**Niklas Nyland**

# Visual Perception in Soccer:

A study of elite and sub-elite defenders.

**Master thesis in Sport Sciences**
Department of Coaching and Psycholgy
Norwegian School of Sport Sciences, 2010

# Forord

I den første uken på masterstudiet ble det holdt en veldig kort introduksjon av alle kursene på NIH, og det var i dette tilfelle hvor jeg ble gjort oppmerksom på persepsjon. Noe senere tok jeg kontakt med førsteamanuensis Geir Jordet, og vi diskuterte muligheter for en masteroppgave innenfor fotball og persepsjon. Allerede tidlig ble det inngått et samarbeid, og planleggingen var i gang.

Flere sentrale spørsmål i forhold til masteroppgaven var: Hva er ønske med min masteroppgave? Hvem skal deltakerne være? Hvordan skal jeg få tilgang til disse? Hva slags metode skal brukes? Tidlig i denne fasen fant jeg ut at jeg ønsket å få publisert masteroppgaven i et vitenskapelig forlag. Etter en litt trøblete start i forhold til hvem som skulle være deltakere og hvordan datainnsamlingen skulle foregå, åpnet det seg en mulighet som jeg aldri vil angre på. Geir Jordet hadde ordnet et samarbeid med professor Mark Williams ved John Moores University, og jeg flyttet til England i en tre måneders tid. Man kan gjerne si at det var her alt begynte – Mark Williams ordnet tilgang til Everton FC, hvor jeg fikk full tilgang til A-lags, reservelags, og U18-akademilags kamper. Videre hadde utrolig flaks hvor jeg kom i kontakt med Ole Gunnar Solskjær som ordnet tilgang til sitt lag.

For å kunne virkeliggjøre dette prosjektet var det mye planlegging og organisering som skulle til: rekruttering til filmteam, lån av videokamera, reise til og fra kamparenaene som ble spilt for fire ulike stadioner, og analysering av datamateriellet. Det ble mange sene kvelder med praktisk arbeid, mange timer reisetid, og mange kalde timer med filming. Uansett, det var verdt hver eneste krone og time brukt på dette prosjektet. Derfor er det nå veldig vemodig å skrive dette forordet, ettersom jeg avslutter et fantastisk kapitel i livet mitt og lurer på hva blir det neste.

Niklas Nyland
Norges Idretthøgskole, 2010

# Takk til bidragsytere!

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Familien og venner for alltid støttet meg og pushet meg.

## Abstract:

The general purpose of this study was to examine how soccer defenders explore the environment for and use the information to deny opponents goals from crosses into the penalty area. A specific aim was to determine which variables differentiated between elite and sub-elite players. An ecological approach was used as conceptual framework. Participants were at the Premier League level - classified as elite (n = 13, m = 28.15 yrs, SD = 3.82) and at the Reserve League and Academy League level - classified as sub-elite (n = 11, m = 18.3 yrs, SD = 1.40). All participants were filmed in at least one game (six were filmed in two game). A high zoom camera recorded and focused solely upon a single player and general game events were obtained from professional camera recordings (obtained from the clubs) using regular zoom. These two videos were edited and synchronized into a split-screen video.

Results indicate that players in the elite group are more perceptually and functionally active than players in the sub-elite group prior to a cross, by exploring more frequently and positioning themselves more with a back-towards-goal posture allowing them to visually perceive more of the actions of the surrounding forwards. However, it was not demonstrated any functional relationship between exportation and performance related to this defensive situation. Further, constraints such as the player’s posture, type of defence, distance between the crosser and defender, and involvement showed some differences between the levels and may affect exploration.

Keywords: ***Visual perception; Ecological approach; Soccer; defence; Exploratory activity***

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# 1. Introduction

*"From as far back I can remember I've understood the language of football – not just what's said, but in my reading of the game. I see where moves are developing a second earlier than some players. The reason I've been able to throw my body in the way of a goal-bound shot so often is I've sensed the danger before it arrived" (Central defender, Carragher, 2008, p. 470)*

Central defenders' primary goal may be to stop the opponents' attack close to one's own goal. If the opponents cross the ball, it may produce goals, as the flank areas are less defended (Miller, 1996). In the '86 World Cup 29% of 132 goals stemmed directly from a cross. Similarly in the '94 World Cup 30% of 141 goals also stemmed directly from a cross. Furthermore, in Netherlands' 5-game championship run in the '88 European Championship, six of nine goals involved a cross, with an average of 35 crosses a match (Miller, 1996). Furthermore, about 70 % of all goals are scored inside "the prime target area" (Bangsbo & Peitersen, 2000). This square area is between the goal kick line (5.5 meters) and 15 meters from the goal line (Hughes, 1990). Therefore, crossing the ball inside "the prime target area" may be a successful goal scoring formula; hence it is logical to assume that central defenders may pay attention to this area as well as other areas on the pitch. The ability to gather information and make appropriate decisions based on what is seen in the environment is a vital component in sports, such as soccer (Williams, Davids, & Williams, 1999). This present article deals with central defenders' perception in defensive situations.

Empirical evidence shows that experts in ball sports are better in their ability to recognize and recall patterns of play, to anticipate their opponents' strategic and tactical weaknesses (McPearson, 1999a, 1999b; Abernethy, 1990; Abernethy & Russell, 1987; Starkes, 1987; Allard, Graham, & Paarsalu, 1980). In soccer empirical evidence suggests that skilled soccer players show more relevant search strategies, generally involving fewer fixations of longer duration, and fixate more on informative areas of the display, facilitates them to predict future action skillfully (Williams & Davids, 1998; Helsen & Pauwels, 1992). According to Williams (2000), the task will constrain skilled players to use different visual search strategies in offensive and defensive situations. Some findings in offensive and defensive situations in soccer will be addressed below.

## *1.1 Offensive situations*

Research in laboratory settings that has examined search patterns used by expert and novice players in attacking sequences as e.g. 3 vs. 3, 4 vs. 4 (Helsen & Pauwels, 1993, 1992), revealed that expert players were more accurate in their decisions, and that their better performance was attributed to an enhanced ability to recognize structure and redundancy within the display. The eye movement data supported their hypothesis that experts have a more economical visual search pattern (with fewer fixations on different areas of the display). Experts were more engaged in the sweeper's position and any possible areas of free space than novice players. In another laboratory study, Helsen and Starkes (1999) revealed that experienced players demonstrated significantly fewer fixations than students. In situations where the tasks were unsuccessfully solved, they fixated more on the player with ball. This can be explained by the greater knowledge of the experts therefore making them able to divide the information into parts so that they can extract more meaningful information from each fixation, and thereby use each fixation more efficiently (Helsen & Starkes, 1999; Williams et al., 1999; Helsen & Pauwels, 1993).

In a field based studies conducted by Jordet, Giske and Olsen (2004b), they used close up video observations in regular games to examine how players moved their bodies and heads in order to perceive future opportunities to act (see Jordet, 2005a). Jordet et al., (2004b) suggest that soccer passing experts prospectively control their action by using exploratory activity, and that soccer players have low search frequency during high pressure, whilst approaching a opponents goal. In a follow up study, interviews were used to obtain players' verbal statements related to a specific situation shown on a video screen, involving the players delivering passes in real games (Jordet, Giske, & Isberg, 2004a). These players were reported to be deliberately and actively engaging in extensive visual exploratory activity. Further, Jordet and Bloomfield (2009) investigated central midfielders' search activity frequency and performance. Results demonstrate that professionals have a significant higher search activity than amateurs. Further, "superstars" have a significant higher search activity than regular professionals and in addition there is a positive relationship between search activity frequency and performance.

## *1.2 Defensive situations*

The visual search behaviour of experienced and inexperienced soccer defenders was examined within a laboratory (Williams, Davids, Burwitz & Williams, 1994) and this research demonstrated that in 11 vs. 11 situations, experienced players used a wider search strategy emphasized by a greater number of fixations of shorter duration on other areas than the area around the ball. Inexperienced players fixated more frequently on the area around the ball. Williams (2000) argues that experienced players in 11 vs. 11 situations use a search strategy that comprises more fixations of shorter durations because this is advantageous for the defenders, since they have to be aware of many sources of perceptual information located disparately across a large area of the field. In another laboratory study, Williams and Davids (1998) showed that experienced players demonstrated superior anticipation in 1 vs. 1 and 3 vs. 3 simulations; however there were no differences in search strategy in 3 vs. 3. In 1 vs.1 experienced players had a higher search rate, involving more fixations of shorter duration and fixated longer on the hip region. In the latter simulation, experienced players were better in anticipating the direction of a pass, and spent less time attending to the ball or the ball passer, and more on other areas of the display (Williams and Davids, 1998). Further, Williams and Davids (1998) suggest that the search strategy will be limited when the ball is approaching the goal. This can be explained by a need to attend to the area around the player with the ball. In penalty situations, Savelsbergh, Williams, Van Der Kamp, and Ward (2002) examined skill-based differences in anticipation and visual search behaviour of expert, and novice goalkeepers in a laboratory. Their results demonstrated that expert goalkeepers were more accurate in predicting the direction of the penalty kick. Experts used a more effective search strategy involving fewer fixation of longer duration, fixated more on the kicking leg, non-kicking leg, and ball areas. There were no differences in visual search behaviour between successful and unsuccessful penalties (Savelsbergh et al., 2002).

Typically, a large body of research has been done with soccer experts and novices in a laboratory by presenting films from different actions (e.g., 1 vs. 1, 3 vs. 3, etc) on a large screen, trying to simulate different situations (e.g. Williams & Davids, 1998). In addition, several studies have employed non-sport specific movement responses such as stepping on a floor mat (Williams & Davids, 1998), and for soccer goalkeepers moving on a joystick back and forth (Savelsbergh et al., 2002). However, laboratory research has provided a significant amount of valuable knowledge about perceptual expertise in team ball sports. This type of study is low on ecological validity, because many have failed to involve tasks and conditions that would seem important to visual perception and action in real game settings (Jordet, 2005a). Laboratories studies lack the functional relationship between perception and natural movements, which are important to capture if the goal is to reveal knowledge about the nature and function of perception (Abernethy, 2001; Gibson, 1979). For example, presenting different actions on a large screen would only give frontally located information, and therefore there would be a lack of information that may be critical to detect when actions take place behind a player's back (Jordet, 2005a). In real game settings a soccer player needs to move his head to receive information about his/her surroundings; in front, back, and on the sides. Hence, a methodological framework with high ecological validity may be needed in the future (see Jordet, 2005a).

## 1.3 An ecological approach to visual perception

In order to learn more about how soccer players perceive and act in a complex and dynamic game such as soccer, Gibson's (1979) ecological approach to visual perception may be an appropriate conceptual framework. Three tenants in the ecological approach to visual perception will be consecutive addressed. Ecologists argue that perception is actually the detection of information, and this approach is branded as direct, because a perceiver is said to perceive the environment (Michaels & Carello, 1981) – *"direct perception is the activity of getting information from the ambient array of light"* (Gibson, 1979, p. 147). This means that information about the surroundings can be picked up and are meaningful for an individual (Reed, 1996). Further, what we perceive of information is specified in the structure of ambient light (Gibson, 1979). Gibson (1979) calls this ecological information, a specified pattern in the energy fields of the environment, not in the organism.

The second tenant is affordances, to describe the environmental opportunities for action for an individual in any given situation (Gibson, 1979). Affordances are resources, embodied in objects and places which surround each individual. In other words, affordances are opportunities for action: they can be used and they can motivate an individual to act (Reed, 1996). The environment contains plenty of information just waiting to be found, therefore to perceive these affordances you need some “looking behaviour” – the process of perceiving information becomes one of the detections (Jordet, 2004; Reed, 1996). Further, in Vicente and Wang’s (1998) constraint attunement hypothesis, experts are more likely than others to perceive affordances that lead to the ultimate goal in the activity. This hypothesis can be related to the abstraction hierarchy model: each level in the hierarchy represents a model of the goal-relevant constraints, where higher levels are less detailed than lower levels. The shifting of one’s representation from a low, detailed level to a higher level of abstraction with less detail makes complex systems look simpler (Vicente & Wang, 1998). In other words, the activity looks simpler higher up on the hierarchy because one explores after few affordances important to the activity. As a result of this, the decision making becomes more constant, economical and successful as the explorations are more constrained and determined (Raab & Johnson, 2007; Araujo, Davids, & Hristovski, 2006; Araujo, Davids, Bennett, Button, & Chapmann, 2004; Johnson & Raab, 2003).

The third tenant is that perception and action posits a strong relationship. Perception is primarily for the guidance of action. More specifically, perception is often directed forward, to guide future actions. Perceiving affordances allows individuals to prospectively control their action (Reed, 1996; Turvey, 1992). Prospective is forward looking (Gibson, 1994). It is called prospective action when future actions are planned and anticipatory adjustments made, and if the rate of errors is low, it is called prospective control (Adolph, Eppler, Marin, Weise, & Wechsler Clearfield, 2000). This is closely related to the term from information processing theories, anticipation. However, whereas anticipation is a cognitive process, refers prospective control of action to the process by which individuals adapt behaviour in advance of the constraints and behavioural opportunities in the environment (Fajen, Riley, & Turvey, 2009; Adoplh et al., 2000). One important element of prospective control is visual exploration, because exploratory movements are often used to perceive information and adjust for these unfolding events (Montagne, 2005; Adolph et al., 2000). In team ball sports, one of the types of visual exploratory activity is body/or head movements in which the player's face is directed actively and temporarily away from the ball (Jordet, 2005b), with the intention of looking for teammates, opponents or other environmental events, relevant to carry out an advantageous action related to the situation. A presumption for this definition is that it is impossible for players of team ball sports to totally perceive all task relevant information without engaging in some kind of active "looking around" behaviour (Jordet, 2005b).

This study was conducted to examine how central defenders used their exploratory activity, to prospectively control their actions prior to a cross being made. One may hypothesize that elite central defenders are more able than others to prospectively control their actions, by perceiving information from the environment and use this information to adjust and control movements into important areas (e.g., "prime target area") to deny opponents space, time, and to apply pressure. When opponents are attacking, a central defender needs to gather information from many sources (e.g., from the ball, opponents, team-mates, the goal, the goal keeper, the space between goal line and the defenders, etc.) to be updated on every movement (e.g., behind him, on the laterals, who is inside the penalty area, and so forth) to stop the attack. A specific aim was to determine which variables differentiated between the elite and the sub-elite players related to the defensive situation crosses. To find out more about this perceptual skill, an observational field based study was employed.

# 2. Method

## *2.1 Participants*

Twenty-four international and national soccer players who played in the English Premier League, Reserve League and Academy League during 2009/10 season were involved in this project. All participants were central defenders. In the elite group, thirteen participants that were involved in Premier League matches were selected (M = 28.15 age, SD = 3.82 age, Min. = 22, Max. = 35). In total, 10 of these players had national team caps (M = 26.46, SD = 27.86, Min. = 0, Max. = 69). In sub-elite group, eleven participants that were involved in Reserve League and Academy League matches were selected (M = 18.3

age, SD = 1.4 age, Min. = 17, Max. = 21). In total, 2 of these players had national team caps (M = 0.36, SD = 0.81, Min. = 0, Max. = 2). Six players were video recorded in two matches, while the rest were video recorded in one match. An agreement with the involved clubs was not to publish their names or players' names used for this research.

## *2.2 Video data analysis*

In total, the video recording generated 236 situations that could be analysed. For a situation to be included for analysis, it had to be an open play where a cross was made from the lateral into the penalty area (see crosser's area in figure 1). When the ball is on the laterals, ready to be kicked into the penalty area, relevant information for the central defender is located in his surroundings: opponents can be behind him, on his side and in front of him. Hence, it is useful to engage in exploratory involving movements of body and head. A cross was operationally defined as a player that kicks the ball from crosser's area into the penalty area. The ball could travel either in air or on the ground. Further, an attempt on cross was defined as either the player missed the ball, got tackled, or the ball was blocked on its way to the penalty area.

Exploratory activity was only registered in the immediate time interval prior to a cross or attempt on a cross into the penalty area. In general, this time interval started 10 seconds prior to a cross or an attempt on cross being made (when the ball left the crosser's foot). However, the time interval was often less, since it was required that every situation accounted for was from open play. Therefore, when a play was stopped and started again within the 10 seconds time interval, immediately the play started again and the cross was made (when the ball left the crosser's foot) and the time interval was established. Exploration or visual search was operationally defined as a body/or head movements in which the player's face is directed actively and temporarily away from the ball (Jordet, 2005b), with the intention of looking for team-mates, opponents or other environmental events, relevant to carry out an advantageous action related to the situation.

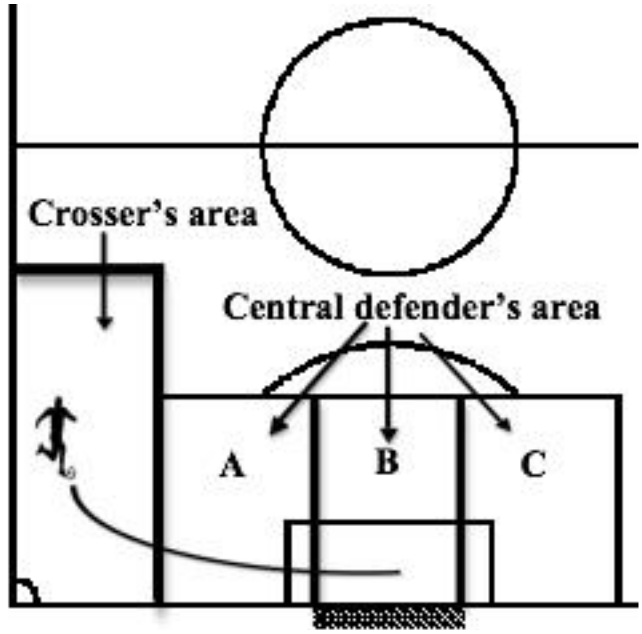


**Figure 1: Areas on the pitch.**
Note. All crosses from the crosser's area were accounted for and crosses outside were excluded. The player inside crosser's area has a chromed arrow that illustrates a cross into the penalty area. Zone A, B and C illustrates the central defender's position in the moment of a cross, if the player was outside penalty area it was given a letter D. If the cross came from the other side, the letters switched side.

To avoid subjective measurements and high variance, it was important to have a maximum agreement between the observers by using prescribed rules (Kerlinger & Lee, 2000). Several variables were selected for analysis:

1) *Central defender's position* was divided into three zones; A, B and C. First, A, B, and C provided information about the central defender's position inside the penalty area in the moment of a cross being made. Second, A was constantly in front of the first goal post, B was between both goal posts, and C was behind second goal post. The central defender was given a letter D if he was outside the penalty area in the moment of a cross. Third, the letters switched sides according to from which side the cross was made.

2) *Players inside penalty area* was accounted for in the moment of a cross being made, whereas players outside were excluded. The participant was not included.

3) *Exploratory activity frequency* was assessed by dividing the number of exploratory searches conducted with the total numbers of seconds in the time interval of that open situation (Jordet, 2005b). As the time interval varied from situation to situation, it was important to not only count the searches but also make the number of searches relative to time.

4) *Three types of body posture* were classified and identified by freezing the split-screen video in the moment the ball left a crosser's foot. The types were:
    A) *Back to goal* was identified as having the upper body, the back to goal. The shoulders were pointing at the sidelines. The shoulders could not point more than 40 degrees angel in relation to the goal line. The player's face could be pointing to one of the sides or in the middle.
    B) *Side to goal* was identified as having the shoulders pointing at each goal and the hip pointing to one of the sidelines. The shoulders could point between 45 degrees and 90 degrees angel in relation to the goal line. The player's face could be pointing to one of the sides, in the middle or to his own goal.
    C) *Front to goal* was identified as having the upper body, chest pointing to its own goal. The shoulders were pointing to one of the sidelines. The player's face could be pointing to one of the sides or to his own goal.

5) *Central defender's* and *the crosser's distance* from the goal line were estimated by using different cues on the playing pitch. The cues were the short line (0 meter), the goal kick area (5.5 meters from the goal line), the penalty mark (11 meters from the goal line), the length of penalty area (16.5 meters from the goal line), and the circle in the middle (circumference 18 meters). Further, the distance between central defender and crosser was calculated by subtracting the crosser's distance from short line with the central defender's distance from the short line (see figure 2 and 3).

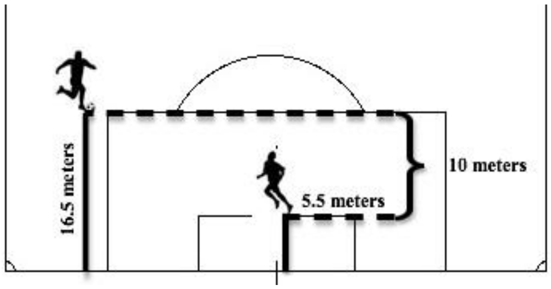


**Figure 2: Distance between the crosser and the central defender.**
Note. The crosser is on the left side with 16.5 meters from the goal line, and the central defender is in the middle with 5.5 meters from the goal line. Distance between them is 10 meters.

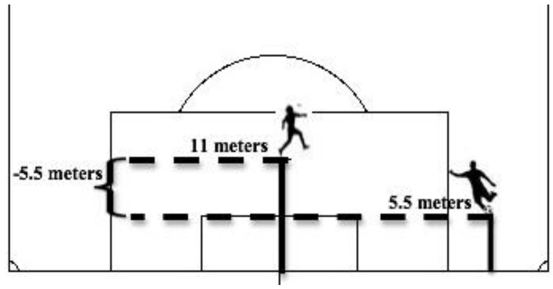


**Figure 3: Distance between the crosser and the central defender.**
Note. The crosser is on the right side with 5.5 meters from the goal line, and the central defender is in the middle with 11 meters from the goal line. Distance between them is -5.5 meters.

6) *Two types of defence* were classified. First, balanced defence in the moment of a cross was recognized as: when both central defenders were close together, either both full-backs were next to each central defender or one of the fullbacks was applying the crosser pressure. Second, unbalanced defence in the moment of a cross was recognized as: when both of the central defenders were not closely together, one central defender applied pressure on the crosser or one of the four defenders (two fullback and two central defenders) were not in their regular defending position or out of position.

7) *Central defenders involvement* was categorized as involvement and no involvement. Further, involvement could either have a positive or negative outcome. If the central defender’s involvement resulted in gaining possession of the ball, winning a physical challenge, blocking a shot or clearing the ball up and away from the penalty area was assessed as a positive involvement. If the central defender’s involvement resulted in losing a physical challenge, not successful in blocking a shot or in clearing the ball in correct direction (e.g., out to corner) was assessed as a negative involvement. If the central defender simply did not involve at all was it seen as no involvement.

## 2.3 Procedure

Four camera operators were recruited and received a camera manual (see appendix A), verbal instructions and a demonstration on how to film the participants. They also practised during the warm-up before a match. All footage was recorded by four high zoom camcorders (most often used Canon MiniDV MD235 with 45x-advanced zoom) that focused solely upon a single player throughout a match (90 min.), in order to have a detailed close-up picture of a player's head movements (see Carling, Bloomfield, Nelsen, & Reilly, 2008; Jordet, 2005a). All camcorders were attached to tripods positioned on a gantry at the long side of the pitch. The distance was about 4-15 meters from the field and at a height of about 5-15 meters. The involved clubs filmed the ball and general game events using professional camcorders with a regular zoom. This was, at a later time, edited and synchronized together to have a split-screen (Jordet, 2005a) with the performance analysis software Sportscode Gamebreaker plus (Australia). The situations that were included for analysis were merged into one video file, and thereafter registered in a simple notation form. The total quantity of recorded games was: 6 games from Premier League, 5 games from Reserve League and 2 games from Academy League.

To develop a good and objective measurement tool to rate central defenders performance, the first author searched on different scientific databases to find relevant articles. However, it was not found any published measurement tools to rate a central defenders performance or on other playing positions. A further step in this process, the first author discussed with the involved clubs' performance analysts, but without managing to develop a tool. Therefore, we used simple measurement parameters.

The first author analyzed all data and three analysts independently analyzed altogether about 60% of the data collection. They were selected on the basis of the knowledge on this subject, because observation on human behaviour requires knowledge and value about the behaviour (Kerlinger & Lee, 2000). To deal with threats to reliability, inter-observer reliability (IOR) scores were assessed for all variables. The formula was $\frac{Agreement}{Agreement+Disagreement}\times 100$ (see Kratochwill & Wetzel, 1977). Guidelines in the literature suggest an 80 % agreement to be adequate (Hrycaiko & Martin, 1996), and the IOR proved to be 79.05% agreement on exploratory activity frequency, 89.37 % agreement on types of defence, 76.57 % agreement on central defender's position, 89.38 % agreement on body posture, 91.49 % agreement on types of involvement, 33.43 % (SD = 1.22%) agreement on central defenders distance from the goal line, and 25.45 % (SD = 6.44%) agreement on the crosser's distance from the goal line. The scores were in some degree as expected, when the study has a field based design it can not be expected that analysis of soccer players performing will be as reliable as analysis in laboratories. Where the scores were below what is acceptable (80% and above), deviation was very low in exploratory activity ($\pm 1$ exploration), and the central defenders distance from the goal line (SD = 1.22). According to Hawkins & Dotson (1975) a problem with the percent agreement formula is that it does not take account of the deviation in scores between the observers, and if this is low, the reliability may be high anyway (Kratochwill & Wetzel, 1977).

## *2.4 Statistical analysis*

Exploration activity frequency, types of defence, distance between the crosser and central defender and involvement data were analyzed using Mann-Whitney test to explore difference between the conditions and groups. The significance level was set at $p <.05$. As the data did not have normal distribution, it was appropriate to use nonparametric tests (Vincent, 2005).

In addition, we used univariate logistic regression analysis and Odds Ratios (OR). Here we operated with a group as a categorical variable while it was treated as a continuous variable when examining the link between the group and different postures. Odds ratio below 1 indicates that the likelihood is lowest in the first group, whereas an odds ratio above 1 indicates that the likelihood is highest in the first group. An odds ratio at 1 indicates that the likelihood is same in both groups (Ringdal, 2001).

# 3. Results

Of six games played in the elite group, 149 crosses and attempts on crosses were made, whereas of seven played games in sub-elite group 87 crosses and attempt on crosses were made. For descriptive statistics see appendix B and C.

## *3.1 Exploratory activity frequency*

The elite group explored significant more than the sub-elite group ($p < .05$) with all types of situation. It was employed two analyses. The first analysis tested the mean exploratory activity frequency with all cases within each group (see figure 4). The second analysis tested also the mean exploratory activity, but the mean of each player was calculated first, thereafter the mean within each group (see figure 5). Both tests showed that it was a significant difference in exploratory activity frequency between the elite and the sub-elite group, however the level of significance and the standard deviation were different.

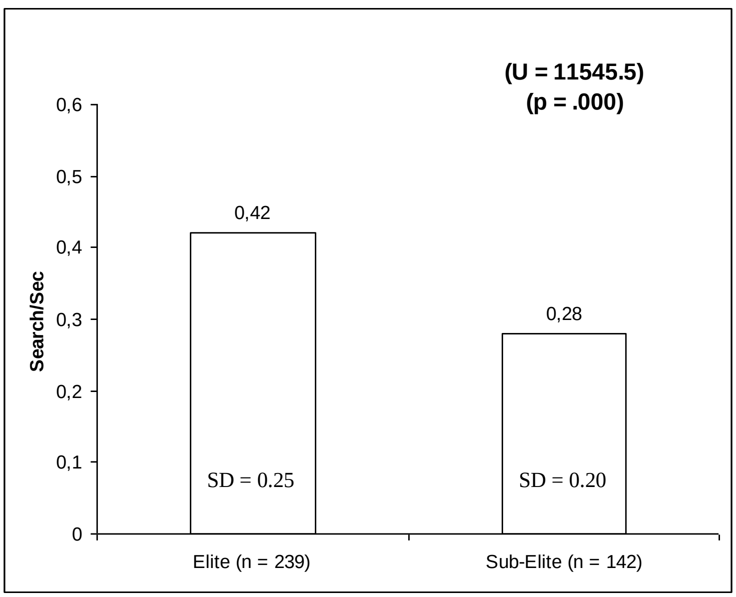


**Figure 4: Mean exploratory activity frequency (exploratory searches/seconds) for each group.**
Note. On group level

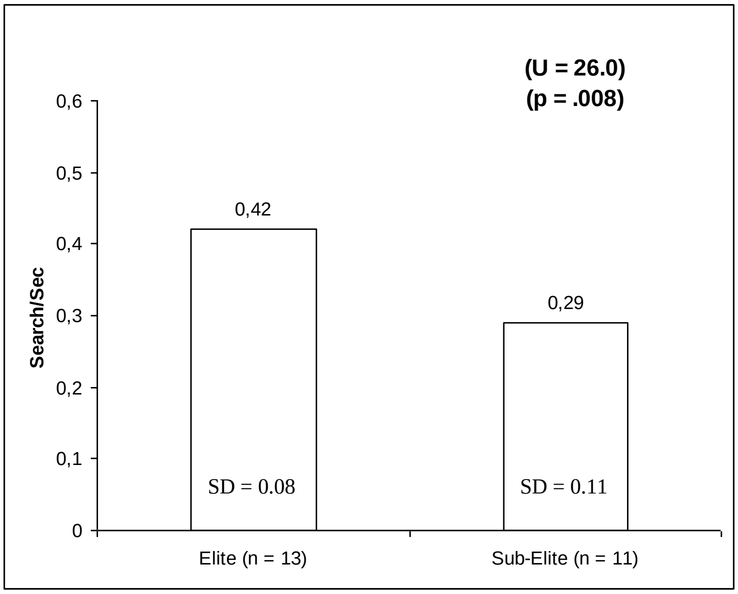


**Figure 5: Mean exploratory activity frequency (exploratory searches/seconds) for each group.**
Note. On player level. The mean of each player individually, thereafter the mean within each group

## 3.2 *Exploratory activity frequency and distance*

The distance between crosser and central defender was subtracted to measure the distance between them (see figure 2 and 3 for further explanation). Figure 6 illustrates the mean exploratory activity frequency in relation to the distance between the crosser and the central defender, in the elite group and the sub-elite group. The distance is in negative meters: this indicates that the crosser was closer to the goal line than the central defender. Where the distance is in positive meters: this indicates that the central defender was closer to the goal line than the crosser.

In the elite group all distances compared with 21.1 meters and above were significant different in mean exploratory activity frequency ($p < .05$). When the distance -10 to -0.99 meters was compared to 0 to 10 meters, the analysis showed no significant difference in mean exploratory activity frequency ($U = 2378.0$, $p = .108$), while the distance 0 to 10 meters and 10.1 to 20 meters was compared, the analysis showed a significant difference in exploratory activity frequency ($U = 2742.5$, $p = .021$).

In the sub-elite group the distance -10 to -0.99 meters compared with 10.1 to 20 meters proved to be significant different in mean exploratory activity frequency (U = 239.5, p = 0.048), whereas the distance 0 to 10 meters compared with 10.1 to 20 meters proved not be significant in mean exploratory activity frequency (U = 360.0, p = 0.069).

When comparing the elite group and the sub-elite group, the analysis showed that -10 to -0.99 meters was significant different (U = 638.5, p = .000) in mean exploratory activity frequency. In addition, the distance 0 to 10 meters was significant different in mean exploratory activity frequency (U = 3668.5, p = .003). The distance 10.1 to 20 meters had not a significant difference in mean exploratory activity frequency (U = 298.0, p = .257).

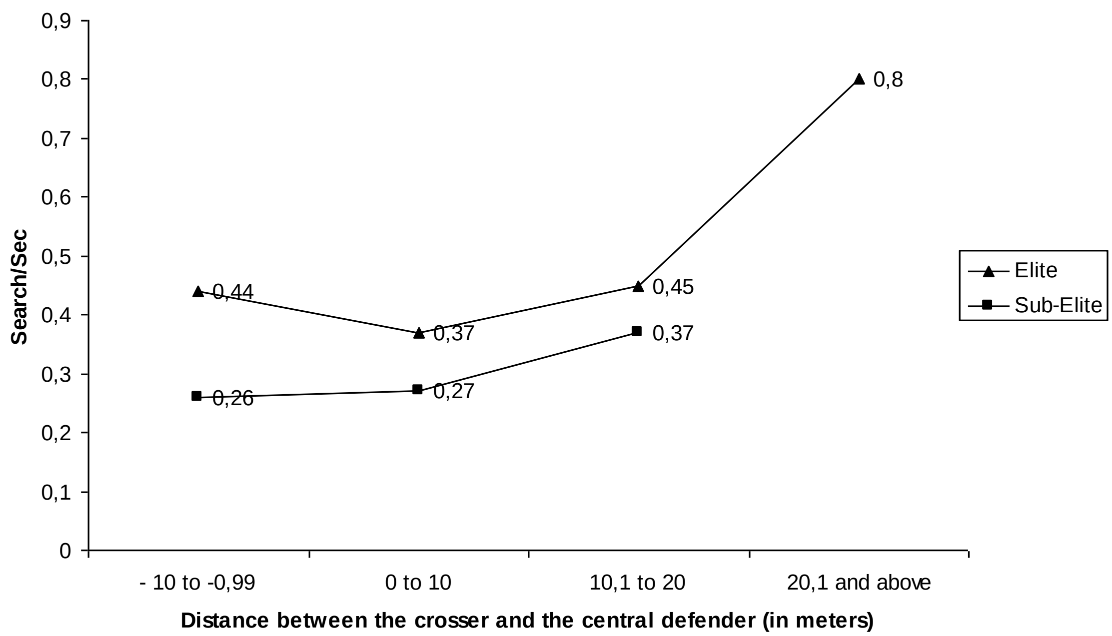


**Figure 6: Mean exploratory activity frequency (exploratory searches/seconds) and distance between the crosser and the central defender (in meters), in and between the elite group and the sub-elite group.**
Note. See figure 2 and 3 for explanation on estimating distances.

## *3.3 Exploratory activity frequency and defending style*

The elite group had a significant difference in mean exploratory activity frequency between balanced defence (SD = 0.26, Sum of Ranks = 25339.5) and unbalanced defence (SD = 0.22, Sum of ranks = 3340.5; see figure 7). The sub-elite had not a significant difference in mean exploratory activity frequency between balanced defence (SD = 0.20, Sum of Ranks = 9091.5) and unbalanced defence (SD = 0.21, Sum of Ranks = 1061.5; see figure 7).

With a balanced defence, the elite group scored higher than the sub-elite group in exploratory activity frequency. Results proved to be significant, U = 82620.0, p = .000. Elite group had a sum of ranks of 38022.0, while sub-elite had a sum of ranks of 16263.0. With an unbalanced defence, elite group had a higher exploratory activity frequency, but the results proved not to be significant, U = 239.0, p = .325. Elite group had a sum of ranks of 1003.0, while sub-elite had a sum of ranks of 375.0.

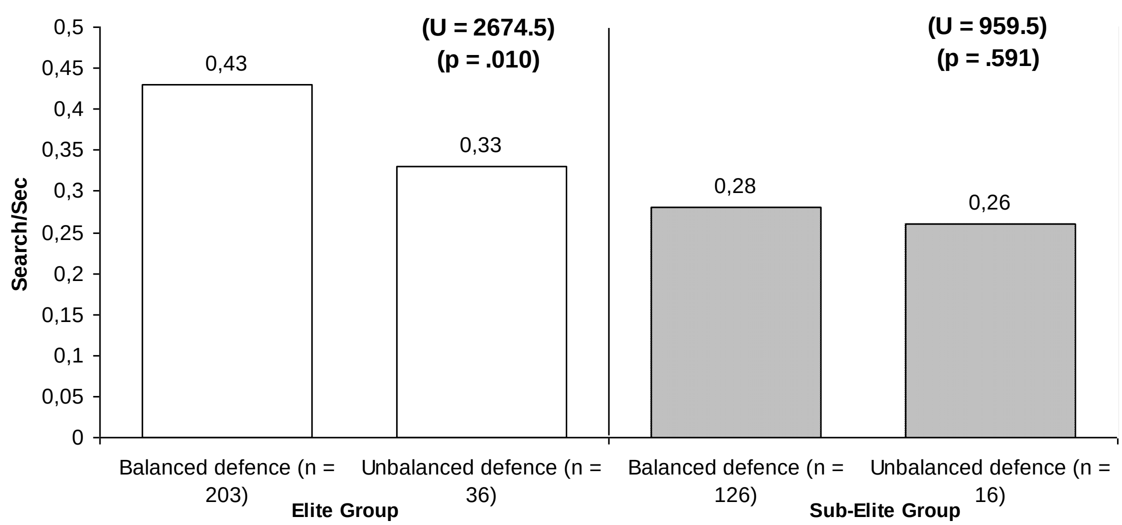


**Figure 7: Mean exploratory activity frequency (exploratory searches/seconds) in the elite group and sub-elite group, with balanced and unbalanced defence.**

## *3.4 Exploratory activity frequency and involvement*

Elite group had a significant difference (p < .05) in exploratory activity frequency (see figure 8) when they did not involve (0.43 search/sec, SD = 0.24, Sum of Ranks = 23609.5) in a situation compared with when they did involve in a situation (0.36 search, SD = 0.27, Sum of Ranks = 5070.5). It was no significant difference when the outcome of the involvement was either positive or negative (p > .05).

The sub-elite group had no significant difference (p > .05) in exploratory activity (see figure 8) when they did not involve (0.26 search/sec, SD = 0.20, Sum of Ranks = 7320.0) in a situation compared with when they did involve (0.32 search/sec, SD = 0.20 Sum of Ranks = 2833.0) in a situation. It was no significant differences when the outcome of the involvement was either positive or negative (p > .05)

Elite group had a significant higher search rate (0.43 search/sec, SD = 0.24, Sum of Ranks = 31631.0) than sub-elite group (0.26 search/sec, SD = 0.20, Sum of Ranks = 11734.0) with no involvement (U = 5956.0, p = .000). With a positive outcome of the involvement elite group (0.35 search/sec, SD = 0.24, Sum of Ranks = 498.0) had a higher exploratory frequency than sub-elite group (0.30 search/sec, SD = 0.17, Sum of Ranks = 405.0), however, it was not a significant difference between both groups (U = 215.0, p = .929). With a negative outcome of the involvement elite group (0.37 search/sec, SD = 0.30, Sum of Ranks = 663.0) had a marginal higher exploratory frequency than sub-elite group (0.35 search/sec, SD = 0.23, Sum of Rank = 372.0), however, it was not a significant difference (U = 228.0, p = .924).

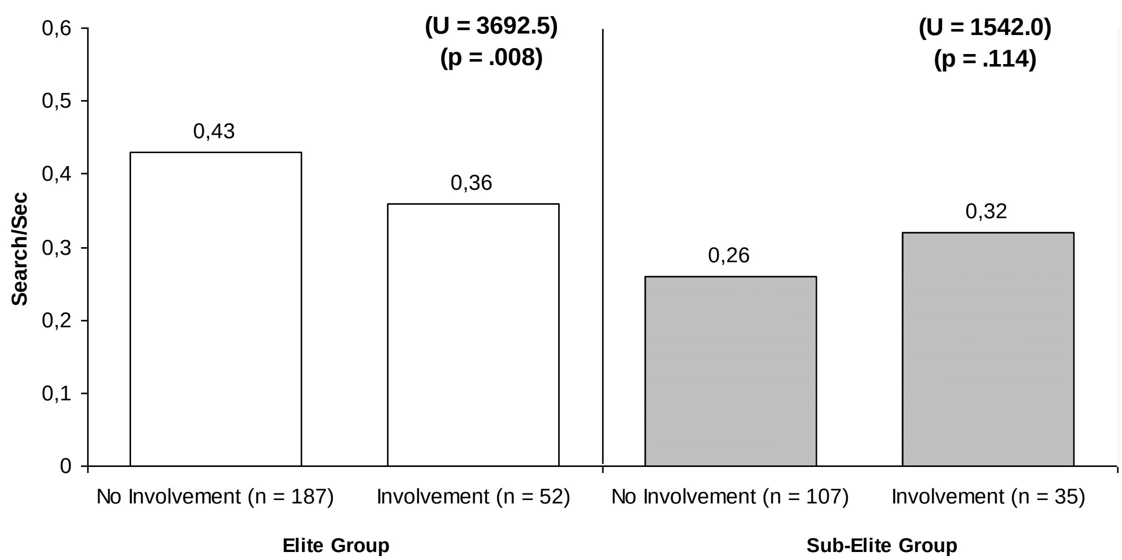


**Figure 8: Mean exploratory activity frequency (exploratory searches/seconds) in the elite group and sub-elite group, with involvement and with no involvement.**
Note. The elite group is on the left side, and the sub-elite group is on the right side.

## 3.5 Body posture

In total, the players in the elite group had their back and side to goal in 89.3 % of all crosses, while players in the sub-elite group had 81.7 %. In 10.7 % of all crosses had the elite group their front to goal whereas the sub-elite group had 18.3 %. Statistically, the likelihood is significantly higher for elite players to have their back to goal and side to goal than sub-elite (OR = 1.871, p = .037). Table 1 demonstrates the elite group and the sub-elite group's posture in the moment a cross was made.

***Table 1***

*Body postures in percent in groups.*

| Level | | *Body posture to goal* Back to goal | Side to goal | Front to goal | Total |
|---|---|---|---|---|---|
| Elite | Count | 22 | 195 | 26 | 243 |
| | % within group | 9,1 % | 80,2 % | 10,7 % | 100 % |
| Sub-elite | Count | 10 | 106 | 26 | 142 |
| | % within group | 7,0 % | 74,6 % | 18,3 % | 100 % |
| Total | Count | 32 | 301 | 52 | 385 |
| | % within group | 8,3 % | 78,2 % | 13,5 % | 100 % |

Note. See method chapter for further explanation.

## 3.6 Central defender's position

The elite group and the sub-elite group had similar results in which zone they were in the moment a cross was made. The elite group and the sub-elite group were most in zone B. Table 2 demonstrates in percent which zone players in the elite group and players in the sub-elite group was in a when a cross was made.

***Table 2***

*Positions in percent in groups*

| Group | Positions in Percent A | B | C | D | Total |
|---|---|---|---|---|---|
| Elite | 23,5 | 60,1 | 0,8 | 15,6 | 100 |
| Sub-Elite | 23,8 | 61,5 | 2,8 | 11,9 | 100 |

Note. See method chapter for further explanation on positions

# 4. Discussion

The general purpose of this study was to examine how central defenders used exploratory activity to prospectively control their actions to defend against crosses. A further aim was to determine which variables differentiated between an elite group (n = 13) and a sub-elite group (n = 11). A high zoom camera focused solely upon a single player throughout a game, in order to have a detailed close-up picture of a player's head movements. This video was in synchronized into a split-screen video with a video of the general game events. This made it possible to examine details in the players' exploratory activity in league games (see Jordet, 2005a), and in addition, the video analysis made it possible to recognize and quantify important elements that may be important to exploratory performance.

In the current study, the hypothesis was that elite defenders are more able to prospective control their action than others. A finding to support this is some degree is that players in the elite group had a significantly higher exploratory activity frequency than players in the sub-elite group prior to a cross. However, this result shows the exploratory activity frequency in all types of situations. Following the ecological approach to visual perception (Gibson, 1979), perception is a matter of detecting of useful information that permits a player to act in an adaptive way, in and upon its environment (Michaels & Carello, 1981). More specifically, players engage in exploratory activity to perceive ambient information for guidance of future actions (Montagne, 2005; Adoplh et al., 2000). However, the reason for the significant difference in exploratory activity may be that players in the elite group have used more deliberate practice to improve exploratory activity than players in the sub-elite group (Ericsson & Charness, 1994). If players in the elite group have used no deliberate practice within this domain they may be seen as novices. In consideration of this, players in the elite group may have used more deliberate practice for a longer period to improve exploratory activity (Ericsson, Krampe & Tesch-Römer, 1993). That being said, they may have consciously performed and refined skills in a domain to get better (Schempp, McCullick & Mason, 2006). The results may be consistent with previous research on defensive situations (see Williams et al., 1994). As Williams (2000) contends, experienced players use a search strategy that comprises more fixation of shorter duration because this is advantageous for defenders, since they have to be aware of many sources of information. The results are much the same as studies on offensive situations (Jordet et al., 2004b; Helsen & Pauwels, 1993, 1992), but in the light of ecological approach (Gibson, 1979), the relationships between the player and the task/environment may be different. Where as in offensive situations a player may explore after the opportunity to pass the ball or shot on goal before he receives the ball – he involves and plays a part in what is going to happen next. While in defensive situations, a player may explore after information that could lead to interception of the ball or stop an opponents attack – he explores after the information to be in advance of what the opponents will do.

Further, the results showed that the significant difference in exploratory activity frequency between players in the elite group and players in the sub-elite group mainly was found in balanced defence and not in unbalanced defence. Thus, the results may only support the hypothesis when elite defenders are in a balanced defence. Interestingly, players in the elite group had significantly lower levels in exploratory activity from balanced to unbalanced defence, whereas players in the sub-elite group decreased marginally. As the likelihood for a goal against may be higher, a central defender may either feel more pressure and stress, and this can constrain the player's exploratory activity (Easterbrook, 1959), or, the situation constrains the central defender to have a more determined search to perceive only the important affordances (Vicente & Wang, 1998). When defenders are in an unbalanced defence, there may be fewer affordances to perceive. The premise that it may be fewer affordances in an unbalanced defence may have some support from Williams et al. (1999). They suggest that if one compares an 11 vs. 11 situations with a 3 vs. 3 situation, there will be less need for visual search when there are fewer players as they have fewer sources of information to take in consideration (Williams et al., 1999).

The elite group explored less when they were involved after a cross than when they were not involved after a cross. In contrast the sub-elite group explored more when they were involved after to a cross when they were not involved after a cross. One assumption for the sub-elite's increase in exploratory activity could be that they have not a determined exploration causing them to perceive irrelevant affordances. However, it can be interesting to investigate the duration of each exploration away from the ball. By doing this we would perhaps have more acceptable results, as the results are now only the amount of exploratory activity relative to time. An elite player and a sub-elite player could have the same frequency, but it does not say anything about the duration of each exploration. Further, it may be useful to also study different types of exploratory activity such as Jordet (2005a) classify different types of exploratory activity. Doing this may provide a broader understanding of how and what kind of exploratory activity that is most functional as a central defender. In order to investigate these issues, one may combine mobile eye tracking equipment, player camera and overview camera. However, one can not do this in official matches, but rather in a research context that secure a high ecological validity.

Exploratory activity may be related to the distance between the crosser and the central defender. Results proved to be in some degree significant, and figure 6 illustrates that the exploratory activity enhances when the distance between the crosser and the central defenders increases. However, the results may have some sources of error as the inter-observer reliability test proved not to be adequate in the central defender's and the crosser's distance from the goal line, and therefore it may be not a reliable result. One assumption for exploratory activity may be related to the distance between the crosser and the central defender is that the search strategy is limited when the ball is getting closer to the goal, because of a desire to attend to the area around the player with the ball (Williams, 2000; see Williams & Davids, 1998). By having the danger away from there own goal, the central defender has "more time" to look around. Research conducted by Jordet et al., (2004) on offensive situations demonstrated that soccer players have lower frequency when approaching opponents' goal. This study may imply that it is not only in offensive situations, but also in defensive situations.

The player's posture may affect exploratory activity. Freezing the split-screen video in the moment of a cross made it possible to identify the player's posture. The logistic regression analysis demonstrated that the probability for elite players' posture to be either side to goal or back to goal is significantly higher than for sub-elite players (OR = 1.871, $p < .05$). In 10.7 % of all crosses players in the elite group had their fronts to goal, while players in the sub-elite group had their fronts to goal in 18.7 % of all crosses. Soccer players depend heavily on the visual system to provide much information for perceiving and acting (Williams et al., 1999), and they may rely on peripheral vision (Williams & Davids, 1998). From a qualitative perspective, it was observed that some players used to run backwards to get into a preferred position. Johansen (2007) reported similar findings. It may be advantageous to have their backs to goal as you can almost acquire information about the ball passer, teammates, and opponents at the same time. Further it was observed that other players used another "tactic": they used to run towards a preferred position, and then when they were about 2 – 3 meters away they adjusted their posture into either having their back to goal or side to goal. This may be functional, but it may require more exploratory activity. Following Gibson's (1979) lead, the observation above may be seen in coherence with perception and action where: while players perceive affordances they also adjust or "tune in" for the cross. More specifically, as they perceive affordances they also prospectively control for the future cross (Reed, 1996; Turvey, 1992). One suggestion may be that soccer defenders should run towards their own goal and when they reach a certain point (e.g., penalty area, 16.5 meters) they should adjust their body posture back to goal or an intermediate of side to goal and back to goal, and thereby use peripheral vision and exploratory activity simultaneously. Having the side to goal may oblige players to look for information located behind them and on the sides. Thus, it may oblige the players to have higher exploratory activity and not exploit the peripheral vision to the same extent as in a back to goal posture. Having the front to goal may give a disadvantage since it may be tougher to explore within all areas of the field, and especially to perceive information about who is inside the penalty area and who in on his way into the penalty area/"the prime target area". One point should be made: the player's posture was registered in the moment when a cross was made. Therefore, in consideration of this it may be interesting in future research to investigate also when players adjust their posture and the duration of it, prior to and at the actual event. In addition, this study did not use multivariate analysis of exploratory activity and types of body posture, because the submission data was too close when it was suggested. However, future research should make an effort to investigate and use multivariate analyses in exploratory activity related to body posture.

## *4.1 Limitations and future work*

This study had an observational field based design with a high ecological validity, but unfortunately, there were some threats to the internal validity and reliability, most of which were a result of possible instrumental and measurement errors. The player camera footage implies that only head and body movements were accounted for and not the participant's eye movement, as this was too difficult to spot on the footage. Moreover, Gibson (1979) argues that the eye must follow the head. Therefore when a player is exploring his environment the eyes must follow automatically and this gives a good indication about where a player is looking. Further, the games were played on different arenas, with various lighting conditions, weather conditions, camera angles and distance to the player from game to game. The quality of footage varied as a result of lighting conditions, weather and human factors, for example following a participant throughout a game (90 min.) without a break. In some cases there were also sequences that were excluded because the focus on the participant was lost. Consequently, an inter-observer reliability test was assessed (see method chapter). The agreement results varied, and were in some degree as expected. Thus, the distance between the central defender and the crosser may not be valid and reliable as the scores for each player's distance were far below the 80 % limit for what is adequate (see Hrycaiko & Martin, 1996). However, it can not be expected that analysis of soccer players performing will be as reliable as analyses in laboratories; researchers should make efforts to increase the reliability under high ecological valid research.

This study failed to demonstrate any relationship between exploration and performance. Some assumptions may be taken into consideration. First, the data collection may have been too small. Of 381 cases, only in 87 cases were players involved after a cross.

Second, the measurement tools might have been too vague or simple. Findings show that there was a difference in exploratory activity between players in the elite group and players in the sub-elite group. However, the findings show that there was no difference in functional performance in this situation. To this date there are no good objective measurement tools to rate a central defender or other positions that are published. As the ball could arrive almost anywhere inside the penalty area, it was difficult to rate the participant's performance. Therefore, in consideration of this it is important to have a good objective performance measurement tool relevant to a player's position when analysing players individually.

To this date a lot of research on visual perception has been made in different sports settings, however, future research with high ecological validity is needed to understand how experts in soccer use the exploratory activity in different positions and situations.

## *4.2 Summary*

This article has presented data indicating that players in the elite group are more perceptually and functionally active than players in the sub-elite group prior to a cross, by exploring more frequently and positioning themselves more with a back-towards-goal posture allowing them to visually perceive more of the actions of the surrounding forwards. As a result of this, the analysis showed that the elite group explored more under all conditions prior to a cross, except one. When the elite group were involved after a cross, the results showed that the exploratory activity was decreased prior to a cross, whereas the sub-elite increased. This may be related to the constraint attunement hypothesis (see Vicente & Wang, 1998). The hypothesis that elite defenders are more able to prospectively control their actions, by perceiving information from the environment may be mainly supported by the significant difference between the elite group and the sub-elite group in exploratory activity frequency when the defence is balanced. The elite group explored significantly more when the distance between the crosser and the central defender increased, whereas the sub-elite increased marginally when compared to the elite group. However this result may have some sources of error. The premise that the exploratory activity decreased when the ball is getting closer to the goal may have some support from previous research (see Williams & Davids, 1998).

The video analysis may have identified some constraints to facilitate and inhibit exploratory activity in soccer central defenders. Specially, constraints such as posture, type of defending distance between the crosser and the central defender, and involvement may influence the visual exploratory activity.

# References

Abernethy, B. (1990). Anticipation in squash: differences in advance cue utilization between expert and novice players. *Journal of Sports Sciences*, *8*, 17 – 34.

Abernethy, B. (2001). Attention. In R.N. Singer, H.A. Hausenblas & C.M. Janelle (Eds.), *Handbook of Sport Psychology* (2nd ed., pp. 174 – 203). New York: John Wiley & Sons.

Abernethy, B., & Russel, D.G. (1987). Expert-Novice Differences in an Applied Selective Attention Task. *Journal of Sport Psychology*, *9*, 326 – 345.

Adolph, K.E., Eppler, M.A., Marin, L., Weise, I.B. & Wechsler Clearfield, M. (2000). Exploration in the service of prospective control. *Infant Behavior & Development, 23*, 441 – 460.

Allard, F., Graham, S., & Paarsalu, M. (1980). Perception in sport: Basketball. *Journal of Sport Psychology*, *2*, 14 – 21.

Araujo, D., Davids, K., Bennett, S., Button, C., & Chapmann, G. (2004). Emergence of sport skills under constraints. In A.M. Williams, & N.J. Hodges (Eds.), *Skill acquisition in sport: Research, theory and practice* (pp. 409 – 433). London: Routledge, Taylor & Francis.

Araujo, D., Davids., K., & Hristovski, R. (2006). The ecological approach to visual anticipation for expert performance in sport. *International Journal of Sport Psychology, 39*, 157 – 165.

Bangsbo, J. & Peitersen, B. (2000). *Angrebsspillet. Teori og øvelser*. København: Forlaget Hovedland.

Carling, C., Bloomfield, J., Nelsen, L., & Reilly, T. (2008). The role of motion analysis in elite soccer: Contemporary performance measurement techniques and work rate data. *Sports Med*, *38,* 839 – 862.

Carragher, J. (2008). *Carra: My Autobiography*. Transworld Publishers

Easterbrook, J.A. (1959). The effect on emotion on cue utilization and the organization of behavior. *Psychological Review*, *66*, 183 – 201.

Ericsson, K.A., & Charness, N. (1994). Expert performance: Its structure and acquisition. *American Psychologst, 49*, 725 – 747.

Ericsson, K.A., Krampe, R.T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*, 263 – 406.

Fajen, B.R., Riley, M.A., Turvey, M.T. (2009). Information, affordances, and control of action in sport. *International Journal of Sport Psychology, 40*, 79 – 107.

Gibson, E.J. (1994). Has psychology a future? *Psychological Science*, *5*, 69 – 76.

Gibson, J.J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Hawkins, R.P., & Dotson, V.A. (1975). Reliability scores that delude: an Alice in Wonderland trip through the misleading characteristics of interobserver agreement scores in internal recording. In E. Ramp & G. Semb (Eds.), *Behavior analysis: areas of research and application*. Englewood Cliffs, New Jersey: Prentice-Hall.

Helsen, W.F., & Pauwels, J.M. (1992). A cognitive approach to visual search in sport. In D. Brogan, & K. Carr (Eds.), *Visual Search II* (pp. 177 – 187), London: Taylor & Francis.

Helsen, W.F., & Pauwels, J.M. (1993). The relationship between expertise and visual information processing in sport. In J.L. Starkes, & F. Allard (Eds.), *Cognitive issues in motor expertise*. Elsevier Science Publishers B.V.

Helsen, W.F., & Starkes, J.L. (1999). A multidimensional approach to skilled perception and performance in sport. *Applied Cognitive Psychology, 13*, 1 – 27.

Hrycaiko, D., & Martin, G.L. (1996). Applied research studies with single-subject designs: Why so few. *Journal of Applied Sport Psychology*, *8*, 183 – 199.

Hughes, C. (1990). *The winning formula*. The Football Association. W. Collins & Sons Co Ltd.

Johansen, P.A. (2007). *“Potte tett!” Hvordan slippe inn få mål i fotall?* Skriftlig oppgave, NFFs trener 3-kurs 2006/2007.

Johnson, J., & Raab, M. (2003). Take the first: Option generation and resulting choices. *Organisational Behavior and Human Decision Processes, 91*, 215 – 223.

Jordet, G. (2004). Perceptual expertise in dynamic and complex competitive team contexts. An investigation of elite football midfield players. Dissertation from the Norwegian University of Sport and Physical Education.

Jordet, G. (2005a). Applied cognitive sport psychology in team ball sports: An ecological approach. In R. Stelter, & K.K. Roessler (Eds.), *New approach to sport and exercise psychology* (pp. 147 – 174). Meyer & Meyer Sport.

Jordet, G. (2005b). Perceptual training in soccer: An imagery intervention study with elite players. *Journal of Applied Sport Psychology*, *17*, 140 – 156.

Jordet, G., & Bloomfield, J. (2009). *Visual exploration in premier league footballers*. Unpublished manuscript, Norwegian School of Sport Sciences & University of Groningen.

Jordet, G., Giske, R., & Isberg, L. (2004a). Visual perception in soccer passing experts: II. An interview analysis. In G. Jordet (Ed.), *Perceptual expertise in dynamic and complex competitive team context. An investigation of elite football midfield players.* Dissertation from the Norwegian University of Sport and Physical Education.

Jordet, G., Giske, R., & Olsen, A.M. (2004b). Visual perception in soccer passing experts: I. A video analysis of prospective control and exploratory activity in real soccer games. In G. Jordet (Ed.), *Perceptual expertise in dynamic and complex competitive team context. An investigation of elite football midfield players*. Dissertation from the Norwegian University of Sport and Physical Education.

Kerlinger, F.N., & Lee, H.B. (2000). *Foundation of behavioral research*. Forth Worth, Tex.: Harcourt Brace Jovanovich College Publ.

Kratochwill, T.R., & Wetzel, R.J. (1977). Observer agreement, credibility, and judgment: some considerations in presenting observer agreement data. *Journal of Applied Behavior Analysis*, *10*, 133 – 139.

McPherson, S.J. (1999a). Tactical Differences in Problem Representations and Solutions in Collegiate Varsity and Beginner Female Tennis Players. *Research Quarterly for Exercise and Sport, 70,* 369 – 384.

McPherson, S.J. (1999b). Expert-Novice Differences in Performance Skills and Problem Representations of Youth and Adults During Tennis Competition. *Research Quarterly for Exercise and Sport, 70,* 223 – 251.

Michaels, C.F., & Carrelo, C. (1981). *Direct perception*. Prentice-Hall, INC, Englewood Cliffs, New Jersey.

Miller, R. (1996). Attack from the flank. *Coach and Athletic director, December*, 59 – 60.

Montagne, G. (2005). Prospective control in sport. *International Journal of Sport Psychology, 36,* 127 – 150.

Raab, M., & Johnson, J.G. (2007). Expertise-based differences in search and option-generation strategies. *Journal of Experimental Psychology: Applied, 13,* 158 – 170.

Reed, E.S. (1996). *Encountering the world: Toward an ecological psychology*. New York: Oxford University Press.

Ringdal, K. (2001). Enhet og mangfold. Samfunnsvitenskapelig forskning og kvantitativ metode. Fagbokforlaget Vigmostad & Bjørke AS.

Savelsbergh, G.J.P., Williams, A.M., van der Kamp, J., & Ward, P. (2002). Visual search, anticipation and expertise in football goalkeepers. *Journal of Sport Sciences, 20,* 279 – 287.

Schempp, P.G., McCullick, B., & Mason, I.S. (2006). The development of expert coaching: Re-conceptualising sports coaching. In R.L. Jones (Ed.), *The Sports Coach as Educator* (pp. 145 – 161), Routledge: Taylor & Francis Group.

Starkes, J.L. (1987). Skill in Field Hockey: The Nature of the Cognitive Advantage. *Journal of Sport Psychology, 9,* 146 – 160.

Turvey, M.T. (1992). Affordances and prospective control: An outline of the ontology. *Ecological Psychology, 4,* 173 – 187.

Vicente, K.J., & Wang, J.H. (1998). An ecological theory of expertise effects in memory recall. *Psychological Review, 105*, 33 – 57.

Vincent, W.J. (2005). *Statistics in kinesiology* (3rd edition). Champaign: Human Kinetics.

Williams, A.M. (2000). Perceptual skill in soccer: Implications for talent identification and development. *Journal of Sport Sciences, 18*, 737 – 750.

Williams, A.M., & 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., Burwitz, L., & Williams, J.G. (1994). Visual search strategies in experienced and inexperienced soccer players. *Research Quarterly for Exercise and Sport, 65*, 127 – 135.

Williams, A.M., Davids, K., & Williams, J.G. (1999). *Visual perception and Action in Sport*. London: E & FN Spon.

# Appendix

# MANUAL FOR THE CAMERA OPERATORS
2009

Made by
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*The Purpose* with this recording is to gather information about the players' ability to "read the game". Pictures of the body and head are therefore important information sources for later analysis. In additional, we want to investigate the players' decisions and choices of decisions during the play, with and without the ball.

*Equipment:*

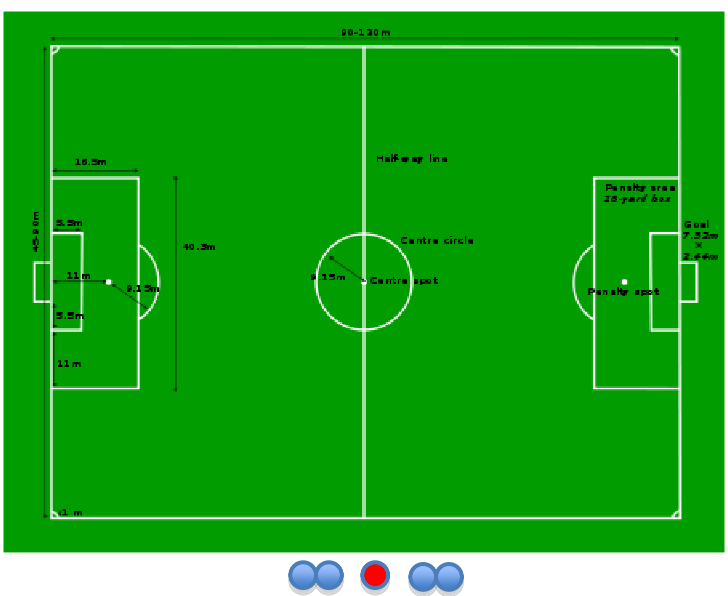
It is of importance that equipment that is to be used is checked and pretested in good time before the game begins. You will then be given the opportunity to get to known the equipment, and to check: the battery capacity, videocassette, the camera zoom and – focus. In additional, you will be able to adjust the friction on the steering wheel and –stick on the tripod (the camera should move easily and smoothly, without any jumpy and sudden moves), and taken a test filming.

It is advised to check if there is any contact plug near where you stand, so there is no need to use the battery capacity on the camera. Specially, during cold temperatures this is important, because batteries loose a lot of electricity without using it. If there is nothing near you, it is very important that you have an extra battery and this may be inside a pocket to keep it on a temperature stable level.

*Placing the camera:*

When you are setting up the equipment you should be aware of that no objects or spectators are in your way during the filming. In additional, the tripod should be placed on a steady ground.

On the picture below, I wish to illustrate where the camera should be in relation to each other. It is important that all cameras are on the same side to receive a similar perceptive later on when the analysis begins.



The blue circles illustrate the player cameras and the red circle illustrates the overview camera.

Last, do not film on ground level, but some meters up to get a better overview of the whole pitch.

*The Overview Camera and the Player Camera:*

The Overview Camera's first object is to focus on the ball, but also with the environment around the ball. The second object is to make it able to identify every player later on during the analysis. The third and last object is that the overview camera is filming most of the pitch and avoids what's outside.

When a team is attacking is it a advance to have the player with the ball to the side of the picture to have the possibility to see all the movements in front of him (see example picture to the right)

For those that has the task of using the Player Camera, it is important that you zoom to get a close-up picture of the player, where one can register the players head and feet (see example picture below). But be sure to have some air above and under the player – if the head is outside the picture in 1/10 of a second during a relevant situation this means that this sequence must be excluded.

It is not as easy as you may think to follow a player, and therefore it is important that you concentrate on the task. To make the task easier, look for specific characteristics of the player (e.g., shirt number, hear, glows, movements characteristics and so on...) This is also for help if you should be unlucky of losing the player out of sight, so it goes faster to regain the focus on the player.

*The Syncing:*

The Overview Camera and The Player Camera is going to be synced to one common picture later on, hence it is important that every one that's participate in the filming press record few second before the match starts. I additional, to make the syncing easier later on, it is wish able that all cameras are focused on the middle when the ball sets off. And thereafter, for those with the player cam, locating the player fast as possible and lets the camera follow the player.

When you start filming it is important to let the record go continually without any stop. Even if there is a stop in the game, the camera must continuing record. The only time when you can stop filming is in the break and when the game ends. This is important because the recordings are going to be synced later on, and if someone has stopped the tape during the game (by e.g., injuries or longer breaks in the game) must it be synchronized one more time.

If there is something that should happened during the recording, e.g., the battery is used up, tell the responsible so he or she has the possibility to note how much time the camera was off – all this to make the synchronizing easier in a later time.

*Remember:*

- Look in the camera display all the time; one little look outside makes it possible to loose the player out of focus.
- Adjust the steering wheel and stick, so the friction is middle low. This will make is easier to follow the player, and give a soft and easily filming.
- Do not set the camera to close to each other, just to avoid any collision or that somebody gets in the way to each other.

**Appendix B**

Descriptive of the participants

| Participant | Level | N | Exploration Frequency | | | | Posture in percent | | | Position (n) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mean | Std. Deviation | Minimum | Maximum | I | II | III | A | B | C | D |
| 1 | 1 | 22 | 0,3018 | 0,27197 | 0 | 1 | 13,6 % | 86,4 % | 0,0 % | 3 | 16 | 0 | 3 |
| 2 | 2 | 8 | 0,3138 | 0,23802 | 0 | 0,71 | 0,0 % | 87,5 % | 12,5 % | 1 | 6 | 0 | 1 |
| 3 | 1 | 22 | 0,4673 | 0,39061 | 0 | 1,67 | 9,1 % | 90,9 % | 0,0 % | 6 | 10 | 0 | 6 |
| 4 | 1 | 19 | 0,4011 | 0,25057 | 0 | 1 | 5,3 % | 84,2 % | 10,5 % | 4 | 12 | 0 | 3 |
| 5 | 1 | 12 | 0,3367 | 0,21474 | 0 | 0,7 | 8,3 % | 66,7 % | 25,0 % | 1 | 7 | 0 | 4 |
| 6 | 1 | 12 | 0,4625 | 0,28291 | 0 | 0,8 | 16,7 % | 75,0 % | 8,3 % | 5 | 5 | 0 | 2 |
| 7 | 1 | 15 | 0,5867 | 0,27740 | 0,2 | 1 | 12,5 % | 68,8 % | 18,8 % | 6 | 7 | 0 | 3 |
| 8 | 2 | 24 | 0,2014 | 0,16782 | 0 | 0,5 | 8,3 % | 66,7 % | 25,0 % | 3 | 15 | 1 | 5 |
| 9 | 2 | 8 | 0,4538 | 0,23046 | 0,1 | 0,8 | 25,0 % | 62,5 % | 12,5 % | 2 | 4 | 0 | 2 |
| 10 | 2 | 21 | 0,3595 | 0,19469 | 0 | 0,8 | 9,5 % | 66,7 % | 23,8 % | 2 | 14 | 3 | 2 |
| 11 | 1 | 34 | 0,4049 | 0,19921 | 0,1 | 1 | 0,0 % | 91,2 % | 8,8 % | 7 | 21 | 2 | 4 |
| 12 | 1 | 32 | 0,4444 | 0,24587 | 0 | 1 | 6,3 % | 81,3 % | 12,5 % | 8 | 19 | 0 | 5 |
| 13 | 2 | 9 | 0,2311 | 0,17345 | 0 | 0,5 | 11,1 % | 77,8 % | 11,1 % | 3 | 6 | 0 | 0 |
| 14 | 2 | 22 | 0,3327 | 0,19876 | 0 | 0,8 | 4,5 % | 72,7 % | 22,7 % | 7 | 13 | 0 | 2 |
| 15 | 2 | 21 | 0,1405 | 0,15461 | 0 | 0,6 | 0,0 % | 90,5 % | 9,5 % | 3 | 16 | 0 | 2 |
| 16 | 2 | 8 | 0,3700 | 0,11502 | 0,2 | 0,5 | 0,0 % | 100,0 % | 0,0 % | 3 | 5 | 0 | 0 |
| 17 | 1 | 11 | 0,3909 | 0,17581 | 0,2 | 0,7 | 8,3 % | 50,0 % | 41,7 % | 5 | 5 | 0 | 2 |
| 18 | 1 | 9 | 0,3000 | 0,13229 | 0,1 | 0,5 | 18,2 % | 72,7 % | 9,1 % | 4 | 7 | 0 | 0 |
| 19 | 2 | 7 | 0,4143 | 0,10690 | 0,3 | 0,6 | 0,0 % | 100,0 % | 0,0 % | 3 | 3 | 0 | 1 |
| 20 | 2 | 6 | 0,1000 | 0,08944 | 0 | 0,2 | 0,0 % | 83,3 % | 16,7 % | 1 | 5 | 0 | 1 |
| 21 | 1 | 19 | 0,3721 | 0,14301 | 0,17 | 0,6 | 0,0 % | 89,5 % | 10,5 % | 4 | 11 | 0 | 4 |
| 22 | 1 | 19 | 0,4858 | 0,27437 | 0,1 | 1,2 | 31,6 % | 63,2 % | 5,3 % | 3 | 14 | 0 | 2 |
| 23 | 1 | 13 | 0,4485 | 0,14843 | 0,2 | 0,8 | 0,0 % | 92,3 % | 7,7 % | 1 | 12 | 0 | 0 |
| 24 | 2 | 8 | 0,2875 | 0,18077 | 0 | 0,5 | 25,0 % | 25,0 % | 50,0 % | 6 | 1 | 0 | 1 |
| | Total | 381 | 0,3666 | 0,24308 | 0 | 1,67 | 8,3 % | 78,2 % | 13,5 % | 91 | 234 | 6 | 55 |

Note. Three postures are identified as I (Back to Goal), II (Side to Goal), III (Front to Goal). For further explanation see method chapter. Central defender's position were divided into four areas: (A) In front of the first goal post, (B) Between both goal posts, (C) Behind the second goal post and (D) Outside the penalty area.

**Descriptive statistics on central defenders environment**

| | Group | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Crossers distance from goal line (in meters) | Elite | 246 | 17,6057 | 10,14743 | 0,5 | 41 |
| | Sub-Elite | 143 | 12,4790 | 9,51757 | 0,5 | 38 |
| Opponents inside the penalty area | Elite | 226 | 2,4646 | 1,28273 | 0 | 6 |
| | Sub-Elite | 134 | 2,3134 | 1,22270 | 0 | 6 |
| Players inside the penalty area | Elite | 226 | 6,6283 | 2,85562 | 1 | 12 |
| | Sub-Elite | 134 | 6,6940 | 2,59620 | 1 | 16 |

Note. Players inside penalty area: All players inside but the participant was excluded.
See method chapter for more.

# *Logistic Regression analysis of posture*

## Case Processing Summary

| Unweighted Cases(a) | | N | Percent |
|---|---|---|---|
| Selected Cases | Included in Analysis | 385 | 99,0 |
| | Missing Cases | 4 | 1,0 |
| | Total | 389 | 100,0 |
| Unselected Cases | | 0 | ,0 |
| Total | | 389 | 100,0 |

**a If weight is in effect, see classification table for the total number of cases.**

## Dependent Variable Encoding

| Original Value | Internal Value |
|---|---|
| 1,00 | 0 |
| 2,00 | 1 |

## *Categorical Variables Codings*

| | | Frequency | Parameter coding (1) |
|---|---|---|---|
| Group | Elite | 243 | ,000 |
| | Sub-Elite | 142 | 1,000 |

**Block 0: Beginning Block**

Classification Table(a,b)

| | | | Predicted | | |
|---|---|---|---|---|---|
| | | | Posture | | Percentage Correct |
| | Observed | | 1,00 | 2,00 | |
| Step 0 | Posture | 1,00 | 333 | 0 | 100,0 |
| | | 2,00 | 52 | 0 | ,0 |
| | Overall Percentage | | | | 86,5 |

**a Constant is included in the model.**

b The cut value is ,500

*Variables in the Equation*

| | | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| Step 0 | Constant | -1,857 | ,149 | 155,083 | 1 | ,000 | ,156 |

Variables not in the Equation

| | | | Score | df | Sig. |
|---|---|---|---|---|---|
| Step 0 | Variables | Group(1) | 4,443 | 1 | ,035 |
| | Overall Statistics | | 4,443 | 1 | ,035 |

**Block 1: Method = Enter**

## *Omnibus Tests of Model Coefficients*

| | | Chi-square | df | Sig. |
|---|---|---|---|---|
| Step 1 | Step | 4,313 | 1 | ,038 |
| | Block | 4,313 | 1 | ,038 |
| | Model | 4,313 | 1 | ,038 |

**Model Summary**

| Step | -2 Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---|---|---|---|
| 1 | 300,532(a) | ,011 | ,020 |

**a Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.**

Classification Table(a)

# Appendix D

| Observed | | | Predicted | | |
|---|---|---|---|---|---|
| | | | Posture | | Percentage Correct |
| | | | 1,00 | 2,00 | |
| Step 1 | Posture | 1,00 | 333 | 0 | 100,0 |
| | | 2,00 | 52 | 0 | ,0 |
| | Overall Percentage | | | | 86,5 |

**a The cut value is ,500**

Variables in the Equation

| | | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| Step 1(a) | Group(1) | ,626 | ,300 | 4,351 | 1 | ,037 | 1,871 |
| | Constant | -2,122 | ,208 | 104,529 | 1 | ,000 | ,120 |

**a Variable(s) entered on step 1: Group.**