame of 3 s. This is not the only type of deception used in handball, but it is the most popular. Deception in handball can also be more complex when these preparatory deceptive hand movements are combined with the deceptive finishing of the throw, as when a thrower uses the wrist at the moment of ball release to deceive the goalkeeper about the throw direction. Taking into account the previous research regarding anticipation, deceptive action may disturb the visual search behavior of athletes and may disrupt the extraction of advance visual cues that perceivers (i.e., goalkeepers) rely on to anticipate the action of a shooter. Hence, it is worthwhile to investigate the expert anticipatory performance in a unique way (by investigating the anticipation of actions in deceptive situations) that may further support the research indicating the superiority of expert performers in sports. In the following section, an extensive review of the effect of

deception in sport is provided, as well as the possible strategies that can minimize the effect of deception on accurate anticipation of opponents' actions.

Theoretical background. James Gibson (1979, 1986) proposed that the visual properties of the environment afford rich and elaborate information that specifies, guides, and controls visual motor activity. This information is specified as kinematic, geometric, and temporal properties and is perceived directly by animals from their environmental optic flow. Such information is not perceived as impoverished visual stimuli requiring cognitive decoration (i.e., information-processing) in order to provide meaning to animals. While this sort of environmental information is public, and naturally everyone can perceive it (Gibson, 1986), it appears that experts or skilled athletes in various sports are more attuned to this kinematic information when it determines the intention of an opponent's action (Abernethy & Russell, 1987, Abernethy & Zawi, 2007; Ward et al., 2002). Such ability ensures that expert athletes are less susceptible to deception compared to their less skilled counterparts, or to novices (Jackson et al., 2006).

Based upon the assumption that information is public and perceivable by everyone (Gibson, 1986) research has confirmed that people can perceive affordances (possibilities of actions) for themselves (e.g., climb-ability: Warren, 1984; Sit-ability: Mark, 1987; reach-ability: Carello, Groszofsky, Reichel, Solomon, & Turvey, 1989; and pass-ability: Warren & Whang, 1987), as well as for others (e.g., reach-ability: Ramenzoni, Riley, Shockley, & Davis, 2008, sit-ability: Stoffregen, Gorday, Sheng, & Flynn, 1999) with remarkable accuracy. The first set of studies, which investigated self-affordances, demonstrated that individuals are quite good at perceiving affordances for

themselves before actually initiating actions. The second set of studies, which investigated others-affordances, indicated that people are able to perceive affordances for other individuals right before their actions are initiated. The preceding studies demonstrated how individuals could perceive affordances for self and for others based on their own body dimensions and the body dimensions of others (e.g., Stoffregen et al., 1999), or based on their action capabilities or on the action capabilities of others (e.g., Ramenzoni, Riley, Davis, Shockley, & Armstrong, 2008).

Whereas body-scaled affordance relies on geometric factors (body dimensions), kinematic movement (Runeson & Frykholm, 1983) appears to play an important role in the perception of affordances for others' actions. Thus, in skill-based activities such as sports, the distinction between body-scaled and action-scaled affordances is critical because efficiently perceiving the kinematic information that precedes others' actions requires an optimal level of perceptual sensitivity that provides advantages for the perceiver over opponents.

For instance, kinematic information was sufficient to support the perception of affordances for maximum sitting height for actors (Stoffregen et al., 1999). In addition, observers' ability to perceive a person's reach-with-jump-ability was improved when the walking pattern for that person was first observed (Ramenzoni et al., 2008). Kinematic information has also been used to study determinants of an actor's identity (Loula, Parasad, Harber, & Shiffrar, 2005), of gender (Brooks et al. 2008), of age (Montepare & Zebrowitz-McArthur, 1988), and of personality traits and emotion (Atkinson, Dittrich, Gemmell, & Young, 2004; Heberlein, Adolphs, Tranel, & Damasio, 2004).

As mentioned above, perceiving such kinematic information that identifies affordances for another person has significance for sport performance (Fajen, Riley, & Turvey, 2008). Athletes who are attuned to the advanced visual kinematic information from different visual cues in their opponents' body parts and who can efficiently use such information to anticipate the future course of an action are those who hold an extensive amount of perceptual and motor experiences. In addition, perceiving such information does not only enhance an athletes' ability to anticipate with a higher level of accuracy but also improves an athletes' ability to detect an opponents' intention to deceive (Jackson et al., 2006).

While in daily life, activities such as stair climbing, chair sitting, street crossing, and reaching information are public and naturally perceivable (Gibson, 1986), in skilled activities such as in sport, medicine, nursing, and music domains (Ericsson et al., 2006) detecting such information requires a particular level of expertise. For example, when compared with non-hockey players, hockey players were able to perceive which hockey sticks were better for power and which were better for precision shots (Hove, Riley, & Shockley, 2006). This suggests that because of their extensive sport experience, athletes, when compared to non-athletes, may be differentially attuned to information that specifies sports-relevant affordances. Thus, as suggested by Abernethy et al. (2001), sport-specific domain athletes appear to acquire perceptual sensitivity that aids the perception of affordances which give them superiority over less skilled athletes or novices.

Given the evidence that individuals can perceive affordances for themselves and for others, and the evidence that athletes may be differentially and perceptually sensitive to the kinematic information about affordances related to their domain of sports, Weast, Shockley, and Riley (2011) examined whether basketball players were more accurate than non-basketball players in perceiving affordances for activity that, on one hand, could be sport-relevant and daily life-relevant, such as reaching while standing and reaching while jumping (Ramenzoni et al., 2008a, 2008b), and that, on the other hand, could be non-sport relevant, such as sitting height (Mark, 1987). Findings revealed that basketball players were more accurate at perceiving the experience-relevant affordance (i.e., maximum reach-with-jump height) for others than were non-basketball players. However, no difference was found in accuracy between basketball players and non-basketball players for perceiving affordances for others in maximum reach-with-stand-height task. Likewise, there was no significant difference between basketball players and non-players in accuracy for perceiving the affordance of maximum sitting height, which is non-experience-relevant (Weast et al., 2011).

The interpretation of the results revealed that differences between basketball players and non-basketball players in the reach-with-jump task were likely due to the exposure to more opportunities to perform and to observe others performing basketball-relevant actions such as jumping to shoot, rebound, and block a shot. Alternatively, the lack of differences between basketball and non-basketball players in the standing-reach height task could simply mean that the perception of standing-reach height is, although relevant to basketball, not specific to basketball. Perceiving standing-reach height might

also be relevant to other aspects of daily life, such as when a caregiver must determine whether a dangerous object could be within a child's reach (Weast et al., 2011)

While the research results are somewhat mixed, sport-specific expertise (Ericsson et al., 2006) or athletic experience appears to be a crucial factor for enhancing the sensitivity of athletes to certain types of perceptual information, in particular to the kinematic information available in others' movement patterns. Moreover, expert or skilled athletes may then have highly developed capacities for perception of affordances related to their sport compared with novices or less skilled athletes (Fajen et al., 2008).

Although distinguishing between visual and motor expertise is difficult, research has attempted to find whether visual or motor expertise is the most influential factor for perceiving others' action possibilities (Aglioti, Cesari, Romani, & Urgesi, 2008; Cañal-Bruland, Mooren, & Savelsbergh, 2011; Loula et al., 2005; Pizzera & Raab, 2012). For example, in an attempt to examine the role of visual and motor expertise in perceiving affordances for other's actions, Aglioti et al. (2008) compared differences between professional basketball players who had an extensive amount of visual and motor expertise with coaches and sports journalists (i.e., expert observers), possessed of extensive visual expertise, and novices. The task was to judge the fate or the intention of free throws.

The findings showed that elite basketball players were faster and more accurate than expert observers and novices at predicting whether a shot would be successful. This indicates that expert athletes can perceive the kinematics of the observed action specifying the outcome of the free throw. Although the non-expert players were visual

experts (coaches and journalists), they were not able to rely on their own movement repertoire for their predictions. The expert basketball players were able to use their own motor repertoire to judge the effects of the movement kinematics in the videos (Aglioti et al., 2008). Thus, the researchers concluded that motor expertise, exclusively, was the crucial factor for perception of kinematic information.

To overcome this limitation, Cañal-Bruland et al. (2011) investigated the effect of perceptual-motor expertise, using expert beach-volleyball players and coaches, and visual expertise, using expert beach-volleyball referees, on judgments of attack outcomes. Results revealed that expert players and coaches (perceptual-motor experts) outperformed referees and novices. There was no difference between players and coaches, suggesting that coaches as well as players have perceptual-motor expertise. In sum, this study supports the idea that visual and motor together enhance an athlete's ability to perceive affordances for others' actions and thus enables athletes to have faster and more accurate anticipation and decisions.

In addition to the preceding research that confirms the effect of both perceptual and motor expertise on anticipatory performance for volleyball athletes and coaches, sports officials from various team sports (soccer, handball, and ice hockey) and one technical sport (trampoline) were examined by relating their performance as officials to their practical experiences as judges or referees to their motor experiences as previous athletes to their visual experiences as spectators. The findings indicate that depending on the sport, officiating, motor, and visual experiences were important factors relating to the performance of sports officials (Pizzera & Raab, 2012). Loula et al. (2005) also asked

participants to identify and to discriminate point-light representations of themselves, friends, or strangers while performing various actions. Performance was best for trials of oneself and friends and worst for trials of strangers. The good performance in judging oneself and friends indicates that participants had previous visual and motor experience that influenced their perception of these actions.

Previous research indicates that perceiving biological motion, or kinematic information, is something people do quite naturally in everyday activities but something that superior athletes do purposely to obtain advantages over their opponents.

Detecting deception in non-sport domains. As previously mentioned, research suggests that visual analysis of bodily movement is sufficient to determine other people's identities, personality traits, gender, age, emotions, and possibilities of actions. Research has examined the role of perceiving such information to not only detect others' actions, but also to detect others' intention to engage in deceptive actions (Grezes, Frith, & Passingham, 2004; Runeson & Frykholm, 1983).

In everyday life, or in sport, situations, deceptive or fake movements are intentional motor actions generated by an actor (e.g., striker in soccer) to misinform a perceiver (e.g., defender in soccer) about his or her real intentions. Whether it is a cheetah chasing a gazelle, or a handball defender trying to stop a skilled playmaker, deceptive movement is used to gain a competitive advantage and beat an opponent. Deceptive actions are used in a variety of sports (e.g., handball, basketball, rugby, football, volleyball, boxing, and fencing) and play a crucial role in high-level competition. Misleading an opponent provides an athlete advantages over opponents.

Such advantages may be very short in time or in distance; however, they may also permit an expert player to hit, shoot, pass, or escape.

Obviously, during competitive situations an actor (e.g., a thrower) attempts to conceal the kinematic information that demonstrates real intention (e.g., pass or throw); however, the perceiver always attempts to detect the actor's kinematic information in advance (to pick up on the advance visual cues) and realize the opponent's action possibilities (i.e., affordances) in order to take an advantage over the opponent (Brault, Bideau, Kulpa, & Craig, 2009; Cañal-Bruland, van der Kamp, & van Kesteren, 2010; Kunde, Skirde, & Weighlt, 2011).

In a classic study, Runeson and Frykholm (1983) were the first to demonstrate that observers are able to distinguish between deceptive and direct intentions from another person's movement (movement kinematics). In Experiment III, they presented participants with videotapes of three college non-expert actors lifting boxes, carrying them to a table, setting them down, and then returning them back to their original positions. In the first part of the experiment, the actors lifted three different boxes weighing 6.5, 11.5, and 19 kg. In the second part, the actors lifted empty boxes but gave viewers the impression that the boxes weighed 6.5, 11.5, or 19 kg. Runeson and Frykholm (1983) found that the kinematic information was not only sufficient for observers to accurately perceive the relative weight of the box, but also to detect the actor's real intention about the real weight of boxes. In other words, observers were able to detect deception using the available kinematic information. The actors in this study

were not expert enough to successfully deceive the participants (observers) about the weight of the boxes.

This study was then replicated (Mark, 2007) with specific modifications including a use of four actors with different skill levels (a trained female mime, a skilled male actor, and two, male and female, novice actors). The researchers assumed that using trained actors or mimes might be more successful in deceiving observers. Parallel to the original study (Runeson & Frykholm, 1983), however, the four actors failed to deceive the observers. The observers indicated awareness of the difference between the weighted and unweighted boxes. The replicated study (Mark, 2007) thus supported the argument that kinematic movement is sufficient for detecting someone's intention to engage in either deceptive or direct actions.

From a neurophysiological point of view, researchers have also employed magnetic resonance imaging (MRI) to record the brain's activity while participants watched an actor lifting a box after being asked to judge whether or not the actor was trying to deceive the participants about the real weight of the box being lifted (Grezes et al., 2004). When subjects judged the actions as reflecting deceptive intention, there was activation of the amygdala and rostral anterior cingulate cortex. According to the researchers, these activations may reflect both the observers' judgments of social intentions toward themselves and an emotional response to being deceived.

Similar to the studies that examined direct actions, findings from deception studies have confirmed that individuals are naturally able to detect deceptive intentions from the actions of others in various daily situations (non-skilled activities). However, in

skilled-based activities such as sports, research has shown that the ability to perceive deceptive actions by others is highly related to the level of perceptual-cognitive expertise in a particular sport domain. In fact, this seems very logical, taking into consideration the amount of research that distinguishes expert from novices, especially in perceptual and cognitive skills (Abernethy et al., 2001).

When it comes to sport-specific situations, it is not sufficient to refer to the work of Runeson and Frykholm (1983) and the work of Mark (2007). The skill base for the sport context and its specific expertise must be taken into consideration. Considering the deception-specific literature provides a more reliable means for considering the possibility and the mechanism of deception detection in skill-based activities.

Detecting deception in sport domains. Research conducted by Jackson et al. (2006) was the first to examine skill-level differences in observers' ability to make judgments when an actor attempts to deceive them. Expert rugby players (those who had played rugby for a mean of 14.5 years and who were at the time of the study competing in a regional league, at the national level, or at the international level) and novice rugby players (those with no prior rugby-playing experience) were presented with video clips showing one-on-one tackle situations where the attacking player runs towards the defending player (the camera, in the study) and changes direction to run past the defending player's left or right. Videos showed either deceptive or normal trials, and were temporarily occluded. In deceptive trials, the attacking player made a misleading side step in which he first pretended to run past the defender on the left side, but ultimately chose the right side, or vice versa.

Results revealed that novices were susceptible to deceptive movements, that is, they predicted the side to which the attacking player intended to go in the direct trials more accurately than in deceptive trials. Expert rugby players, however, were not susceptible to deceptive movement, that is, they accurately predicted the running directions for both deceptive and direct trials. Jackson et al. (2006) concluded that expert rugby players were better in perceiving the advance visual kinematic information, and thus, they were less affected by deception than novice rugby players.

In accordance with previous research on anticipation, which has shown that superiority in experts' predictions of opponents' future actions is due to visual skills such as advance visual cues and visual search behavior (Abernethy & Zawi, 2007; Mann et al., 2007; Williams, Ward, Knowles & Smeeton, 2002), Jackson et al. (2006) claimed that visual expertise made experts more proficient in detecting deceptive actions that are initiated by opponents.

Alternatively, Sebanz and Shiffrar (2009) came to a different conclusion. The researchers invited expert basketball players (defined as those who had played for 12.4 years and were still playing once/week) and novices (defined as those who had never played basketball) to watch short video clips and static images of basketball players to examine the role of expertise in the recognition of deceptive movements. Participants were asked to predict whether the presented basketball player was passing the ball (actually handing the ball off) or only pretending to pass the ball.

Sebanz and Shiffrar (2009) found that experts performed significantly better and more accurately than novices in recognizing the deceptive movements in the video. In

addition, when they used point-light display, the experts maintained their superior performance while novices performed at about the chance level. Based upon the findings that expert players outperformed novices only when dynamic movements (videos and point-light animations) were presented, but not with static slides, the authors argued that motor expertise is crucial for detecting deceptive movements. Their conclusion was in line with those previous arguments that refer to motor expertise as the crucial factor for perception of kinematic information that specifies affordances for others (Aglioti et al., 2008).

In sum, two justifications account for expert-novice differences in detecting deceptive movements by opponents. Jackson et al. (2006) suggested that visual expertise is crucial for successfully distinguishing between deceptive and direct actions, while Sebanz and Shiffrar (2009) claimed that motor expertise is the major factor that explains the superior performance of experts in detecting deceptive and direct movements.

Nevertheless, these two explanations do not seem to be mutually exclusive (Cañal-Bruland & Schmidt, 2009). Jackson et al. (2006) and Sebanz and Shiffrar (2009), respectively, examined expert rugby and basketball players who, in fact, were visual and motor experts. In both studies, the expert groups had extensive visual expertise as they had observed countless deceptive and direct actions throughout years of playing rugby or basketball. Additionally, the expert groups had extensive motor expertise, having performed hundreds of deceptive and direct actions themselves.

Therefore, from these two studies it cannot be concluded that visual or motor expertise contributes exclusively to making perceptual judgments on deceptive intentions

in others' movements. Rather, both visual and motor expertise must contribute cooperatively in detecting deceptive and direct actions.

In an attempt to further explore the contribution of both visual and motor expertise in recognizing intention to deception, Cañal-Bruland and Schmidt (2009) asked skilled handball field players (motor experts in producing deceptive and direct shots), skilled handball goalkeepers (visual experts in observing many deceptive and direct shots), and novices (those with no handball experience) to identify deceptive and direct handball 7-m throws in video clips captured from the side of the court. Both expert players and goalkeepers outperformed novices in detecting deceptive and direct handball 7-m throws. Significantly, the findings showed that expert goalkeepers and field players performed equally well in discriminating deceptive from direct 7-m throws.

Given that goalkeepers (visual experts) and handball field players (motor experts) performed equally, Cañal-Bruland and Schmidt argued that the motor expertise explanation (Sebanz & Shiffrar, 2009) could not fully explain the skill-related advantage in identifying deception, especially considering that field players were holding an advantage as the viewing condition (i.e., viewing the thrower from the side), which was not the habitual viewing perspective (i.e., the front view) for goalkeepers. If the assumption of the motor expertise is exclusive, then the field players must outperform the goalkeepers. Therefore, the individual contributions of motor or visual expertise to the recognition of the intention to engage in deceptive actions were examined by manipulating the viewing perspective (Cañal-Bruland et al., 2010). With the same task of distinguishing deceptive and direct 7-m throws, expert field players, expert goalkeepers,

and novices watched video clips of 7-m throw situations in handball from the front view (the goalkeeper's view) and the side view. Given that the frontal view is the habitual viewing perspective for goalkeepers, an influence of visual expertise would predict an advantage for goalkeepers.

However, the results indicated that neither motor nor visual expertise could solely explain the successful recognition of the intention to engage in deceptive movements. In both viewing perspectives highly skilled goalkeepers and field players equally outperformed the novices and reliably identified the deceptive shots.

The findings confirmed the findings of a previous study (Cañal-Bruland & Schmidt, 2009) in which visual and motor expertise could not be separated from one another in the identification of deceptive and direct actions. In addition, findings from these two studies (Cañal-Bruland & Schmidt, 2009 & Cañal-Bruland et al., 2010) are in accordance with previous investigations that refer to motor and visual expertise together as crucial factors for superior performance in detecting kinematic information that explains the possibilities for others' actions (Cañal-Bruland et al., 2011; Loula et al., 2005; Pizzera & Raab, 2012)

Overall, these sport-related results are noteworthy in light of Runeson and Frykholm's (1983) argument that the kinematic pattern of an actor's movements is rich in information about his/her intention, and about what to expect from that actor. However, in skilled activities it is not that easy to detect deception because domain-specific expertise, not general expertise, appears to play a significant role in determining expert from novice performers (see Ericsson et al., 2006). In addition, maturation per se, or

growing while playing a particular sport is not enough to gain such perceptual superiority, but sport-specific practice and sport-specific experience are the appropriate ways to achieve that superiority (Abernethy, 1988; Williams & Ericsson, 2005).

The information regarding local versus global cues extraction strategy (see information extraction approaches) suggests that enhancing domain-specific experience in extracting global, not local, information from an opponent's body supports athletes' ability to detect deception and supports their ability to anticipate future outcomes of deceptive actions. Although the subsequent studies after Jackson et al. (2006) have confirmed the superior performance of experts over novices in detecting deception (Cañal-Bruland & Schmidt, 2009; Sebanz & Shiffrar, 2009), some studies have found that experts are also susceptible to deception (Rowe et al., 2009; Dicks et al., 2010). In tennis, for instance, Rowe et al. (2009) found that although they outperformed novices in both types of groundstrokes, expert players were less accurate in anticipating ball directions from deceptive groundstrokes than from real ones. In addition, in soccer, Dicks et al. (2010) found that the goalkeepers' saving performance was impaired when they were unable to watch the penalty kicker's approaching motion toward the ball, and to a larger degree for kicks with deceptive motion than without deception (Dicks et al., 2010).

Can Expertise Be Developed?

As highlighted previously, the exceptional perceptual skills of skilled athletes in different sports have served as a starting point for numerous studies seeking an empirical base for perceptual training programs (Farrow & Abernethy, 2002; Hagemann et al., 2006). In contrast to the general commercial vision training programs that promise to

improve depth perception, visual acuity, and peripheral vision, but provide no measurable benefits (Abernethy & Wood, 2001; Farrow & Abernethy, 2002), there is broad empirical evidence that perceptual-cognitive skills can be developed and trained in sport. The study of perceptual training in the sports domain has quite a long history. Studies in the literature are generally encouraging in their findings with respect to the potential of perceptual training. Although some field-based training studies exist (see Williams & Grant, 1999 for review), the prototypical approach has involved video-based simulation. This approach involves filming the appropriate display (i.e., a 7-m throw in handball) from the goalkeeper's viewing perspective. The film is then played back to participants with varying degrees of instruction, visual attention, and/or feedback. Some programs have involved persistent exposure to the training film followed by feedback concerning the correctness of participant responses, while others involve more explicit instruction whereby key cues and their relevance to subsequent performance are highlighted (Savelsbergh et al., 2010; Williams & Burwitz, 1993). The available interventional studies have taken different avenues of investigation. Thus, the following section will focus on each avenue of investigation undertaken by different sport scientists.

The instruction: explicit vs. implicit. Based on Anderson's (1982) theory of cognitive skill acquisition, which provided a rationale for the use of explicit instruction, early studies revealed improvement in anticipatory performance for participants who were given perceptual training compared to participants who were given no perceptual training (Abernethy, Wood, & Parks, 1999; McMorris & Hauxwell, 1997; Williams et al., 2003). For the past decade, there has been a growing awareness of the potential

limitations of the use of explicit instruction and the type of perceptual learning that it may promote (Jackson & Farrow, 2005). In real-sport tasks, where anticipation may not be totally predictable from one situation to another, less prescriptive types of instruction might be preferable in comparison to an explicit rule-based method. It has been argued that in perceptual training of regular movement patterns in sports, explicitly directing attention to the cues that emphasize certain movement features will likely lead to a worse performance than will implicit learning (Farrow & Abernethy, 2002) or guided discovery (Smeeton et al., 2005).

Therefore, Farrow and Abernethy (2002) perceptually trained intermediately skilled tennis players to anticipate the direction of a tennis serve occluded at racket-ball contact. One group was instructed to estimate the speed of the serve. This instruction was designed to draw the players' attention implicitly to key kinematic information in the service action but without accompanying explicit instruction. A second group was explicitly told what key kinematic parameters to attend to in order to anticipate service direction. Compared with the explicit, control, and placebo groups, participants in the implicit learning group were able to increase their anticipatory skill significantly in the post-test. In addition, Williams et al. (2002) compared the anticipatory performance of tennis players under two different instruction approaches (guided discovery and explicit instruction). While results revealed that no difference in anticipatory performance was found between the two groups, the two experimental groups were more accurate than control groups.

Smeeton et al. (2005) compared the anticipatory performance for tennis players in explicit learning groups, players in a guided discovery group, players in a discovery group, and players in a control group in pre-and post-training anticipation tests and under stress conditions. The aim of the stress task was to assess the proposition that the performance of the groups who learned under more implicit conditions (guided discovery) would be more resistant to failure under elevated cognitive anxiety than the group that explicitly learned the skills. Although improvement in decision time was greater for all three intervention groups than for the control group, Smeeton et al. concluded that guided discovery represents the best option for training anticipatory skills based on the dual characteristics of fast acquisition and stress resistance.

Fostering of visual attention. As some researchers aimed to manipulate the instructional techniques (e.g., Abernethy & Farrow, 2002; Williams et al., 2002; Smeeton et al., 2005), other researchers have tried to manipulate the visual display to direct participants' visual attention toward the important cues in their opponents' bodies during perceptual training. For example, Hagemann and colleagues (2006) directed the attention of badminton players of different skill levels, using a transparent red patch, to the most important anticipatory cues available in the hitting action of opposing players. Compared to participants given no training, novice participants given perceptual training reported significant improvement in their anticipatory performance in the post-test and in the retention test. More recently, Savelsbergh et al. (2010) examined a strategy designed to improve perceptual anticipation of penalty kick directions. The researchers attempted to optimize the goalkeeper's visual search behavior by directing the goalkeeper's gaze in a

systematic way to the most informative areas on the penalty taker's body. Novice goalkeepers were presented with a video-based anticipation pre-test, perceptual training, and a post-test on a large screen. After the pre-test, the participants were randomly assigned to the guided perceptual training group, the unguided perceptual training group, or the control group. The guided perceptual training group viewed video clips that were edited to highlight relevant information during the run-up and the kick; the unguided group viewed the same clips but without the highlighted information. The results showed that after four training sessions over six days, participants in the guided discovery group improved their anticipatory performance.

Abernethy, Schorer, Jackson, and Hagemann (2012) examined the efficacy of color cueing in improving the anticipatory performance of handball goalkeepers. In direct contrast to the improvements in learning found for three separate groups given explicit rules to guide anticipation, verbal direction toward the location of the critical anticipatory cues, or an implicit pattern-matching intervention, no training effect was found for participants trained with color cueing. The change in performance for the group given color cueing was no better than a control group who performed without training, irrespective of whether testing was compared immediately after the training intervention or at a retention test five months after the intervention.

An alternative approach to enhance perceptual learning is referred to as *reduced usefulness training* (Smeeton, Huys, Jacobs, 2013). Instead of focusing on the useful information on the opponents' body by highlighting or coloring the critical cues (Savelsbergh et al., 2010; Abernethy et al., 2012), this approach aims to stimulate

observers to detect more useful information by lessening the usefulness of the variables used initially by novice perceivers (Jacobs, Runeson, and Michaels, 2001). From an ecological point of view on visual perception (Gibson, 1986), Jacobs and colleagues investigated how to manipulate the usefulness of visual information to help observers discover the more useful information for the perception of the relative mass of two colliding balls. A pretest-practice-posttest design was used. To manipulate the usefulness of variables, two methods were applied (i.e., no-variation method and zero-correlation method). In the first, referred to as the no-variation method, Jacobs et al., (2001) composed a set of practice displays in which the considered non-specifying variables had the same value on every trial (e.g., after each collision the two balls had the same exit-speed). This means that an observer who relies exclusively on that variable (exit speed difference) would perceive the two balls as being of the same mass on each trial, which makes the variable useless for the task at hand. In the second one, referred to as the zero-correlation method, Jacobs et al., (2001) generated a set of practice displays in which the considered non-specifying variables were varied normally but in which they were also entirely uncorrelated with relative mass. In contrast to no-variation method, this zero-correlation method was successful in the sense that all perceivers learned to ignore the non-specifying variables used in a pretest. They did not regress to the non-specifying variables in the posttest, as in no-variation practice. In sum, the objective of this method was to motivate learners/perceivers to detect more useful informational variables.

An innovative type of reduced usefulness training was applied and experimentally investigated (Smeeton et al., 2013) who manipulated the information relevant to specific

body regions using a technique based on principal component analysis (PCA). Their findings support the claim that the relative usefulness of informational variables during practice affects the perceptual learning process, and that reduced usefulness training can be used to learn to anticipate human movement. To put it together, techniques that foster the visual attention of learners have been applied in sport-related and non-sport-related tasks. The most used techniques in sport-related tasks include occluding or highlighting particular variables in videotaped or computer-based stimuli, and explicitly instructing perceivers as to what variables to attend. In the present study a novel type of reduced usefulness training is proposed and experimentally investigated in which participants were stimulated to detect more useful cues by lessening the usefulness of the cues used by novices, or found to have no impact on handball throw velocity and accuracy.

Although significant progress has been made during the last decade in determining the training approaches most likely to enhance the acquisition of perceptual skills, the variances in their methodological designs pose a number of unanswered questions, specifically the frequency and the duration of the intervention, the most meaningful age or the skill level for such intervention, the most effective type of response provided during training, the most effective type of feedback provided for participants, and finally the most effective type of instruction used during intervention. Although the most appropriate approach for developing expertise remains unknown, it is worth pointing out that recent work (Fajen & Philips, 2012; Huys et al., 2008; Huys et al., 2009; Smeeton et al., 2005; Smeeton & Huys, 2011) suggests that implicit and/or guided discovery learning is a more effective instructional technique for long term development

and for performing under real competitive conditions. In addition, the recent research paints a clearer picture of whether or not a performer should use a local or global information pick up strategy to effectively anticipate the future actions of their opponents. The literature in this area supports the notion that a global extraction strategy is more effective for developing the skills for anticipation and for minimizing the effect of deception.

Summary

An extensive overview of the research on expertise in sport and in other areas was presented in this chapter. Although it appears that experts in non-sport domains have special attributes that differentiate them from novices, experts in sport domains have sport-specific attributes that differentiate them from novices. In particular, expert athletes possess rich sport-specific perceptual-cognitive skills that enable them to perform efficiently. When compared with novices, expert athletes are faster and more accurate in recalling and determining the pattern of the game, are more accurate and better at utilizing advance visual cues from their opponents, and employ effective visual search strategies.

Although deception has a significant impact on athletic performance in many sports, there is little research that has focused on the effect of deception on anticipatory performance. Recently, a group of researchers have investigated deception in various sports; however, the topic of deception needs more investigation, especially in sports such as team handball, basketball, soccer, and volleyball, where deception plays such a major role.

The previous literature indicates that the superior performance of experts is not the result of maturation, but is developed through sport-specific practice. The path of excellence is not easy. Thus, researchers have been investigating the area of expertise to find the appropriate interventions for the development of perceptual and cognitive skills. Although the studies focused on intervention have resulted in encouraging conclusions, the differences in their intervention and methodological approaches indicate the need for further investigation.

Chapter 3 : Methodology

Introduction

The current study examined the effects of video-based perceptual training on the performance of handball goalkeepers when anticipating the directions of both direct and deceptive 7-meter throws (i.e., penalty throws). Data were collected in July and August 2013 using a group of 42 volunteer male Kuwaiti handball goalkeepers in Kuwait City, Kuwait.

Before designing the handball-specific video-based anticipation test and perceptual training program for the main study (Study III), two preliminary studies (Study I and Study II) were conducted so as to determine any localized and appointed problems. Each of the three studies described below had different objectives, although the dependent variables and some key terms were the same. Response Accuracy (RA) was recorded as the main dependent variable for all studies. It represented the number of trials in which each participant correctly anticipated the direction of the 7-m throws. Other consistent key terms were the throwing condition (TC), which described the mechanism of a field handball player's execution of a 7-m throw, and the temporal occlusion (TO) point, which described the point of blocking information from the perceiver.

Since the aim of the preliminary studies, Studies I and II, was to strengthen the design of the main study, Study III, a comprehensive discussion of Studies I and II is provided in this chapter. The implications of these studies in relation to the design of the main study are also discussed, and the methodology used for Study III is explained.

Study I

Introduction

The penalty throw in team handball is an important skill that requires a goalkeeper to accurately and quickly anticipate the direction of the ball before it is released. Research suggests that expert handball goalkeepers anticipate the ball direction on the basis of the movement pattern of their opponents (Schorer & Baker, 2009). The practical problem faced by handball goalkeepers occurs when a thrower executes one or two of two types of deception: first, the thrower can quickly and randomly move the throwing arm forward and backward before ball release, and second, the thrower can use wrist movement to change the throw direction at the moment of ball release. Study I focused on the first type of deception, as it is the most used by handball players.

Study I, the first pilot study, explored the effect of the first type of deceptive arm movement on the accuracy of a goalkeeper's judgment when anticipating 7-m throw directions. Goalkeepers' RA scores were recorded when they anticipated 7-m throw directions under three throwing conditions (see TC.1, TC.2, and TC.3 in Table 1).

Table 1

Key Terms and Abbreviations for Study I

Key Term	Type	Description
Throwing Conditions	TC.1	Penalty throws without employing any deceptive action.
	TC.2	Penalty throws with one deceptive action: Throw (TH)- No Throw (NTH) – Throw (TH).
	TC.3	Penalty throws with two deceptive actions: TH – NTH – TH – NTH – TH.

It was hypothesized that the accuracy of goalkeepers' judgments under TC.1 would be greater than their judgment accuracy when anticipating 7-m throw directions under TC.2 and TC.3. In addition, because TC.3 consisted in a greater number of deceptive arm movements, it was predicted that the accuracy of goalkeepers' judgments under TC.2 would be greater than under TC.3 (i.e., $TC_{.1} > TC_{.2} > TC_{.3}$).

Method

Participants. Thirteen male Kuwaiti handball goalkeepers volunteered to participate in this study. Participants had an average age of 25 years ($SD = 5.2$) and an average of 12.38 ($SD = 4.48$) years of playing experience. At the time of the study, all participants were representing their club teams in the Elite Kuwaiti Handball League.

Testing-film construction. The camera for the testing film was set up to record the goalkeeper's perspective. It then recorded an individual national elite handball player performing 7-m throws. Using video editing software (Apple iMovie '11), the film was then combined, and the sixty 7-m throws were edited. For each throw, the film was occluded at the frame prior to the ball release, the ball still in the thrower's hand. This process was repeated for each throwing condition, (TC.1, TC.2, and TC.3). These video clips were combined to create a testing film that included three blocks of 20, 7-m throws, with an inter-trial interval of 3 s and a 2 min resting period after each block. The testing film was then presented to the goalkeepers via a large screen that was placed on the 7-m line (Figure 1).

Procedure. After five minutes of general handball warm-up drills, each participant was asked to stand in the handball goal area and view the testing film. In the goal area, each participant was allotted five minutes of practice trials and was then asked to anticipate the

direction of each throw as quickly and accurately as possible by physically moving toward the predicted direction with proper goalkeeper's technique (see Figure 1).



Figure 1. Mainframe: demonstrations of the testing stimuli from the goalkeeper's perspective; Inset: the goalkeeper's task.

Results

As can be seen in Figure 2, the anticipatory performance for participants under each throwing condition was different. There was a remarkable difference in performance in RA between the direct throwing condition (TC.1) and the deceptive throwing conditions (TC.2 and TC.3). However, there was no notable difference in performance in TC.2 and TC.3.

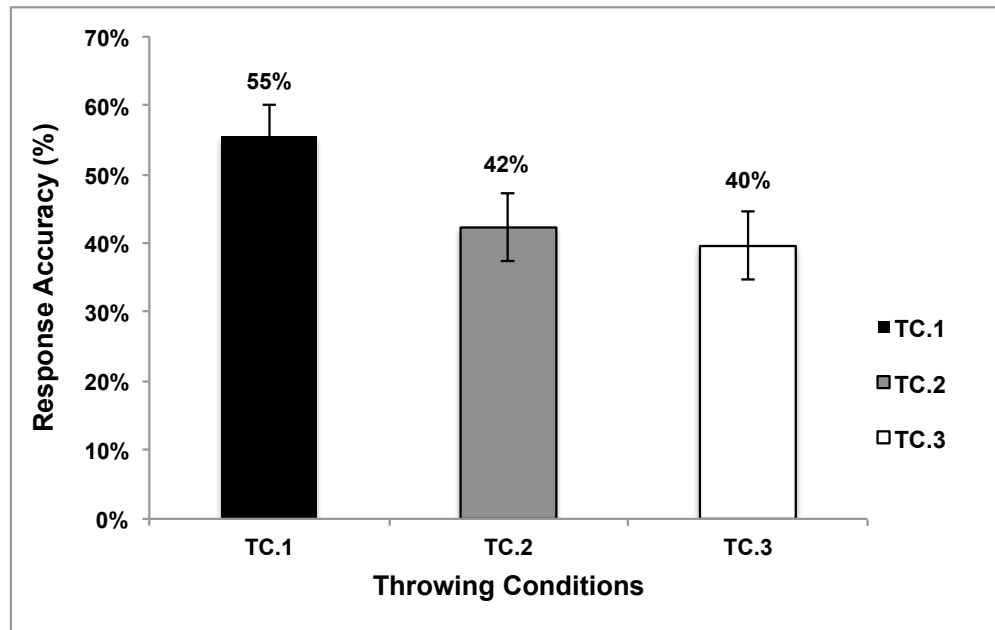


Figure 2. Goalkeepers' anticipatory performance (RA%) when anticipating 7-m throws in direct (TC.1), deceptive (TC.2), and double deceptive (TC.3) throwing conditions.

When participants anticipated 7-m throw directions under throwing condition TC.1, the average RA was 55% ($SE = 4$). When they anticipated throw directions under conditions TC.2 and TC.3, the average response accuracy for TC.2 was 42% ($SE = 3$), and for TC.3 it was 40% ($SD = 4$).

A one-way within-subjects ANOVA showed a significant effect of throwing condition, $F(2, 11) = 8.15, p = .007$. A Bonferroni corrected post hoc analysis revealed that the RA for participants under TC.1 was significantly higher ($p = .006$) than under TC.2 and significantly higher ($p = .012$) than under TC.3. There was no difference between TC.2 and TC.3 (Figure 2).

Discussion and Implications for Study III

Findings from Study I confirmed that deceptive arm movements (TC.2 and TC.3) significantly reduced the accuracy of goalkeepers' judgments when anticipating the

directions of 7-m throws. Contrary to the hypothesis, however, the RA of goalkeepers was approximately identical under the two deceptive throwing conditions (TC.2 and TC.3). After the completion of Study I, it was determined that the two types of deceptive arm movements could be categorized as one type of deception. Thus, several changes were made to the next testing and training protocols. The findings from Study I provided information to strengthen the design of perceptual training in Study III (the primary study), and indicated the necessity of determining the critical temporal point at which expert handball goalkeepers make the most accurate judgments when anticipating 7-m throw directions.

In addition, the findings from Study I underscored two critical limitations related to the design of the testing film. First, the testing film included three blocks of 20 throws for each throwing condition. Second, the testing film contained only one handball thrower. These two issues may have inadvertently increased the chance of a learning effect. Consequently, to overcome these limitations, in the following two studies the design of the test films was modified by recording two handball throwers in Study II and six throwers in Study III, by randomizing the throws based on the throwing conditions, and by including coaches and national former goalkeepers in the selection process. In addition, the sample size was increased to include 20 skilled goalkeepers in Study II. In Study III, the main study, this pool was expanded further to include 42 skilled goalkeepers representing elite and youth handball populations.

Thus, based on the findings and the limitations of Study I, Study II was conducted to examine the optimal temporal point at which expert goalkeepers make their judgments about 7-m throw directions.

Study II

Introduction

The early and accurate anticipation of future events is a defining characteristic of expert performance in sport tasks (Abernethy & Zawi, 2007). Advance pick up of information is a critical characteristic of experts in many types of competitive sports. Studies have reported that experts pick up information to more accurately anticipate a forthcoming event such as the direction of a tennis serve, the landing position of badminton shuttle, or the type of throw of a baseball pitch. This information is available prior to ball release and is known as advance information (Müller et al., 2010). Studies have compared experts to novice observers by applying temporal occlusion at different points in the kinematics of an opponent's action in order to understand the timing of information pick up (Abernethy & Russell, 1987; Jones & Miles, 1979).

Despite an abundance of temporal occlusion studies that investigate the timing of information pick up in interceptive sports, there is a dearth of such studies in team sports, in which interceptive tasks occur in many different game situations (e.g., goalkeeper vs. field player in handball). It is important for researchers and practitioners to determine the timing of information pick up used by expert goalkeepers to make their decisions when anticipating the directions of 7-m throws because such information may lead to more effective training programs that may assist in efficiently improving today's less skilled goalkeepers.

The early pick up of information is an important characteristic of experts in sports, and the research in this area has confirmed that each sport has its own unique perceptual-cognitive qualities. Study II did not attempt to compare experts and novices, as it has been

scientifically confirmed that experts outperform novices in all sport-specific perceptual-cognitive tasks. Instead, the purpose of Study II was to determine the critical temporal occlusion point at which expert handball goalkeepers pick up information to accurately predict the direction of a 7-m throw. Determining the point that expert goalkeepers make their most accurate decisions was considered a meaningful addition to the understanding of expertise and a necessary determinant in designing handball-specific testing and perceptual training films for Study III. Based upon the research findings from different sports (Müller et al., 2010; Panchuk & Vickers, 2006; Shim et al., 2005; Williams & Burwitz, 1993), it was hypothesized that the response accuracy of handball goalkeepers would decrease as the available kinematics information was reduced, and that their most accurate advanced judgments would coincide with one frame before ball release (TO.3; see Figure 4).

Method

Participants. Twenty Kuwaiti expert handball goalkeepers volunteered to participate in Study II. Their average age was 27.8 years ($SD = 4.84$). At the time the study took place, the summer of 2013, the goalkeepers had played handball for an average of 17.1 years ($SD = 4.12$). All participants had represented at least one Kuwaiti National team at some point in their career (e.g., youth, junior, and/or men's national team), which indicated that they were among the best goalkeepers in Kuwait. At the time Study II took place, four participants were representing the Kuwaiti National Team. All had normal or corrected-to-normal vision.

Testing-film construction. Unlike Study I, two male handball players from the Elite division of the Kuwaiti Handball League were selected by a handball coaching staff to execute 7-m throws (i.e., penalty throws). The players were videotaped during the execution

of 7-m throws from the perspective of the goalkeeper. To enhance the accuracy of their throws, a handball-specific target net containing an open spot in each corner was used (see Figure 3). Players were encouraged to feel as though they participated in a real game. A high-definition handycam camcorder (Sony HDR-CX580) was placed at the center of the goalkeeper's line to film the players while they were executing 7-m throws. The throwers were asked to perform 50 throws from each throwing condition (i.e., 25 from TC.1 and 25 from TC.2+TC.3), without employing any deceptive wrist movement at the last moment of ball release.



Figure 3. Clockwise from top left: Demonstration of the research settings, testing stimuli, and the goalkeeper's task.

The recorded footage was then presented to a former national goalkeeper and to a handball coach to exclude any non-representative throws and to include the most representative 7-m throws. The exclusion and inclusion process was based on the following specific criteria:

- Exclude any throw that does not pass any open corner in the target handball net.
- Exclude any throw that has a clear indication of the throw's direction (e.g., communication via eye or posture direction).
- Include only representative 7-m throws (e.g., strong, quick, hard to predict).

Using these guidelines, 16 throws were selected by the former goalkeeper and the coach (8 direct and 8 deceptive) from the film of both players.

The footage was then edited and arranged to terminate at five different temporal occlusion points (TO.1, TO.2, TO.3, TO.4, and TO.5), using video editing software (Apple iMovie '11). The edited footage generated 80 video clips (5 occlusion points multiplied by 16 throws). The 80 video clips were duplicated and arranged in random order to generate a testing film with 160 mixed throws, with an inter-trial interval of 2 s, and with a 3-min resting interval after each block of 40 mixed throws. An illustration of temporal occlusion conditions used in this study is provided in Figure 4.

Procedure. After five minutes of warming up with drills, each goalkeeper was asked to stand 7-5 m from a large screen placed at the 7-m line. After the practice drills, each goalkeeper was asked to anticipate the direction of the throw as accurately and as quickly as

possible by physically moving toward the predicted direction with correct goalkeeper's technique (Figure 3).

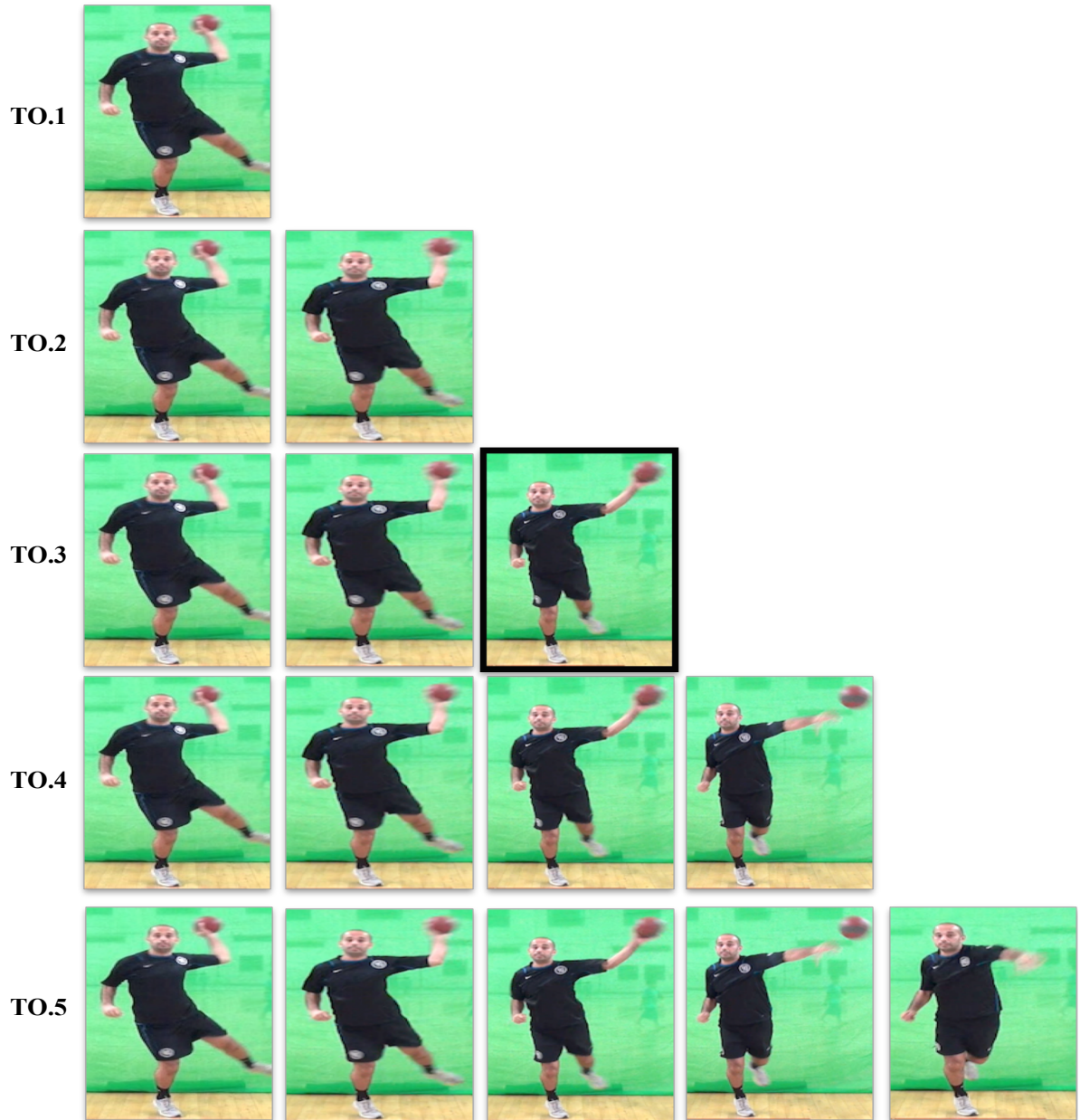


Figure 4. A demonstration of temporal occlusion technique. Visual information increases with the progressive occlusion of the display. TO.1 represents an occluded throw at three frames before the point of ball release; TO.2 represents an occluded throw at two frame before the point of ball release; TO.3 one frame before the point of ball release; TO.4 one frame after ball release; TO.5 two frames after ball release.

Dependent variables and data analysis. A one-way repeated measures ANOVA was carried out to examine the effect of progressive occluding visual information (TO.1, TO.2, TO.3, TO.4, and TO.5) on the accuracy of goalkeepers' judgments when anticipating the directions of 7-m throws. Response accuracy (RA) was recorded as a dependent variable. The five points of temporal occlusion (TO.1, TO.2, TO.3, TO.4, and TO.5) were assigned as the independent variable. RA was calculated as the number of trials in which the participants correctly anticipated the direction of the throws. Prior to analysis, the RA data were first subjected to a test of normality (the Kolmogorov-Smirnov test). Results for the Kolmogorov-Smirnov test for normality indicated that the RA distribution in five testing conditions did not deviate significantly from a normal distribution. A Greenhouse-Geisser correction to the degrees of freedom accounted for violations of sphericity. Significant effects were followed up using Bonferroni post hoc tests, and the alpha level for significance was set at $p = .05$ for all statistical comparisons.

Results

Figure 5 clearly supports the central hypothesis that prediction accuracy of handball goalkeepers would decrease as the available kinematics information was reduced and that their most accurate judgments, prior to ball release, would coincide with a single point before the ball release (i.e. TO.3). The graph shows that prediction performance for participants increased with progressive increase of the display. The gray bars represent the point of ball release TO.4 and the point after TO.5. The white bars and the black bar represent three points before ball release (TO.1, TO.2, TO.3). The accuracy of prediction improved from TO.1

($M=47\%$, $SE= 3\%$), TO.2 ($M=49\%$, $SE= 3\%$), TO.3 ($M=56\%$, $SE= 4\%$), TO.4 ($M=66\%$, $SE= 4\%$), to TO.5 ($M=79\%$, $SE= 6\%$).

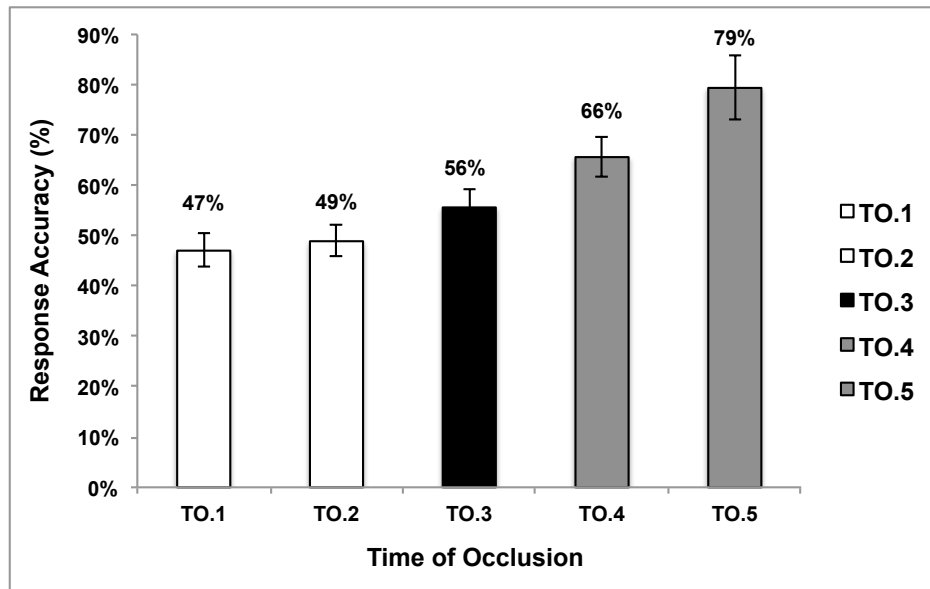


Figure 5. Goalkeepers' anticipatory performance (RA %) when anticipating 7-m throws at each occlusion point. The TO.1 displayed minimum information, and TO.5 displayed maximum information.

A one-way within-subjects ANOVA, with a Greenhouse-Geisser correction, was used to compare the prediction scores under the five occlusion conditions. The results revealed a significant main effect for the time of occlusion on the prediction accuracy of goalkeepers when anticipating 7-m throws: $F(4, 76) = 32.04$, $p < .001$, for all sphericity assumption correction tests. Post hoc tests using the Bonferroni correction revealed that prediction accuracy at TO.3 (56%) was significantly greater ($p = .012$) than TO.1 (47%), and greater than TO.2 (49%). On the other hand, the prediction accuracy at TO.3 was significantly lower than TO.4 (66%) ($p = .006$) and TO.5 (79%) ($p = .001$). Because anticipation of future action was the core of this study, however, the later occlusion points (TO.4 and TO.5) were not of interest as they represented the moments after ball release.

Discussion and Implications for Study III

The findings from Study II confirmed the central hypothesis that the goalkeepers' accuracy judgments would decrease with a progressive reduction of visual kinematic information, and their most accurate decisions would be associated with a point 33 msec prior to ball release (i.e., TO.3). The findings of this study are in agreement with previous research (Müller et al., 2009; Shim et al., 2005; Williams & Burwitz, 1993) that found that experts were accurate above chance level at anticipating future events before they occurred. The significant difference between TO.1 and TO.3, and the chance difference between TO.2 and TO.3 suggested that TO.3 was the optimal perceptual point associated with the most accurate judgments prior to ball release. Although earlier (TO.3) information pick up showed the superiority in anticipatory performance, information pick up that occurs too early (TO.1 and TO.2) causes poor decisions, especially in tasks where deceptive movements often occur. For instance, if a goalkeeper were advised to initiate an action at TO.2, the chance of being deceived by a thrower would be higher than TO.3. Supporting this argument, Savelsbergh et al., 2005 found that skilled-successful soccer goalkeepers waited longer before initiating response.

Therefore, it was concluded that to minimize the effect of deception and make accurate judgments, goalkeepers should anticipate the direction of 7-m throws early enough (TO.3) but not too early (TO.2). Thus, TO.3 was chosen as the optimal perceptual point for designing the anticipation and perceptual training films for Study III.

The use of one group (expert goalkeepers) might be a limitation of Study II. However, the past three decades is rich with studies that have investigated expert-novice differences in

many sports (e.g., Allard & Starkes, 1980; Borgeaud & Abernethy, 1987; Shin et al., 2005; Williams et al., 2006; Williams et al., 1993; Williams & Davids, 1998). Despite the diversity and differences in the nature of each sport reported in previous studies, there is general agreement that skilled performers demonstrate a superior ability to pick up advance visual information from an opponent's postural orientation prior to a key event, such as soccer ball-contact (Savelsbergh et al., 2002). Therefore, Study II focused on expert goalkeepers only to determine when they make their most accurate judgments when anticipating 7-m throw directions. In the future, less skilled goalkeepers might be able to use such information to improve their anticipatory performance.

As mentioned earlier, findings from Study I confirmed that deceptive arm movements (i.e., TC.2 and TC.3) significantly reduced the accuracy of goalkeepers' judgments when anticipating the directions of 7-m throws. Contrary to the hypothesis, the RA of goalkeepers was approximately identical under the two deceptive throwing conditions (TC.2 and TC.3). Therefore, after the completion of Study I, it was determined that two types of deceptive arm movements could be categorized under one type of deception.

Developing a perceptual training model was the central aim of Study III, the final study. Thus, determining the point associated with the most accurate decision regarding throw direction (Study II) supported the design of the final video-based anticipation test and the perceptual training methods used in Study III. Findings from Study II provided an indication of when expert handball goalkeepers make their most accurate decision regarding throw directions (at TO.3). In addition to these findings, the pilot studies supported the main study in how to effectively videotape throwers while executing 7-m throws, how to

effectively select those throwers by including external handball experts in the selection process, and how to involve coaching staff in excluding and including the most representative 7-m throws. Therefore, the pilot studies strengthened the methodology of the main study. Next, the methodology of Study III is discussed supported by the findings of the pilot studies and previous literature.

Study III

As in any goalkeeping situation, to stop 7-m throws (penalty throws) in team handball, expert goalkeepers exhibit high levels of motor and perceptual expertise that require years of sport- and task-specific training. In handball, the ball can reach a velocity that exceeds the goalkeeper's capability of tracking the direction of the ball. Thus, expert goalkeepers anticipate the ball flight on the basis of their opponents' movement patterns (Schorer & Baker, 2009). As found in Study I, handball goalkeepers face a practical problem when a thrower executes a deceptive arm movement before the point of ball release. Thus, anticipating the direction of a throw too early may increase the likelihood that a goalkeeper will make an incorrect decision. Deceptive skills are common in team handball, but little is known about how perceptual expertise can minimize the effect of deception, and little is known about the effect of deception on the accuracy of anticipation.

The current study aimed to determine the effect of a handball-specific perceptual training program that included a mix of deceptive and direct 7-m throws on the accuracy of goalkeepers' judgments when anticipating both direct and deceptive throw directions. It was hypothesized that the group receiving handball-specific perceptual training would be more accurate in anticipating throw directions than either control or placebo groups. It was also hypothesized that anticipation of deceptive throws will show less improvement compared to direct throws.

Method

Participants. Forty-two male handball Kuwaiti goalkeepers volunteered to complete Study III. Participants had an average age of 22.74 ($SD = 7.1$) years. The participants

included 21 elite goalkeepers with an average age of 28.67 ($SD = 5.28$) years and 21 youth goalkeepers with an average age of 16.81 ($SD = .98$) years. The elite goalkeepers had an average of 16 ($SD = 5.8$) years of playing experience, while the youth goalkeepers had an average of 7.33 ($SD = 1.24$) years of playing experience. All participants had normal or corrected-to-normal vision. Participants were randomly assigned to matched-ability groups based on pre-test scores. The average correct prediction scores, represented as the percentage of accurately predicted 7-m throw directions for the three groups were $M_{\text{control}} = 40\%$; $M_{\text{perceptual}} = 41\%$; $M_{\text{placebo}} = 40\%$. They were assigned to a control group ($n = 14$; 7 elite + 7 youth), a perceptual training group ($n = 14$; 7 elite + 7 youth), and a placebo training group ($n = 14$; 7 elite + 7 youth).

Testing and training-film construction. Six male handball players from the elite and youth divisions of the Kuwaiti Handball League were selected by a local coaching staff based on their performance in executing the 7-m throw (penalty throw) in both leagues. Three of the participants chosen were skilled youth (age = 18 years), and three were skilled elite handball players (age = 24, 28, and 31 years). Two players were left-handed and four were right-handed.

Each player was asked to execute 25 direct 7-m throws and 25 deceptive 7-m throws into four corners (upper-left, upper-right, lower-left, lower-right). To enhance the accuracy of their throws, a handball-specific target net containing an open spot in each corner was used (see Figure 3). To avoid fatigue effects, each player was asked to execute 10 throws and rest. Using the same model as in Study II, players were encouraged to feel as though they participated in a real game; accordingly, a local referee voluntarily participated to blow a

whistle for each throw. The players were videotaped during the execution of 7-m throws from the perspective of the goalkeeper. A high-definition handycam camcorder (Sony HDR-CX580) was placed at the center of the goalkeeper's line to film the players while they executed 7-m throws.

The same skilled former goalkeeper and coaching staff used in Study II viewed the recorded footage and were asked to exclude any non-representative throws and to include the most representative 7-m throws. The exclusion and inclusion process was based on the following specific criteria:

- Exclude any throw that does not pass any open corner in the target handball net.
- Exclude any throw that has a clear indication of the throw's direction (e.g., communication via eye or posture direction).
- Include only representative 7-m throws (e.g., strong, quick, hard to predict).

The panel was asked to select an equal number of direct and deceptive 7-m throws.

After the selection process, a total of 122 throws (72 right-handed and 50 left-handed) were validated for use in the study. From the total of 122 throws, 56 throws were selected for the testing film, 56 throws for the perceptual training film, and the remaining 10 throws were used for pre- and-post-test practice trials. Each series of 56 throws contained 28 direct and 28 deceptive throws. Then, the selected footage was edited using video editing software (Apple iMovie '11) to create the testing and the perceptual training-films.

Testing-film construction. Based on Study II, the most accurate decisions made by expert goalkeepers when anticipating 7-m throw directions occurred at one frame before ball release (TO.3), or 33 msec prior to ball release. Hence, the testing footage was edited and

terminated at the third temporal occlusion point (TO.3), in which the thrower still held the ball (see Figure 4).

The edited footage generated 56 video clips that contained temporally occluded 7-m throws. Those 56 throws were ranked in a randomized order based on the throwing conditions (deceptive and direct) to generate a testing film with 56 mixed throws, with an inter-trial interval of 3 s, and with a 2-min resting interval after 28 throws. The post-test had the same pool of 56 mixed throws, but with a different randomized order to minimize the possibility of any learning effect.

Perceptual training-film construction. The second block of footage (56 clips), edited for the perceptual training program, was edited differently. First, each throw was produced in triplicate to generate three copies. Each copy was edited separately. The first copy displayed a thrower's whole body and was occluded at TO.3; the second copy displayed the thrower's upper body and was occluded at the point of ball release and played at a speed 25% slower than normal. The third copy displayed the thrower's whole body and showed a full throw (without occlusion), with a blinking signal indicated the direction of the throw (lower-right corner, lower-left corner, upper-right corner, and upper-left corner). The objective of the editing technique was to stimulate goalkeepers to detect more useful cues that were distributed across the upper body of the thrower by lessening the usefulness of the cues used by novices, or those cues on the lower body of the thrower which had no role on throw velocity or accuracy (Bourne et al. 2011; Fradet et al. 2004; Wagner et al. 2010; Wagner et al., 2006) (see Figure 6). The training method is referred to as reduced usefulness training (Jacobs et al., 2001; Jacobs et al., 2003; and Smeeton et al., 2013). The objective of the

editing method used for the third copy was to effectively enhance goalkeepers' anticipatory performance by providing performance-related information about the results of their predictions.

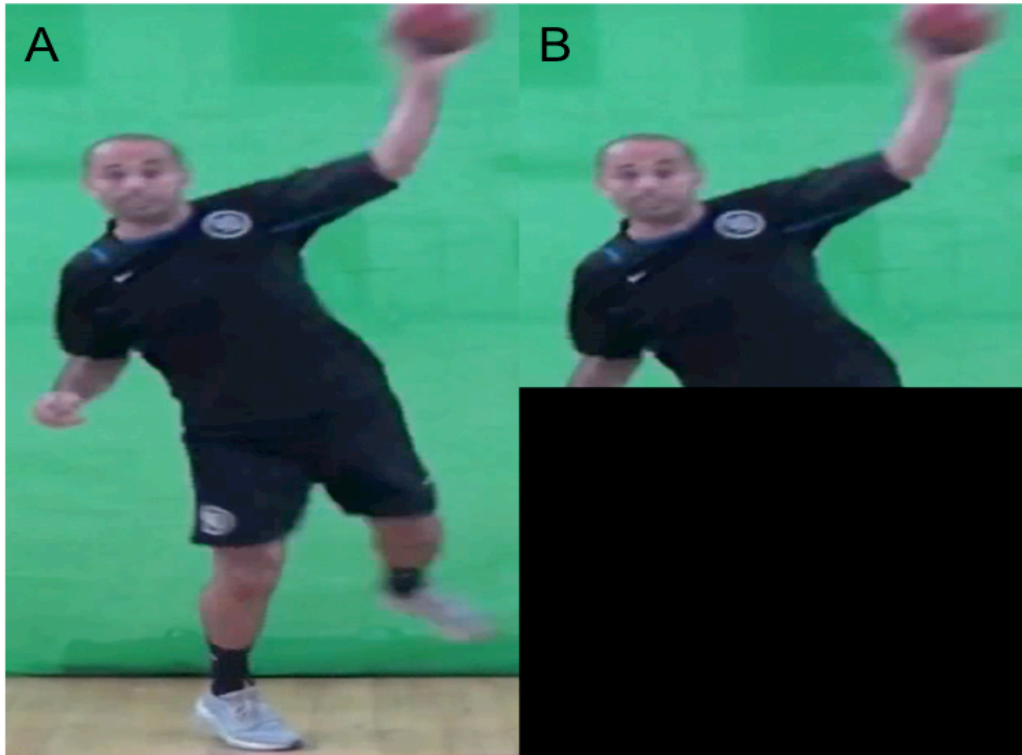


Figure 6. A demonstration of the editing technique used in perceptual training. (A) Represents the first copy of the throw that displays a whole body of the thrower. (B) Represents the second copy of the throw that reduced the usefulness of the cues that do not contribute to handball accuracy and velocity.

The video clips were then combined together to create a 20-minute perceptual training film. The film was uploaded to 5 iPads. The film was introduced with instructions, in Arabic, guiding the goalkeepers to use this training efficiently on their own. The objective of using iPads instead of regular screens was to provide a self-training tool for handball goalkeepers to enhance the amount of training time (i.e., off-field practice hours) and quality (i.e., perceptual-cognitive training) based on the theory of deliberate practice (Ericsson, 1993) that argues that such practice yields quantifiable results. Unlike earlier research, this study used

an iPad to display perceptual training for athletes, as previous research indicated that the size of the screen used in perceptual-cognitive training had no significant effect on perceptual skills (Spittle et al., 2010). For the placebo training group, a collection of real 7-m throws captured from real handball competition were combined to create a 20-minute placebo video-based training film.

Testing procedure. After going through five minutes of warming up with drills, all participants began the pre-test. In the pre-test, each participant was asked to stand 7-5 m from a large screen placed at the 7-m line. After practice trials that familiarized participants with the task, each participant was required to anticipate the direction of the throw as accurately and as quickly as possible by physically moving toward the predicted direction of the throw with correct goalkeeper's technique.

Perceptual training procedure. Participants were divided randomly into three groups (control, perceptual training, and placebo groups) of equal ability based on their pre-test performance. Participants assigned to the control group received no form of training. Participants assigned to the perceptual training group were then asked to participate in seven training sessions, one training sessions per day for seven consecutive days. Sessions consisted of viewing perceptual training-film twice in each training session. Participants assigned to the placebo training group were asked to participate in seven training sessions, one training session per day for seven consecutive days. Sessions consisted of viewing placebo training-film twice in each training session. Both perceptual and placebo training groups viewed their training films via the same displaying devices (iPads) under the supervision of the researcher.

Variables and data analysis. Response accuracy (RA) was recorded as a dependent variable. RA was calculated as the number of trials in which the participants correctly anticipated the direction of the throw. The independent variables were group (control, perceptual training, placebo), throwing condition (direct or deceptive), and skill level (elite or youth). Prior to analysis, the RA data were first subjected to a test of normality (the Kolmogorov-Smirnov test). Results for the Kolmogorov-Smirnov test for normality indicated that the RA distribution in all testing conditions did not deviate significantly from a normal distribution.

To account for changes in performance from pre-test to post-test for both direct and deceptive throws between three groups and between two skill levels, data were subjected to a 2 x 2 x 2 x 3 Mixed-ANOVA where time from pre-test to post-test was a within-subjects factor, and throwing conditions (direct and deceptive), skill level (elite and youth) and designated groups (control, perceptual, and placebo) were between-subjects factors.

In ANOVA test, significant effects involving types of training (control vs. perceptual training vs. placebo) were followed up using Bonferroni post-hoc tests, and the alpha level for significance was set at $p = .05$ for all statistical comparisons.

Chapter 4 : Results

In this chapter, the results of the data analysis for Study III are presented. The data were collected and then processed in relation to the main research question. The research questions inquired about the effect of a handball-specific perceptual training program on the accuracy of goalkeepers' judgments when anticipating either direct or deceptive 7-m throw directions.

Statistical tests yielded a number of significant findings related to the effect of handball-specific perceptual training on the accuracy of goalkeepers' judgments when anticipating 7-m throw directions in general, and under each throwing condition in particular.

Table 2

Descriptive Data (M and SE) for the Group-Based Anticipatory Performance in Pre- and Post-Tests, and in Direct and Deceptive Throwing Conditions.

Group N=42	Pre-test			Post-test		
	All Throws	Direct	Deceptive	All Throws	Direct	Deceptive
	M & SE	M & SE	M & SE	M & SE	M & SE	M & SE
Perceptual n=14	40% ± (4)	44% ± (4)	36% ± (3)	69% ± (3)	76% ± (3)	61% ± (3)
Control n=14	41% ± (4)	47% ± (3)	35% ± (4)	42% ± (3)	49% ± (3)	34% ± (4)
Placebo n=14	41% ± (3)	46% ± (4)	37% ± (3)	42% ± (3)	49% ± (3)	35% ± (3)

A total of 42 participants were divided into three matched ability groups based on their pre-test performance. Table 2 shows that in the pre-test, the average correct prediction score, represented as the percentage of accurately predicted 7-m throw directions was 40% ($SE=4$) for the perceptual training group, 41% ($SE = 4$) for the control group, and 41% ($SE= 3$) for the placebo training group. In the post-test, the average prediction score was 69% (SE

= 3) for the perceptual training group, 42% ($SE = 3$) for participants in the control group, and 42% ($SE = 3$) for the placebo training group.

In addition, within both the pre-test and post-test there were two types of throws (direct and deceptive). In the pre-test, the average correct prediction score, represented as the percentage of accurately predicted direct 7-m throw directions was 44% ($SE = 4$) for the perceptual training group, 47% ($SE = 3$) for the control group, and 46% ($SE = 4$) for the placebo training group. Less than the anticipatory performance for direct throws, the average correct prediction score, represented as the percentage of accurately predicted deceptive 7-m throw directions was 36% ($SE = 3$) for the perceptual training group, 35% ($SE = 4$) for the control group, and 37% ($SE = 3$) for the placebo training group. In the post-test, the average correct prediction score for direct throws was 76% ($SE = 3$) for the perceptual training group, 49% ($SE = 3$) for the control group, and 49% ($SE = 3$) for the placebo training group. Compared to direct throws, the average correct prediction score for deceptive throws was 61% ($SE = 3$) for the perceptual training group, 34% ($SE = 3$) for the control group, and 35% ($SE = 4$) for the placebo training group.

In general, it appears that participants who received perceptual training improved their performance from pre-test to post-test under both throwing conditions. Furthermore, Table 2 shows that, for all participants, the performance in deceptive situations is always poorer than in direct situations. Even for participants who received perceptual training (perceptual training group) the difference in performance in direct and deceptive throwing conditions was obvious. This difference confirms the findings from previous literatures and from Study I (pilot study) that not only novices, but also experts are susceptible to deception.

The Effect of Perceptual Training on Anticipation

Figure 7 shows the impact of perceptual training on the overall prediction accuracy for goalkeepers when anticipating 7-m throw directions. As can be readily observed, the group that received perceptual training improved markedly compared to both the control and placebo groups, both of which remained essentially the same from pre-test to post-test.

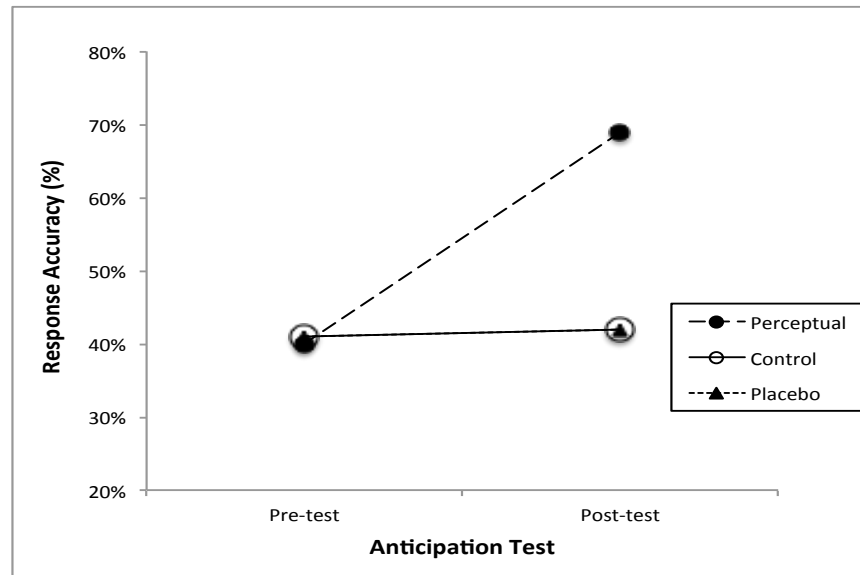


Figure 7. Change in overall anticipatory performance from pre- to post-test for participants in control, perceptual, and placebo training groups.

A mixed between-within subjects-ANOVA was conducted, and the results revealed a significant main effect of time: $F(1, 72) = 70.904, p < .001, \text{partial } n^2 = .496$ indicating the significant change in performance from pre-test to post-test when participants anticipated the directions of 7-m throws. Significant main effect of group was also observed: $F(2, 72) = 11.019, p < .001, \text{partial } n^2 = .234$. There was a significant main effect for throwing condition: $F(1, 72) = 21.566, p < .001, \text{partial } n^2 = .230$. The main effect for skill level was not significant: $F(1, 72) = .803, p < .373, \text{partial } n^2 = .011$. The anticipatory performance for both elite and youth goalkeepers improved significantly from pre-to post-test. Bonferroni corrected pairwise comparisons showed that the difference between the changes in

performance for elite and youth goalkeepers was not significant ($p = .373$). There was significant interaction between group and time: $F(2, 72) = 61.242, p < .001$, partial $\eta^2 = .630$ (Figure 7). The interaction between throwing condition and time was also significant: $F(1, 72) = 4.546, p < .036$, partial $\eta^2 = .059$ indicating the significant change in performance under direct and deceptive throwing conditions (Figure 8 and Figure 9).

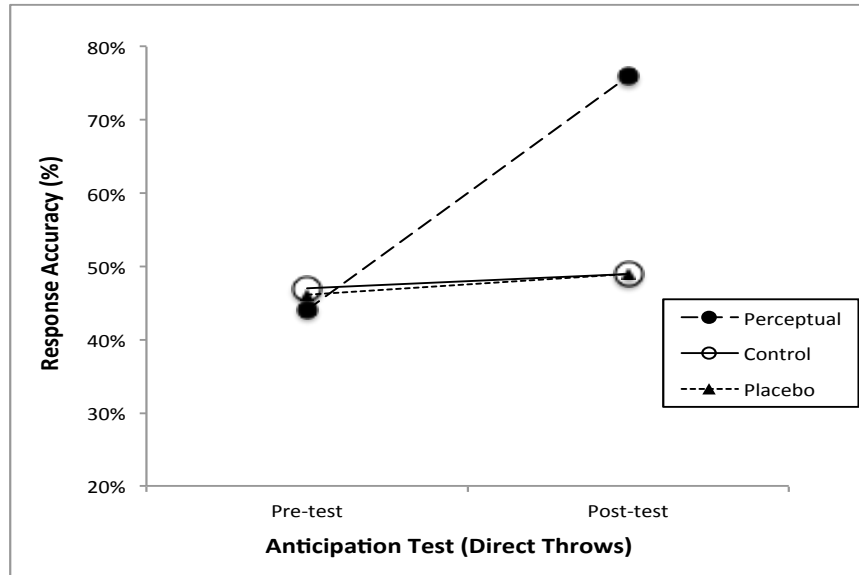


Figure 8. Change in anticipatory performance in direct throwing conditions from pre- to post-test.

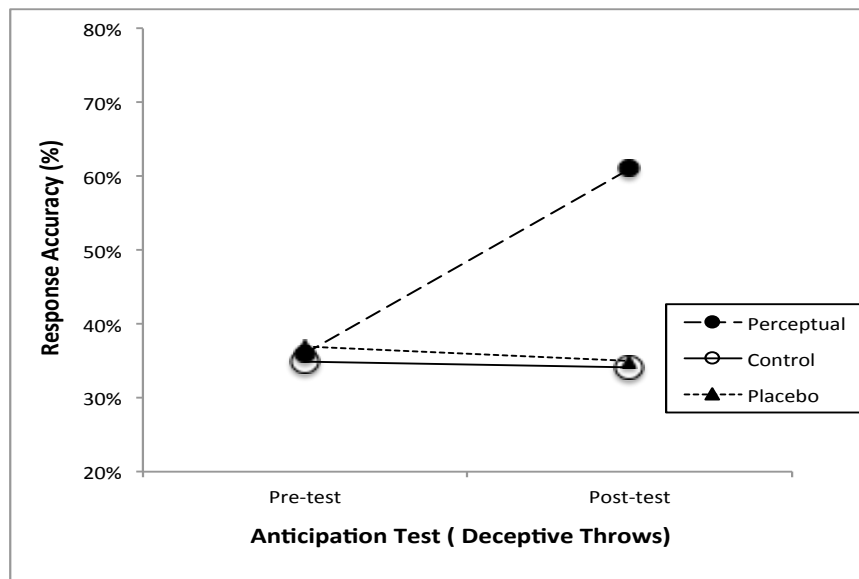


Figure 9. Change in anticipatory performance in deceptive throwing conditions from pre- to post-test.

Bonferroni corrected post hoc analyses revealed that RA of goalkeepers' judgments in the perceptual training group improved significantly more than either the control group ($p = < .001$) or the placebo training group ($p = .001$). There was no significant difference between the control group and the placebo training group. Confirming the first research hypothesis, the results showed that participants in perceptual training group significantly improved their performance significantly greater than participants in control and placebo training groups.

The Size of Improvement

The previous ANOVA showed that anticipatory performance in both throwing conditions improved significantly after perceiving perceptual training. An additional repeated measure ANOVA was conducted to examine whether the size of improvement for anticipating deceptive throws was significantly less than anticipating direct throws. Figure 10 illustrates that the anticipation of deceptive throws showed less improvement (25%) compared to anticipation of direct throws (32%).

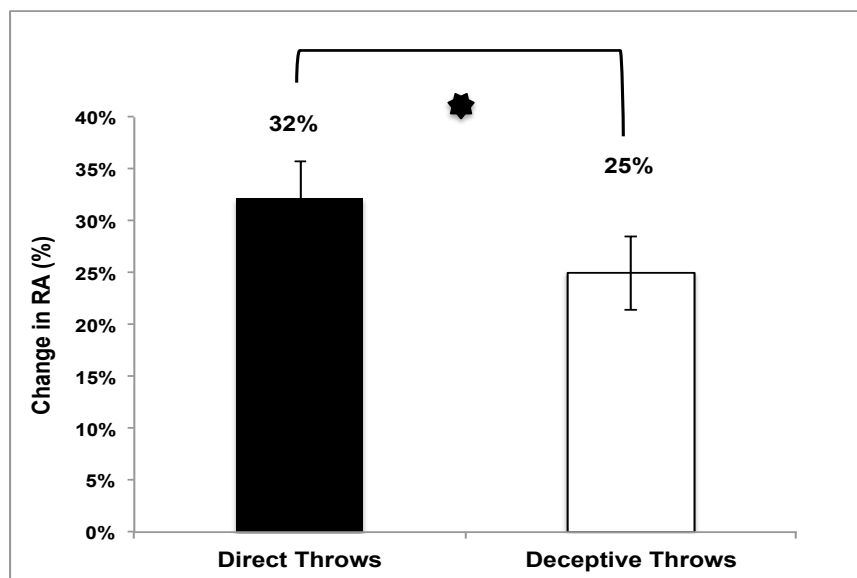


Figure 10. Bars graphs represent the size of the improvement for RA in direct throws and in deceptive throws. The significant difference in improvement rates

indicates that perceptual training was more effective for direct than deceptive throws.

The ANOVA's results revealed that the average prediction score, represented as the percentage of accurately predicted deceptive 7-m throw directions improved significantly less than the average prediction score for direct throw directions: $F(1, 13) = 14.480, p = .002$, partial $\eta^2 = .527$. Confirming the second research hypothesis, these results showed that although perceptual training improved anticipation of both direct and deceptive throws, anticipation of deceptive throws showed less improvement compared to direct throws.

The Size of the Difference Before and After Perceptual Training

As mentioned earlier, compared to direct throws, anticipation of deceptive throws showed less improvement after perceptual training. This confirms the findings from Study I (i.e., Pilot Study), that deception has a significant impact on anticipation. Therefore, the size of difference between anticipation of direct and deceptive throws did not change from pre- to post-test. Figure 11 demonstrates the differences evident after comparisons between anticipatory performances in direct (44%) and deceptive (36%) throwing conditions in the pre-training period, and between direct (76%) and deceptive (61%) throwing conditions in the post-training period for participants in the perceptual training group. These differences illustrate that although improvement occurred after training, anticipation of deceptive throws was always lower than anticipation of direct throws.

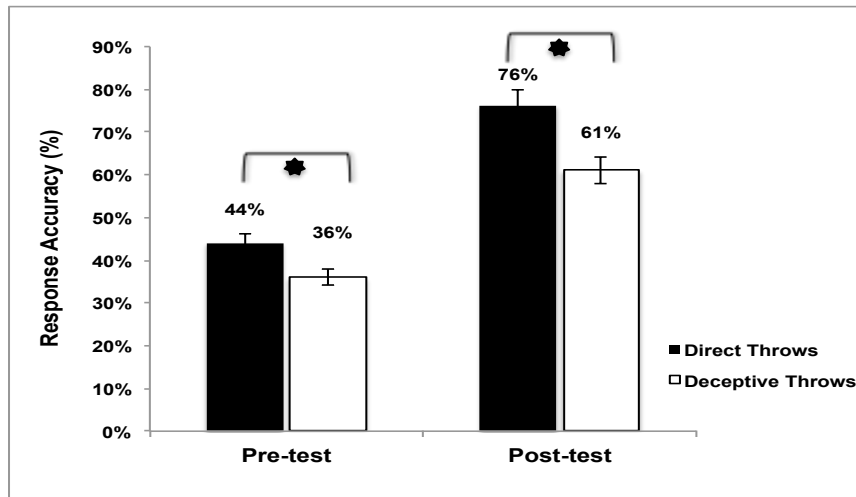


Figure 11. Anticipatory performance in direct and deceptive throwing conditions for participants in the perceptual training group. The first pair of bars represents the differences before training, and the second pair of bars represents differences after training.

A paired-samples t-test was conducted to compare anticipation of direct and deceptive throws before and after training. Before training, there was a significant difference between anticipation of direct (44%) and deceptive (36%) throws; $t(13) = 4.587, p = .001$. After training, there also was a significant difference between anticipation of direct (76%) and deceptive (61%) throws; $t(13) = 8.272, p < .001$. Confirming findings from Study I (i.e., pilot study), these results suggest that deception is a challenging task and always associated with lower anticipation.

Summary of the Results

To put it briefly, the previous Mixed-ANOVA showed that goalkeepers receiving handball-specific perceptual training significantly improved their accuracy when anticipating the directions of both direct and deceptive 7-m throws. Furthermore, an additional ANOVA confirmed that compared to direct throws, anticipation of deceptive throws showed less improvement. The difference in the size of improvement encouraged the researcher to re-examine the size of the difference between anticipation of direct and deceptive throws before

and after training. Confirming the findings of Study I, the significant size of difference between anticipation of direct and deceptive throws persisted even after perceptual training.

The main results support the first research hypothesis that group receiving perceptual training would be more accurate than either the control and placebo groups. In addition, these results support the second hypothesis that anticipation of deceptive throws would show less improvement compared to direct throws. Skill level showed no effect on performance as both elite and youth participants showed significant improvement in anticipation of both direct and deceptive throws.

Chapter 5 : Discussion and Conclusion

The current study examined whether the accuracy of goalkeepers' anticipatory performance could be improved by exposure to a video-based perceptual training. The training included a mix of videotaped direct and deceptive 7-m throws. It was predicted that the anticipation of both direct and deceptive 7-m throw directions could be improved with perceptual training. It was also predicted that anticipation of deceptive throws would show less improvement compared to direct throws.

The main findings of the current study suggest that handball-specific perceptual training containing a mix of deceptive and direct throwing conditions was a significant factor that enhanced goalkeepers' anticipatory performance. Although anticipation of both direct and deceptive throws was significantly improved, anticipation of deceptive throws showed less improvement compared to anticipation of direct throws. Additional findings showed that deception was a challenging task that negatively affected anticipation even improvement in anticipation has occurred. The following sections provide theoretical and scientific interpretation of the current research findings.

The Effect of Perceptual Training

Although the significant disparity between the accuracy of anticipating direct and deceptive 7-m throw directions persisted after perceptual training, the current findings, as predicted, showed that similar to anticipation of direct throws, anticipation of deceptive throws could also be improved. The perceptual training film was designed to enhance the efficacy of goalkeepers' visual search behavior by stimulating them to detect more useful information or cues by lessening the usefulness of the cues used by novices, or cues not-related to throw velocity or accuracy (Jacobs et al., 2001; and Smeeton et al., 2013). In

other words, perceptual training was designed in such a way that guides attention toward the most relevant global information on the upper body of the thrower, instead of guiding attention toward information distributed on the lower body.

Group comparisons were made between goalkeepers' response accuracy between groups given perceptual training, groups given placebo training, and the control group. The RA scores for participants summed across groups for pre-and post-anticipation tests revealed a clear difference in the level of improvement of RA percentages (Figure 12).

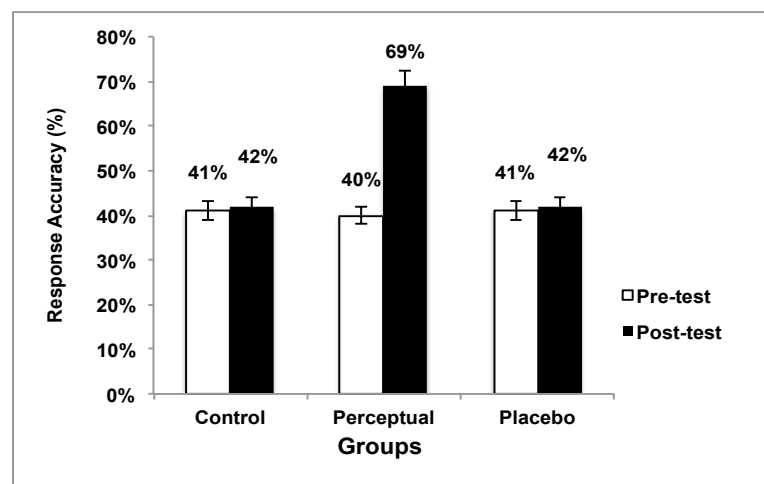


Figure 12. Prediction accuracy (%) for participants across three groups (control, perceptual, and placebo training groups).

As it can be readily seen in Figure 12, from the pre-training to the post-training test, only the perceptual training group showed a significant improvement in their response accuracy scores. The current findings are in agreement with the previous research that showed how sport-specific perceptual training could lead to better anticipation of opponents' forthcoming action (Farrow & Abernethy, 2002; Helsen & Starkes, 1999; McMorris & Hauxwell, 1997; Meeton et al. 2005; Williams et al. 2003; Williams et al. 2002). Because participants in the perceptual training group alone improved from pre-test to post-test, it appears that goalkeepers were able to learn to extract, analyze, and read the cues that explain the possible actions of their opponents.

This is the first study that involves a combination of deceptive and direct throws in perceptual training. Although little is known about using deception-specific perceptual training, the significant improvement in the accuracy of anticipation continued for the perceptual training group, even when a comparison was drawn between the improvements in anticipation of direct and anticipation of deceptive 7-m throws. Figure 13 demonstrates the group-based improvement in prediction accuracy when anticipating direct and deceptive 7-m throws.

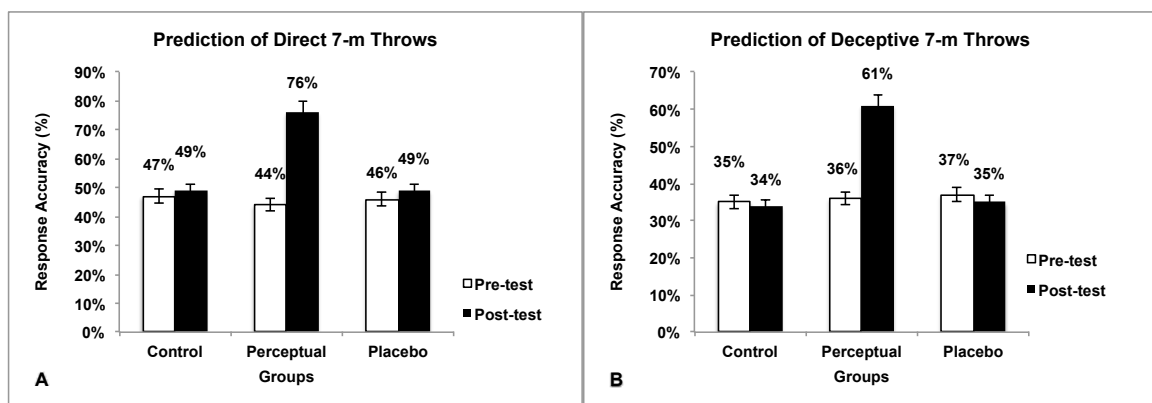


Figure 13. Changes in anticipatory performance from pre- to post-test for participants in three experimental groups. (A) represents prediction accuracy for direct 7-m throws; (B) represents prediction accuracy for deceptive 7-m throws.

This study adds to the perceptual training literature that not only can anticipation of forthcoming action under regular throwing conditions be improved, but also that anticipation of forthcoming action under deceptive throwing conditions can be improved. Including deceptive throwing conditions in video-based perceptual training programs can improve the detection of deception and improve anticipation of deceptive throwing conditions.

Reasons for Performance Improvement

The large improvement in performance for participants in the perceptual training group was somewhat surprising. This improvement in RA scores in general (Figure 12),

and under deceptive and direct throwing conditions (Figure 13), might be related to the following reasons:

1. The method (reduced usefulness training) used to guide goalkeepers' attention toward the most important global cues.
2. The general, and deception-specific, perceptual expertise status for participants prior to the experiment.

With respect to the first reason, the perceptual training applied in this study could be classified as reduced usefulness training (Jacobs et al., 2001; Jacobs et al., 2003; Smeeton et al. 2013). This training resulted in a large improvement in the accuracy of anticipating 7-m throw directions under deceptive and direct throwing conditions. Although the aim of the study was not to stress the appropriate instructional approaches for improving anticipation skills (e.g., Smeeton et al. 2005), it was found that fostering goalkeepers' attention toward more useful information or cues followed by feedback concerning the correctness of participant responses offered an encouraging approach for improving the response accuracy of goalkeepers' judgment under deceptive and direct throwing conditions. Instead of having goalkeepers discover the useful cues from the display of a throwers' whole body, by using highlighting techniques (Abernethy et al., 2012; and Savelsbergh et al., 2010), the display was cropped to present only the throwers' upper body (useful information) and included screen subtitles to guide the goalkeepers' attention toward the most important global cues (Bourne et al. 2013; Wagner et al. 2010). Instead of having goalkeepers direct their attention to local cues, the aim was to guide attention toward global information within the upper body of the throwers. It appeared that goalkeepers in the perceptual training group were able to

reduce perceptual uncertainty, which in turn facilitated their detection of deception and anticipation of future actions in real world situations. Thus, the reduced usefulness training approach used in the current study may be an important factor accounting for the significant improvement in anticipatory performance found in the current study.

Local or global information extraction strategy. It has been shown that when it comes to anticipating ball direction, expert performers extract useful cues from areas within display and not from any single body segment (Huys et al. 2009; Huys et al. 2008; Williams et al. 2009). The 7-m throw in handball is a complex skill that involves a coordinated pattern of movements that span the entire upper-body, reflecting the formation of motor synergies and involving multiple upper body segments. For example, to generate a powerful and accurate 7-m throw while maintaining stability and executing deceptive actions, a thrower is required to use hips, trunk, shoulders, arms, and to some extent wrist and fingers (Wagner et al., 2010). Thus, the information used by goalkeepers to detect deception and/or anticipate the direction of a 7-m throw might be distributed around, rather than localized to one particular segment (see Huys et al. 2009; Williams et al. 2009).

Recent handball research (Bourne et al., 2013) found that skilled participants relied on information that was spread globally across the handball thrower's body, confirming previous findings that experts employ a global, rather than a local, extraction strategy. Being sensitive to local, rather than global, information makes the observer more likely to be deceived (Jackson et al., 2006) or to be confounded by a local cue that may have been observed but incorrectly interpreted. This view has become more logical since research has determined expert-novice differences in relation to the ability to

perform under deceptive conditions (Brault et al. 2010; Dicks et al., 2010; Mori & Shimada, 2013; Sebanz & Shiffrar, 2009). For example, expert handball players and goalkeepers were able to detect deception at significantly higher rates than novices (Cañal-Bruland & Schmidt, 2009), and they detected deception equally even when the perceptual viewing perspective was modified to fit a goalkeeper's visual expertise (Cañal-Bruland et al. 2010). Although the mechanism behind the ability to extract information globally is not clear at present, and further research will be necessary, it seems clear that a global information extraction strategy may allow for greater perceptual flexibility when certain information sources are constrained or deceived (Bourne et al. 2013). Therefore, the preceding instructional approach in which the goalkeepers' visual attention was guided toward global, rather than local, cues on the handball thrower's upper body that determine the throw's accuracy and velocity have significantly improved goalkeepers sensitivity to detect deception and accurately anticipate the directions of both direct and deceptive throws.

With respect to the second reason, the deficit in goalkeepers' general perceptual expertise and their deception-specific perceptual expertise before receiving perceptual training may also explain the large improvement in their anticipatory performance. This seems logical, taking into account the style/type of practice used by coaches both in Kuwait and more generally in other regions. Coaches often pay more attention to physical, technical, tactical aspects of training and neglect goalkeepers' needs for domain-specific perceptual training in general and for perceptual training in deceptive situations in particular. Participants in the current study stated that they had never received deception and/or non-deception-specific perceptual training, such as video-

based training. The unique new perceptual experience they gained after intensive video-based perceptual training might be a significant factor in reducing the noise in their perceptual systems that may occur when a thrower performs effective deceptive arm movements. This perceptual experience may have enabled them to effectively extract and interpret global cues from the upper-body of the throwers.

In an intervention study (Hageman et al., 2006), novice badminton players given perceptual training performed better than novices given no training. However, no remarkable benefits were found for national level players, perhaps because they may have already acquired perceptual skills. In the current study, although participants (elite and youth) were considered skilled goalkeepers (based on years of playing experience [7.3 years for youth and 16 years for elite]), they showed significant and sharp improvement in performance.

It is noteworthy that both elite and youth goalkeepers showed meaningful improvement in anticipatory performance under both throwing conditions following an intensive seven sessions of perceptual training. Thus, not the general expertise but the domain-specific expertise (Abernethy et al. 2009; Abernethy & Russell, 1987; Abernethy & Zawi, 2007; Farrow & Abernethy, 2003; Ward et al. 2002) could explain the significant improvement in anticipatory performance. The more task-specific perceptual training the goalkeepers have, the more that accurate and efficient RA will emerge when anticipating 7-m throw directions.

In team handball, the pace of the play is often too fast to permit slow interpretation of a situation. Thus, reading a thrower's action must be done accurately and quickly. Goalkeepers must become adept at detecting deception and at shifting their

senses from detecting deception to anticipating throw directions. Quick, accurate, and smooth shifting requires a high level of domain-specific perceptual expertise that can only be developed through the same domain-specific perceptual training. When it comes to goalkeeper-thrower interaction, no one can guarantee what an opponent might do. Each opponent (e.g., a thrower and a goalkeeper) would try to minimize information that might determine his/her intentions. Therefore, deception will continue to be a challenging task that expert handball goalkeepers can minimize, but cannot, eliminate its effect. Thus, this can explain why the anticipation of deception throws, compared to direct throws, showed less improvement.

In sum, this study confirms that with perceptual training not only can anticipation of forthcoming action under regular throwing conditions be improved, but also that anticipation of forthcoming action under deceptive throwing conditions can be improved. Including deceptive throwing conditions in perceptual training and guiding the goalkeepers' visual attention toward global important cues can improve their ability to efficiently detect deception and accurately anticipate the directions of both direct and deceptive throws.

Portable Perceptual Training Devices

In the current study, an innovative methodological intervention was used to enhance the quality and the quantity of domain- and task-specific perceptual training for handball goalkeepers. The previous literature indicated that to develop perceptual-cognitive skills and to seek superiority in performance, deliberate practice (Ericsson et al. 1993) and/or deliberate play activities (Côté, 1999; Côté, Baker, & Abernethy, 2007) is the path of excellence. These two views explain how important the quantity and the

quality of practice together are for achieving superiority. Practically, as indicated earlier, coaches mainly focus on developing technical, physical, and psychological skills and tend to neglect perceptual-cognitive skills. Even though there is a desire to develop perceptual-cognitive skills, such as reading the future actions of opponents, coaches often look for practical, affordable, effective, simple, enjoyable, and non-time consuming perceptual training equipment. Between the desires of coaches and the suggestions of sport scientists, the findings of the current study suggest that using portable devices, such as an iPad, as a training supplement for perceptual-cognitive expertise is a good choice for coaches and athletes. In addition to their daily practice routine, goalkeepers can use that perceptual training as off-field training. By doing so, they will enhance the quality of their perceptual expertise by adding perceptual-specific practice to their daily technical practice and will increase the quantity of their training hours by using such a tool out of regular practice hours.

Although this study provided participants with perceptual training via iPad under supervision, it was suggested that players practice perceptual training on their own to see how self-practice might influence perceptual expertise. The training film was designed in such a way so as to be played on any portable device such as an iPad or iPhone. This study suggests that coaches and their assistants can use the findings to design their own sport-task-specific video-based perceptual training program. Then, they can advise their players to use such training to supplement their regular practice.

Limitations

1. Due to time constraints and the commitment of participants to preparatory summer-training camps, a limitation of this study would be its lack of a retention test to

determine any permanent change in performance. From coaching perspective, however, when coaches notice improvement in performance associated with particular training they will continue using that training to keep their athletes' performance at appropriate level.

2. It is possible that in 7-m throws, differences in ball flight will occur subsequent to minor modifications in wrist and finger mechanics in the final stages of the throw (Bourne et al. 2011). Although the wrist contributes less to ball velocity (Van den Tillaar & Etemma, 2004, 2007; Wagner et al. 2010), it has been suggested that it might contribute to throwing accuracy (Hore, Wats, Martin, & Miller, 1995). Thus in the current study when participants responded to the stimuli they may have encountered difficulties in determining the height of the throw but not the side of the throw. Viewing cues such as the trunk, shoulder, elbow, and forearm can determine the side of the throw, but the wrist greatly determines the height of the throw, as it is the last segment that affects throw direction before ball release. Practically speaking, the researcher has observed that goalkeepers are not generally able to extract any information from the wrist to determine the throw direction, as the wrist is hidden behind the ball. Thus, perceptual expertise may help goalkeepers to predict the throw side direction, and the goalkeepers' physical readiness could determine the throw height.

3. A suitable test was not employed to examine whether training facilitated performance in the real handball game context. An appropriate transfer test is essential to determine whether any improvements wrought by perceptual training will transfer to the game situation (Abernethy, 2002; Williams et al., 2003).

Practical Implications

Deceptive action in handball provides athlete advantages over an opponent. Such advantages may be no longer than 100 msec in time or half a meter in distance; however, they will permit an expert player to hit, shoot, pass, escape, or deceive. Obviously, during competitive situations (e.g., a 7-m throw in handball), an opponent attempts to conceal the kinematic information that calls attention to a particular movement; the perceiver, at the same time, always attempts to detect that kinematic information in advance to determine the opponent's action possibilities (i.e., affordances) in order to have an advantage over an opponent (Brault et al. 2009; Cañal-Bruland et al. 2010; Kunde et al. 2011). Thus, perceiving such information not only enhances an athlete's ability to anticipate forthcoming actions with a higher level of accuracy but also improves an athlete's ability to detect an opponent's intention to engage in deceptive actions (Jackson et al. 2006). The findings of the current study have important implications for sport scientists, coaches, and goalkeepers:

The inclusion of deceptive throws in the video-based perceptual training film appeared to be beneficial for enabling goalkeepers to anticipate deceptive (in addition to non-deceptive) actions. Thus, it is important for sport scientists to include a mix of deceptive and direct trials in any proposed perceptual training program that aims to enhance athletic perceptual superiority, especially in sports where deception often occurs.

Coaches can begin to integrate the findings of the current study into their training routines to improve deception skills for the field players and anticipation skills for the goalkeepers. Coaches may include deception-specific training for throwers so as to encourage throwers to become expert at deceiving their opponents (e.g., goalkeepers),

and they may provide perceptual training to goalkeepers to enhance their abilities to use a global (over local) information pick up strategy to minimize the effect of deception.

In thrower-goalkeeper interpersonal interaction, the thrower must produce deceptive action accurately and quickly to hide any cues that might be easily extracted by goalkeepers. Thus, coaches must assist field players at becoming adept at performing an action (e.g., deceptive arm movements) and then shifting to another without committing to the first course of action, and without demonstrating any anticipatory cues about the forthcoming actions. Thus, with deception-specific practice, a field player will approach the appropriate level of expertise, honing those deceptive skills that are hard for goalkeepers to predict and stop.

On the other hand, the goalkeeper must extract and interpret the information accurately and quickly to detect deception and to accurately anticipate the subsequent actions. To reduce the suspicion of deception and to enhance the accuracy of anticipation, the findings of the current study suggest that goalkeepers must hold task-specific perceptual expertise. Thus, goalkeepers must receive deception- and non deception-specific perceptual training to enhance their ability to detect deception and anticipate the forthcoming actions.

In brief, regularly practicing deception will enhance field players' deception-specific motor expertise (Sebanz & Shiffrar, 2009) and goalkeepers' deception-specific visual expertise (Jackson et al. 2006) and therefore enhance field players' and goalkeepers' anticipatory performance in deceptive situations (Cañal-Bruland & Schmidt, 2009; Cañal-Bruland et al. 2010).

Accordingly and as mentioned earlier, the results and the related literature confirmed that for every deceptive action there is a countermeasure action that could decrease the chances of deception. The researcher sought to provide handball goalkeepers with some practical recommendations based on the findings of the current study supported by findings from the previous literature:

- Be sensitive to a thrower's attempt to hide a real intention. A deceiver may spontaneously "leak" withheld information or send clues of intention, either of which may be useful to opponents.
- Goalkeepers must know an opponent's favorite style of throw. For players who are superior in making deceptive actions, deception often becomes habitual. A careful goalkeeper can detect that a thrower's preparatory acts are just deceptive movements. However, a goalkeeper must be careful of being biased toward deception (Jackson et al. 2006). According to Barnett (1971:29): If a thrower always passes without faking, or always fakes before a pass, the defender will anticipate this. If a thrower fakes now and then, he or she will throw a defender off guard.
- Take the initiative. This strategy is indicated in Mawby and Mitchell (1986): "taking the play away from the opponent aims to make throwers react to your actions" (p. 319). Kuhn (1988) suggested that three quarters of soccer kickers use strategies that are reactive to movements of goalkeepers.
- Goalkeepers should read the physical status of the thrower. For instance, players may get tired during the last minute of a demanding handball game or after having performed many throws during a game. Thus, deception if employed by a tired thrower may be easily detected.

- Goalkeepers must be aware of the rule of the game and know that a thrower has only 3 s to complete a 7-m throw after the referee's whistle. Thus, if a thrower starts moving exactly after the whistle, the chance of executing deceptive arm movement is high, while if a thrower does not start moving until after the whistle, the thrower has less time to execute deceptive movements.
- Goalkeepers must realize the status of the competition. Players under psychological and social pressure often avoid deceptive actions.

Finally, in the world of team handball, an evaluation of the response accuracy of goalkeepers in 7-m throw situations during the last five world championships for elite, junior, and youth (Figure 14) raises questions as to what extent deception has affected the overall performance of expert and novice, or best and worst, goalkeepers. What was the total number of deceptive 7-m throws out of overall penalties that have been thrown up to the most recent world championship? The researcher argues that determining the effect of deception on goalkeepers' performance will open doors to develop appropriate training that focuses on goalkeepers' anticipation skills and overall performance.

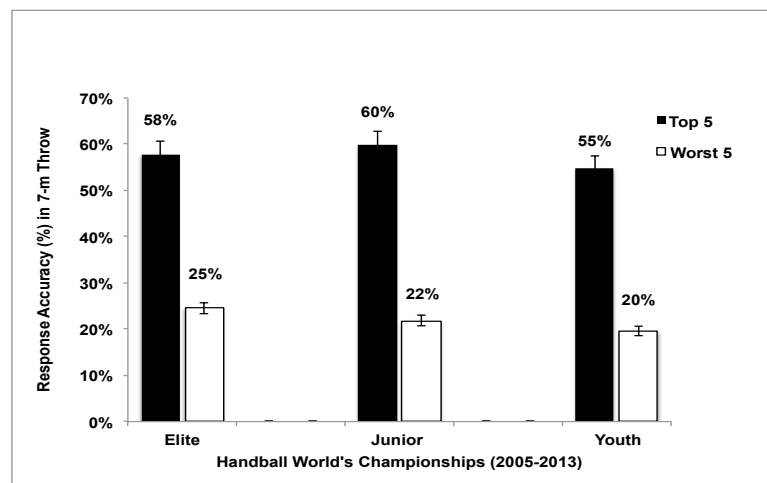


Figure 14. 7-m throw saving accuracy scores (%) in the Handball World Championships from 2005-2013.

Conclusion

The effect of video-based perceptual training on the performance of handball goalkeepers when anticipating the direction of direct and deceptive 7-meter throws was examined. The size of improvement in anticipation of direct and deceptive throws was also tested. In addition, the size of the difference between response accuracy in direct and deceptive throwing conditions was examined before and after perceptual training. Results found across this study produced the following conclusions:

- Handball-specific perceptual training containing a mix of direct and deceptive throws can enhance handball goalkeepers' ability to accurately anticipate the directions of 7-m throws in direct and deceptive throwing conditions.
- Although anticipation of both direct and deceptive throws was significantly improved, anticipation of deceptive throws showed less improvement compared with anticipation of direct throws.
- Deception in handball is a challenging task that perceptually skilled goalkeepers can minimize, but not eliminate, its effect.

In conclusion, this research, in conjunction with previous research, indicates that general experience and maturation cannot alone account for successful prediction (Abernethy, 1988; Abernethy & Russell, 1987; Williams & Ericsson, 2005) of 7-m throw directions in direct and deceptive situations. However, video-based handball-specific perceptual training that includes a mix of deceptive and direct throws can enhance the accuracy of goalkeepers' judgments when anticipating 7-m throw directions under both throwing conditions. Thus, practitioners in the fields of sport science and handball should collaborate to provide handball goalkeepers with effective perceptual training that pays greater attention to deceptive actions. In the practical world, it is not about a goalkeeper

who tries to save goals or about a thrower who tries to score goals, it is about how a goalkeeper enhances perceptual ability to extract and interpret the available information from a thrower's body in advance and about how a thrower enhances motor ability to conceal kinematic or biological anticipatory cues that might be used by goalkeepers. Thus, the phenomena of deception is itself self-fulfilling. We should therefore work hard to improve throwers' and goalkeepers' ability to produce effective deceptive actions on one hand, and accurately perceive, detect, and response to deceptive actions on other hand.

The present study took a systematic step forward by including deception in perceptual training designed to enhance athletes' anticipatory performance. Deception in sport is still in its infancy and requires more attention and investigation, as research will likely lead to enhanced athletic performance.

References

- Abernethy, B (1987) Selective attention in fast ball sports: I: General Principles.
Australian Journal of Science and Medicine in Sport, 19(4), 3-6.
- Abernethy, B. (1987) Selective attention in fast ball sports. II: Expert novice differences.
Australian Journal of Science and Medicine in Sport, 19 (4), 7-16.
- Abernethy, B. (1988). The effect of age and expertise upon perceptual skill development in a racquet sport. *Research Quarterly*, 59, 210-221.
- Abernethy, B. (1990). Expertise, visual search, and information pick-up in squash.
Perception, 19, 63-77.
- Abernethy, B., & Wood, M. (2001). Do generalized visual training programs for sport really work? An experimental investigation. *Journal of Sports Sciences*, 19, 203-222.
- Abernethy, B., & Zawi, K. (2007). Pickup of essential kinematics underpins expert perception of movement patterns. *Journal of Motor Behavior*, 39, 353-367.
- Abernethy, B., and Russell, D. (1987). Expert-novice differences in an applied selective attention task. *Journal of Sport Psychology*, 9, 326-345.
- Abernethy, B., Baker, J., & Côté, J. (2005). Transfer of pattern recall skills may contribute to the development of sport expertise. *Applied Cognitive Psychology*, 19, 705-718.
- Abernethy, B., Farrow, D., Gorman, A. D., & Mann, D. L. (2012). Anticipatory behavior and expert performance. In J. Nicola, A. Hodges, & M. Williams (Eds.), *Skill acquisition in sport: Research, theory and practice*, 287. New York: Routledge.
- Abernethy, B., Gill, D., Parks, L., & Packer, T. (2001). Expertise and the perception of

- kinematic and situational probability information. *Perception*, 30, 233-252.
- Abernethy, B., Neal, J., & Koning, P. (1994). Visual-perceptual and cognitive differences between expert, intermediate, and novice snooker players. *Applied Cognitive Psychology*, 8, 185-211.
- Abernethy, B., Wood, J. M., & Parks, S. (1999). Can the anticipatory skills of experts be learned by novices?. *Research Quarterly for Exercise and Sport*, 70(3), 313-318.
- Aglioti, M., Cesari, P., Romani, M., & Urgesi, C. (2008). Action anticipation and motor resonance in elite basketball players. *Nature Neuroscience*, 11, 1109-1116.
- Allard, F., & Starkes. (1980). Perception in sport: volleyball. *Journal of Sport Psychology*, 2, 22-33.
- Allard, F., Graham, S., & Paarsalu, M. E. (1980). Perception in sport: Basketball. *Journal of Sport Psychology*, 2, 14-21
- Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review*, 89, 369-406.
- Atkinson, P., Dittrich, H., Gemmell, J., & Young, W. (2004). Emotion perception from dynamic and static body expressions in point-light and full-light displays. *Perception*, 33, 717-746.
- Barnett, D., & Borgi, A. (1971). *Inside basketball*. Contemporary Books.
- Bayios, I., Georgiadis, G., & Boudolos, K. (1998). Accuracy and throwing velocity in handball. *Proceeding of the XVIth International Symposium on Biomechanics in Sports (Edited by HJ Riehle and MM Vieten)*, 1, 55-58.
- Beek, P. J., Jacobs, D. M., Daffertshofer, A., & Huys, R. (2003). Expert performance in sport: Views from the joint perspectives of ecological psychology and dynamical

- systems theory. In J. L. Starkes & E. K.A. (Eds.), *Expert performance in sports: Advances in research on sport expertise* (pp. 321-344). Champaign, IL: Human Kinetics Publishers.
- Berry, J., Abernethy, B., & Côté, J. (2008). The contribution of structured activity and deliberate play to the development of expert perceptual and decision-making skill. *Journal of Sport & Exercise Psychology, 30*, 685-708.
- Borgeaud, P., & Abernethy, B. (1987). Skilled perception in volleyball defense. *Journal of Sport Psychology, 9*, 400-406.
- Bourne, M., Bennett, J., Hayes, J., & Williams, M. (2011). The dynamical structure of handball penalty shots as a function of target location. *Human Movement Science, 30*, 40-55.
- Bourne, M., Bennett, J., Hayes, J., Smeeton, N., & Williams, M. (2013). Information underpinning anticipation of goal-directed throwing. *Attention, Perception, & Psychophysics, 75*, 1559-1569.
- Brault, S., Bideau, B., Kulpa, R., & Craig, C. (2009). Detecting deceptive movement in 1 vs. 1 based on global body displacement of a rugby player. *International Journal of Virtual Reality, 8*, 31-36.
- Brooks, A., Schouten, B., Troje, F., Verfaillie, K., Blanke, O., & van der Zwan, R. (2008). Correlated changes in perceptions of the gender and orientation of ambiguous biological motion figures. *Current Biology, 18*, 728 -729.
- Cañal-Bruland, R., & Schmidt, M. (2009). Response bias in judging deceptive movements. *Acta Psychologica, 130*, 235–240.
- Cañal-Bruland, R., Mooren, M., & Savelsbergh, G. J. (2011). Differentiating Experts'

- Anticipatory Skills in Beach Volleyball. *Research Quarterly for Exercise and Sport*, 82, 667-674.
- Cañal-Bruland, R., van der Kamp, J., & van Kesteren, J. (2010). An examination of motor and perceptual contributions to the recognition of deception from others' actions. *Human Movement Science*, 29, 94-102.
- Carello, C., Grosfokky, A., Reichel, D., Solomon, Y., & Turvey, T. (1989). Visually perceiving what is reachable. *Ecological Psychology*, 1, 27-54.
- Chaouachi, A., Brughelli, M., Levin, G., Boudhina, N. B. B., Cronin, J., & Chamari, K. (2009). Anthropometric, physiological and performance characteristics of elite team-handball players. *Journal of sports sciences*, 27(2), 151-157.
- Chapman, R., & Underwood, G. (1998). Visual search of driving situations: Danger and experience. *Perception-London*, 27, 951-964.
- Chase, W. G., & Simon, A. (1973). Perception in chess. *Cognitive Psychology*, 4, 55-81.
- Côté, J. (1999). The influence of the family in the development of talent in sport. *The sport psychologist*, 13, 395- 417.
- Côté, J., Baker, J., & Abernethy, B. (2007). Practice and play in the development of sport expertise. *Handbook of Sport Psychology*, 3, 184-202.
- Diaz, G. J., Fajen, B. R., & Phillips, F. (2012). Anticipation from biological motion: The goalkeeper problem. *Journal of Experimental Psychology: Human Perception and Performance*, 38, 848-864.
- Dicks, M., Davids, K., & Button, C. (2010). Individual differences in the visual control of intercepting a penalty kick in association football. *Human Movement Science*, 29, 401-411.

- Ericsson, K. A., Charness, N., Hoffman, R. R., & Feltovich, P. J. (Eds.). (2006). *The Cambridge handbook of expertise and expert performance*. New York: Cambridge University Press.
- Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*, 363-406.
- Fajen, B. R., Riley, M. A., & Turvey, M. T. (2008). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology*, *40*, 79-107.
- Farrow, D., & Abernethy, B. (2002). Can anticipatory skills be learned through implicit video based perceptual training? *Journal of Sports Sciences*, *20*, 471-485.
- Farrow, D., & Abernethy, B. (2003). Do expertise and the degree of perception-action coupling affect natural anticipatory performance? *Perception*, *32*, 1127-1139.
- Farrow, D., Abernethy, B., & Jackson, R. C. (2005). Probing expert anticipation with the temporal occlusion paradigm: Experimental investigations of some methodological issues. *Motor Control*, *9*, 330-349.
- Fine, P., Berry, A., & Rosner, B. (2006). The effect of pattern recognition and tonal predictability on sight-singing ability. *Psychology of Music*, *34*, 431-447.
- Foretić, N., Uljević, O., & Prižmić, A. (2010). Some metric characteristics of tests to assess ball speed during overarm throw performance. *Sport Logia*, *6*, 59-67.
- Fradet, L., Botcazou, M., Durocher, C., Cretual, A., Multon, F., Prioux, J., & Delamarche, P. (2004). Do handball throws always exhibit a proximal-to-distal segmental sequence? *Journal of Sports Sciences*, *22*, 439-447.
- Garland, D. J., & Barry, J. R. (1990). Sport expertise: the cognitive advantage. *Perceptual and Motor Skills*, *70*, 1299-1314.

- Garland, D. J., & Barry, J. R. (1991). Cognitive advantage in sport: The nature of perceptual structures. *The American Journal of Psychology*, *104*, 211-228.
- Gibson, J. J. (1986). *The ecological approach to visual perception*. Hillsdale, NJ: Erlbaum.
- Gutierrez-Davila, M., Rojas, F. J., Ortega, M., Campos, J., & Parraga, J. (2011). Anticipatory strategies of team-handball goalkeepers. *Journal of Sports Sciences*, *29*(12), 1321-1328.
- Grezes, J., Frith, C. D., & Passingham, R. E. (2004). Inferring false beliefs from the actions of oneself and others: An fMRI study. *NeuroImage*, *21*, 744–750.
- Hasan, A., Rahaman, J., Cable, N., & Reilly, T. (2007). Anthropometric profile of elite male handball players in Asia. *Biology of sport*, *24*, 3-12.
- Hagemann, N., Strauss, B., & Cañal-Bruland, R. (2006). Training perceptual skill by orienting visual attention. *Journal of sport and exercise psychology*, *28*, 143-158.
- Heberlein, A. S., Adolphs, R., Tranel, D., & Damasio, H. (2004). Cortical regions for judgments of emotions and personality traits from point-light walkers. *Journal of Cognitive Neuroscience*, *16*, 1143-1158.
- Helsen, W. F., & Starkes, J. L. (1999). A multidimensional approach to skilled perception and performance in sport. *Applied Cognitive Psychology*, *13*, 1-27.
- Hore, J., Watts, S., Martin, J., & Miller, B. (1995). Timing of finger opening and ball release in fast and accurate overarm throws. *Experimental Brain Research*, *103*, 277-286.
- Hove, P., Riley, M. A., & Shockley, K. (2006). Perceiving affordances of hockey sticks by dynamic touch. *Ecological Psychology*, *18*, 163-189.
- Huys, R., Cañal-Bruland, R., Hagemann, N., Beek, P. J., Smeeton, N. J., & Williams, A. M. (2009). Global information pickup underpins anticipation of tennis shot direction.

- Journal of Motor Behavior*, 41, 158-171.
- Huys, R., Smeeton, N. J., Hodges, N. J., Beek, P. J., & Williams, A. M. (2008). On the dynamic information underlying visual anticipation skill. *Perception & Psychophysics*, 70, 1217-1234.
- Inglis, M., & Alcock, L. (2012). Expert and novice approaches to reading mathematical proofs. *Journal for Research in Mathematics Education*, 43, 358-390.
- International Handball Federation. Rules of the game. Basel: IHF, 2010.
- Jackson, R. C., & Farrow, D. (2005). Implicit perceptual training: How, when, and why?. *Human Movement Science*, 24, 308-325.
- Jackson, R. C., Warren, S., & Abernethy, B. (2006). Anticipation skill and susceptibility to deceptive movement. *Acta Psychologica*, 123, 355-371.
- Jacobs, D. M., Runeson, S., and Michaels, C. F. (2001). Learning to visually perceive the relative mass of colliding balls in globally and locally constrained task ecologies. *Journal of Experimental Psychology- Human Perception & Psychophysics*, 70:1217-1038.
- Jones, C. M., & Miles, T. R. (1978). Use of advance cues in predicting the flight of a lawn tennis ball. *Journal of Human Movement Studies*, 4, 231-235.
- Kajtana, T., Vuleta, D., Pori, M., Justin, I., & Pori, P. (2012). Psychological characteristics of slovene handball goalkeepers. *Kinesiology*, 44(2), 209-217.
- Kioumourtzoglou, E., Kourtessis, T., Michalopoulou, M., and Derri, V. (1998). Differences in several perceptual abilities between experts and novices in basketball, volleyball, and water polo. *Perceptual and Motor Skills*, 86, 899-912.
- Kuhn, W. (1988). Penalty-kick strategies for shooters and goalkeepers. In T. Reilly, A. Lees,

- K. Davids, & W. J. Murphy (Eds.), *Science and football* (pp. 489-492). London, England: E & FN Spon.
- Kunde, W., Skirde, S., & Weigelt, M. (2011). Trust my face: Cognitive factors of head fakes in sports. *Journal of Experimental Psychology: Applied*, *17*, 110-127.
- Lavalle D, Kremer J, Moran AP, Williams AM (2004). Sport Expertise. In: D. Lavalle, J. Kremer, A. P. Moran, & A. M. Williams (Eds.). *Sport Psychology: Contemporary Themes*. New York: Palgrave Macmillan, 139-158.
- Loula, F., Prasad, S., Harber, K., & Shiffrar, M. (2005). Recognizing people from their movement. *Journal of Experimental Psychology: Human Perception and Performance*, *31*, 210–220.
- Mann, D. T., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual cognitive expertise in sport: a meta-analysis. *Journal of Sport and Exercise Psychology*, *29*, 457- 478.
- Mark, L. S. (1987). Eyeheight-scaled information about affordances: A study of sitting and stair climbing. *Journal of Experimental Psychology: Human Perception and Performance*, *13*, 361-370.
- Mark, L. S. (2007). Perceiving the actions of other people. *Ecological Psychology*, *19*, 107-136.
- Marques, M. C., Van Den Tillaar, R., Vescovi, J. D., & González-Badillo, J. J. (2007). Relationship between throwing velocity, muscle power, and bar velocity during bench press in elite handball players. *International Journal of Sports Physiology & Performance*, *2*(4), 414-422.
- Mawby, R., & Mitchell, R. (1986). Feints and ruses: An analysis of deception in sports. In R.

- W. Mitchell & N. S. Thompson (Eds.), *Deception: Perspectives on human and non-human deceit* (pp. 313–322). Albany, NY: SUNY Press.
- McMorris, T., & Hauxwell, B. (1997). Improving anticipation of soccer goalkeepers using video observation. *Science and football III*, 290-294.
- Montepare, J. M., & Zebrowitz-McArthur, L. (1988). Impressions of people created by age-related qualities of their gaits. *Journal of Personality and Social Psychology*, 55, 547-556.
- Mori, S., & Shimada, T. (2013). Expert anticipation from deceptive action. *Attention, Perception, & Psychophysics*, 75, 751-770.
- Müller, S., & Abernethy, B. (2012). Expert anticipatory skill in striking sports: A review and a model. *Research Quarterly for Exercise and Sport*, 83, 175-187.
- Müller, S., Abernethy, B., & Farrow, D. (2006). How do world-class cricket batsmen anticipate a bowler's intention? *The Quarterly Journal of Experimental Psychology*, 59, 2162-2186.
- Müller, S., Abernethy, B., Eid, M., McBean, R., Rose, M., (2010). Expertise and the spatio-temporal characteristics of anticipatory information pick-up from complex movement patterns. *Perception*, 39, 745 - 760.
- Müller, S., Abernethy, B., Reece, J., Rose, M., Eid, M., McBean, R., & Abreu, C. (2009). An in-situ examination of the timing of information pick-up for interception by cricket batsmen of different skill levels. *Psychology of Sport and Exercise*, 10, 644-652.
- Panchuk, D., & Vickers, J. N. (2006). Gaze behaviors of goaltenders under spatial–temporal constraints. *Human Movement Science*, 25, 733-752.
- Paull, G., & Glencross, D. (1997). Expert perception and decision making in baseball.

International Journal of Sport Psychology, 28, 35-56.

Pizzera, A., & Raab, M. (2012). Perceptual Judgments of Sports Officials are influenced by their Motor and Visual Experience. *Journal of Applied Sport Psychology*, 24, 59-72.

Pori, P., Šibila, M., Justin, I., Kajtna, T., & Pori, M. (2012). Correlation between the motor abilities and competitive performance of Slovenian handball goalkeepers.

Kinesiologia Slovenica, 18, 19-26

Ramenzoni, V. C., Riley, M. A., Davis, T., Shockley, K., & Armstrong, R. (2008a). Tuning in to another person's action capabilities: perceiving maximal jumping-reach height from walking kinematics. *Journal of Experimental Psychology: Human Perception and Performance*, 34, 919-928.

Ramenzoni, V. C., Riley, M. A., Shockley, K., & Davis, T. (2008b). An information-based approach to action understanding. *Cognition*, 106, 1059–1070.

Rivilla-García, J., Muñoz, A., Grande, I., Sanchís Almenara, M., & Sampedro, J. (2013). A comparative analysis of visual strategy in elite and amateur handball goalkeepers.

Journal of Human Sport & Exercise, 8(3), 743-753.

Rowe, R., Horswill, M. S., Kronvall-Parkinson, M., Poulter, D. R., & McKenna, F. P. (2009). The effect of disguise on novice and expert tennis players' anticipation

ability. *Journal of Applied Sport Psychology*, 21, 178-185.

Runeson, S., & Frykholm, G. (1983). Kinematic specification of dynamics as an informational basis for person-and-action perception: Expectation, gender recognition, and deceptive intention. *Journal of Experimental Psychology: General*, 112,

Salmela, J. H., & Fiorito, P. (1979). Visual cues in ice hockey goaltending. *Canadian*

Journal of Applied Sport Sciences, 4, 56-65.

Savelsbergh, G. J., Van der Kamp, J., Williams, A. M., & Ward, P. (2005). Anticipation and visual search behavior in expert soccer goalkeepers. *Ergonomics*, 48, 1686-1697.

Savelsbergh, G. J., Williams, A. M., Van Der Kamp, J., & Ward, P. (2002). Visual search, anticipation and expertise in soccer goalkeepers. *Journal of Sports Sciences*, 20, 279-287.

Schorer, J. (2005). Being right-on-time shows the sensory-motor expertise of national handball goalkeepers. *Journal of Sport and Exercise Psychology*, 27, S135.

Schorer, J., & Baker, J. (2009). An exploratory study of aging and perceptual-motor expertise in handball goalkeepers. *Experimental Aging Research*, 35, 1-19.

Sebanz, N., & Shiffrar, M. (2009). Bluffing bodies: Inferring intentions from actions. *Psychonomic Bulletin and Review*, 16, 170–175.

Shim, J., Carlton, L. G., Chow, J. W., & Chae, W. S. (2005). The use of anticipatory visual cues by highly skilled tennis players. *Journal of Motor Behavior*, 37, 164-175.

Shim, J., Miller, G., and Lutz, R. (2005). Visual cues and information used to anticipate tennis ball shot and placement. *Journal of Sport Behavior*, 28, 186-200.

Šibila, M., & Pori, P. (2009). Position-related differences in selected morphological body characteristics of top-level handball players. *Collegium antropologicum*, 33(4), 1079-1086.

Smeeton, N. J., & Huys, R. (2011). Anticipation of tennis-shot direction from whole-body movement: The role of movement amplitude and dynamics. *Human Movement Science*, 30, 957-965.

Smeeton, N. J., Huys, R., & Jacobs, D.M. (2013). When less is more: Reduced usefulness

- training for the learning of anticipation skill in tennis. *PLOS ONE*, 8 (11): 1-11.
- Smeeton, N. J., & Williams, A. M. (2012). The role of movement exaggeration in the anticipation of deceptive soccer penalty kicks. *British Journal of Psychology*, 103, 539-555.
- Smeeton, N. J., Ward, P., & Williams, A. M. (2004). Do pattern recognition skills transfer across sports? A preliminary analysis. *Journal of Sports Sciences*, 22, 205-213.
- Smeeton, N. J., Williams, A. M., Hodges, N. J., & Ward, P. (2005). The relative effectiveness of various instructional approaches in developing anticipation skill. *Journal of Experimental Psychology: Applied*, 11, 98-110.
- Spittle, M., Kremer, P., & Hamilton, J. (2010). The effect of screen size on video-based perceptual decision making tasks in sport. *International Journal of Sport and Exercise Psychology*, 8, 360-372.
- Sporiš, G., Vuleta, D., Vuleta, D. jr., & Milanović, D. (2010). Fitness Profiling in Handball: Physical and Physiological Characteristics of Elite Players. *Collegium antropologicum*. 34, 1009-1014.
- Starkes, J. L. (1987). Skill in field hockey: The nature of the cognitive advantage. *Journal of Sport Psychology*, 9, 146-160.
- Starkes, J. L., & Lindley, S. (1994). Can we hasten expertise by video simulations? *Quest*, 46, 211-222.
- Stoffregen, T. A., Gorday, K. M., Sheng, Y. Y., & Flynn, S. B. (1999). Perceiving affordances for another person's actions. *Journal of Experimental Psychology: Human Perception and Performance*, 25, 120-136.
- Stokes, A., Kemper, K., & Kite, K. (1997). Aeronautical decision making. Naturalistic

Decision Making. LEA, Mahwah, NJ.

- Vaeyens, R., Lenoir, M., Williams, A. M., Mazyn, L., and Philippaerts, R. M. (2007). The effects of task constraints on visual search behavior and decision-making skill in youth soccer players. *Journal of Sport and Exercise Psychology*, 29, 147-169.
- Van Den Tillaar, R., & Ettema, G. (2004). A force-velocity relationship and coordination patterns in overarm throwing. *Journal of Sports Science and Medicine*, 3, 211-219.
- Van Den Tillaar, R., & Ettema, G. (2007). A three-dimensional analysis of overarm throwing in experienced handball players. *Journal of applied biomechanics*, 23, 12-19.
- Van den Tillaar, R., & Ettema, G. (2009). Is there a proximal-to-distal sequence in overarm throwing in team handball?. *Journal of sports sciences*, 27(9), 949-955.
- Vuleta, D., Sporis, G., Vuleta, D_{jr}, Purgar, B, Herceg, Z., & Milanovic, Z. (2012). Influence of attacking efficiency on the outcome of handball matches in the preliminary round of men's Olympic games 2008. *Sport Science*, 5, 7-12.
- Wagner, H., & Müller, E. (2008). The effects of differential and variable training on the quality parameters of a handball throw. *Sports Biomechanics*, 7(1), 54-71.
- Wagner, H., Buchecker, M., von Duvillard, S. P., & Müller, E. (2010). Kinematic description of elite vs. low level players in team-handball jump throw. *Journal of Sports Science and Medicine*, 9, 15-23.
- Wagner, H., Pfusterschmied, J., Von Duvillard, S. P., & Müller, E. (2012). Skill-dependent proximal-to-distal sequence in team-handball throwing. *Journal of Sports Sciences*, 30, 21-29.
- Wagner, H., Pfusterschmied, J., von Duvillard, S. P., & Müller, E. (2011). Performance and kinematics of various throwing techniques in team-handball. *Journal of Sports*

Science and Medicine, 10, 73-80.

- Ward, P., & Williams, A. M. (2003). Perceptual and cognitive skill development in soccer: The multidimensional nature of expert performance. *Journal of Sport and Exercise Psychology, 25*, 93-111.
- Ward, P., Williams, A. M., & Bennett, S. J. (2002). Visual search and biological motion perception in tennis. *Research Quarterly for Exercise and Sport, 73*, 107-112.
- Warren, W. H. (1984). Perceiving affordances: Visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance, 10*, 683-703.
- Warren, W. H., & Whang, S. (1987). Visual guidance of walking through apertures: Body-scaled information for affordances. *Journal of Experimental Psychology: Human Perception and Performance, 13*, 371-383.
- Waters, A. J., & Underwood, G. (1998). Eye movements in a simple music reading task: A study of expert and novice musicians. *Psychology of Music, 26*, 46-60.
- Weast, J. A., Shockley, K., & Riley, M. A. (2011). The influence of athletic experience and kinematic information on skill-relevant affordance perception. *The Quarterly Journal of Experimental Psychology, 64*, 689-706.
- Wiegmann, D. A., Goh, J., & O'Hare, D. (2002). The role of situation assessment and flight experience in pilots' decisions to continue visual flight rules flight into adverse weather. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 44*, 189-197.
- Williams, A. M., Huys, R., Cañal-Bruland, R., & Hagemann, N. (2009). The dynamical information underpinning anticipation skill. *Human Movement Science, 28(3)*, 362-370.

- Williams, A. M., & Burwitz, L. (1993). Advance cue utilization in soccer. In Reilly, T., Clarys, J., & Stibbe, A. *Science and Football II*. London: E. & F. N. Spon.
- Williams, A. M., & Ericsson, K. A. (2005). Perceptual-cognitive expertise in sport: Some considerations when applying the expert performance approach. *Human movement science, 24(3)*, 283-307.
- Williams, A. M., & Ford, P. R. (2008). Expertise and expert performance in sport. *International Review of Sport and Exercise Psychology, 1*, 4 -18.
- Williams, A. M., & Grant, A. (1999). Training perceptual skill in sport. *International Journal of Sport Psychology, 30(2)*, 124-220.
- Williams, A. M., and Davids, K. (1998). Visual search strategy, selective attention, and expertise in soccer. *Research Quarterly for Exercise and Sport, 69*, 111-128.
- Williams, A. M., Davids, K. & Williams, J.G. (1999). *Visual perception and action in sport*. London: Taylor & Francis.
- Williams, A. M., Hodges, N. J., North, J. S., & Barton, G. (2006). Perceiving patterns of play in dynamic sport tasks: Investigating the essential information underlying skilled performance. *Perception 35*, 317 – 332.
- Williams, A. M., Ward, P., & Chapman, C. (2003). Training perceptual skill in field hockey: Is there transfer from the laboratory to the field? *Research Quarterly for Exercise and Sport, 74*, 98-103.
- Williams, A. M., Ward, P., Knowles, J. M., & Smeeton, N. J. (2002). Anticipation skill in a real- world task: measurement, training, and transfer in tennis. *Journal of Experimental Psychology: Applied, 8*, 259-270.
- Williams, A. M., Ward, P., Smeeton, N. J., & Allen, D. (2004). Developing anticipation

skills in tennis using on-court instruction: Perception versus perception and action.
Journal of Applied Sport Psychology, 16, 350-360.

Williams, M. A., Ward, J. D., Ward, P., & Smeeton, N. J. (2008). Domain specificity, task specificity, and expert performance. *Research quarterly for exercise and sport, 79*(3), 428-433.

Williams, M., Davids, K., Burwitz, L., & Williams, J. (1993). Cognitive knowledge and soccer performance. *Perceptual and Motor Skills, 76*, 579-593.